Insights into Amino Acid Requirements for Dairy Cattle. Where to Next?

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Virginia Tech Dept. of Dairy Science

“Agriculture in the 21st century faces multiple challenges: it has to produce more food...to feed a growing population...adopt more efficient and sustainable production methods and adapt to climate change.”

Adapted from FAO “High-Level Expert Forum”, 2009

Challenges of Production

• Environmental issues
  – Leaching, volatilizations, and gas emissions
• Health concerns
  – Spread of disease

“Agriculture in the 21st century faces multiple challenges: it has to produce more food...to feed a growing population...adopt more efficient and sustainable production methods and adapt to climate change.”

Adapted from FAO “High-Level Expert Forum”, 2009
Improving Efficiency

- Swine and Poultry Production
  - dietary protein and EAA supplementation
  - Gross N efficiencies of 40% or greater
- Dairy Production
  - Achieve N efficiency of ~25%
  - N requirements expressed in terms of MP
  - Overfeed EAA results in poor N efficiency

Current AA Requirements

- Flow of MP and EAA
  - Dietary RUP and microbial protein
  - Requirements for Lys & Met as a proportion of total MP required
- Splanchnic and mammary removal of EAA differs among AA
  - Defining AA in aggregate or as fixed proportion of MP likely over/under-predicts requirement for other EAA

- Intestinal digestibility
  - RUP based on digestion coefficients for protein in each feed ingredient
  - Microbial protein assumed to be 80%
- Comparison of coefficient predictions and net portal appearance of absorbed EAA
  - Predictions with small errors suggesting this method works within range of observed data

NRC, 2001; Hanigan et al., 2001; El-Kadi et al., 2006; Sequeira et al., 2000

Source: Broderick, 2003; Kalscheur et al., 2006

Source: Nahm, K. H., 2002; Tamminga, 1992
Current AA Requirements

- Post-Absorptive AA Requirement
  - Restricts AA requirement for production to MP supply
  - Lys and Met AA limiting protein yield
- Improved milk production and efficiency observed independent of MP supply
  - Indicates that one or more EAA was still limiting even at high level of dietary MP

NRC, 2001; Haque et al., 2012

Current AA Requirements

- Blood
- Mammary Gland

NRC, 2001; Hristov et al., 2004; Arriola Apelo et al., 2014

Current AA Requirements

- Blood
- Mammary Gland

NRC, 2001; Doepel and Lapierre, 2010; Doepel and Lapierre, 2011; Bequette et al., 2000

In-Vitro Responses

Treatment

Appuhamy et al., 2012
Objective: Shift the single limiting AA paradigm and amend the current model for AA requirements in order to improve AA utilization by dairy cattle.

In-Vitro Responses

- Challenge the single-liming AA theory
  - Ile, Leu, Met, Thr
  - Saturable responses
  - Max response
  - DMI depression
- Determine independent milk protein yield and DMI responses

In-Vivo Responses

- Experimental Design
  - 48 lactating cows
    - Blocked into 4 groups (1 group for each AA)
    - 4x4 LSD replicated within Block (AA)
    - 4, 12-d periods
    - Fed 1 of 4 doses of encapsulated AA based on block
  - 75% of NRC MP requirement (13.5% CP, %DM)
- Sample collection
  - Last 5d of each period
  - Daily feed intake, milk yield, milk composition, BW
In-Vivo Responses

Aguilar et al., unpublished

<table>
<thead>
<tr>
<th>Dose</th>
<th>Ile</th>
<th>Leu</th>
<th>Met</th>
<th>Thr</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>50%</td>
<td>68</td>
<td>30</td>
<td>16</td>
<td>40</td>
</tr>
<tr>
<td>100%</td>
<td>136</td>
<td>59</td>
<td>31</td>
<td>80</td>
</tr>
<tr>
<td>150%</td>
<td>204</td>
<td>89</td>
<td>47</td>
<td>120</td>
</tr>
</tbody>
</table>

Doses of AA calculated as the difference between NC and the supply of each AA provided by a properly balanced diet at NRC requirements for MP.

In-Vivo Responses

Aguilar et al., unpublished

Determine independent and interactive effects of AA on milk protein synthesis and post-absorptive efficiency of use for milk protein synthesis.
In-Vivo Responses

• Experimental Design
  – Incomplete LSD replicated within block
  • 3, 21-d periods
  • Blocked by milk protein yield
  – 48 lactating cows blocked into 4 groups of 12
  • 75% of NRC MP requirement (14% CP, %DM)
  • Fed 1 of 12 treatments in individual calan gates
  • CNC, I, L, M, T, LT, MT, IL, ILM, ILT, ILMT
  – 48 lactating cows blocked into 4 groups of 12
  • 100% of NRC MP requirement (16.2% CP, %DM)
  • Fed treatment in 1 of 4 pens

• Experimental Design cont’d
  – Doses of AA (g/d/cow)
    • Met, 31 (100% Dose)
    • Ile, 204 (150% Dose)
    • Leu, 89 (150% Dose)
    • Thr, 120 (150% Dose)
  – Isotopic Infusion
    • 40 animals given continuous infusion of a stable, isotopically labeled AA mixture
    • Blood collected during 2 hour infusion and 1 hour post infusion
    • Milk samples collected pre and post infusion

The ultimate goal is to use this information to derive new AA requirement equations that will more appropriately represent true biological behavior and that will provide more accurate AA requirement predictions.
Questions?
WHAT IS AN ALTERNATIVE FEED INGREDIENT?

1. Criteria determined by the operation
2. Agri Stats definition

Any ingredient which will replace corn, soybean meal or fat in the diet

ALTERNATIVE FEED INGREDIENTS

Primary Energy - Corn & Fats
- Wheat
- Milo - low tannin

Primary Protein/amino acids - Soybean Meal
- Canola/Sunflower Meals
- DDG's
- Expelled soybean meal
- Bakery Meals
- Meat and bone meal & animal protein blends
- Vegetable Protein Blends
Determining true savings/costs

- Savings per ton of feed x tons of feed = $$$$ savings
- Decision made
- True Savings?

Determining true savings/costs

- Availability
  - How long will supply last?
  - Worth the effort? Do savings hold true?
  - Delivery - dependable or variable?
    - Railroad - demurrage costs
    - Trucks - 3rd Generation Trucking Rules
    - Time of year - summer versus winter
    - Overtime costs to handle
    - Bird performance
    - FSMA!
    - Veterinary Feed Directive (VFD)

Determining true savings/costs

- Bin Space
  - Enough ingredient bin space to handle?
  - Will ingredient flow through system?
  - Does ingredient need to be ground? e.g. wheat replacing corn

Determining true savings/costs

- Impact on production of final feeds
  - Effect on through-put?
  - Effect on pellet quality and thus bird performance?
The Bird
Feed Mill
Feed Formulation
People

Ingredient must be priced to lower the feed cost per pound of meat/dozen eggs or increase yield which the birds will tell us. Strain and bird size needs to be considered.

Consistency and reliability of product performance will be key.

Eliminate the "trader" mentality. Not all DDG’s, animal proteins, grains the same!

Can the ingredient be used in the feed mill? Every feed mill is different!

- Bin Space
- Receiving Issues/costs
- Hassle factor for the feed mill - must be quantified via overtime, demurrage costs etc.

People

- People business
- Purchasing, nutrition, feed mill and live production all need to work together to determine the value of alternative ingredients.
- Eliminate “silos” and “conflicting goals” and respect each other’s positions.
THANK YOU!
FEEDING THE HIGH PRODUCING DAIRY HERD

Dr. L. E. Chase
Professor Emeritus – Animal Science
Cornell University

What is A High Producing Dairy Herd?

- How many are there?
- What is the highest herd average?

Daily Inputs Required

The Cow Needs
Raleigh DHI Data – 1/16

- Used the Dairy Metrics program to query the database.
- Search criteria:
  - Holstein and Jersey herds.
  - Total herds and herds in the South.
  - Sorted by milk production groups.
- Goal – Define some herd parameters associated with milk production levels.
- Holstein Herds:
  - All herds = 10,121
  - South = 806 (Virginia = 259 herds)
- Jersey Herds:
  - All herds – 568 (Virginia = 9 herds)
Jersey Herds, % of Herds

<table>
<thead>
<tr>
<th>RHA- Thousands</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;12</td>
</tr>
<tr>
<td>All Herds</td>
</tr>
</tbody>
</table>

Cows/Herd – Holstein Herds by Milk Production Level

<table>
<thead>
<tr>
<th>RHA, lbs./cow</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;16</td>
</tr>
<tr>
<td>All Herds</td>
</tr>
</tbody>
</table>

% 1st Calf Heifers – Holstein Herds

<table>
<thead>
<tr>
<th>RHA, lbs./cow</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;16</td>
</tr>
<tr>
<td>All Herds</td>
</tr>
</tbody>
</table>

% 3+ Lactation Cows – Holstein Herds

<table>
<thead>
<tr>
<th>RHA, lbs./cow</th>
</tr>
</thead>
<tbody>
<tr>
<td>13896</td>
</tr>
<tr>
<td>All Herds</td>
</tr>
</tbody>
</table>
Interim Summary

- Higher producing herds have:
  - More 1st lactation heifers and less older cows.
  - Lower age at calving for 1st calf heifers.
  - Similar number of cows that die.
  - Lower somatic cell counts.
  - Higher 21 day pregnancy rates.

Highest Herds

- Holstein -
  - Highest is 35045 lbs./cow.
  - 44 herds > 32,000 lbs./cow.
  - South = 31,875 lbs./cow. (highest herd)
  - South = 30 herds > 28,000 lbs./cow.
- Jersey herds -
  - Highest herd is 22,638 lbs./cow.
  - 10 herds are > 21,000 lbs./cow.
  - Highest South herd is 21,067 lbs./cow.

Rations in High Producing Herds

- How do high producing herds get enough units of nutrients per day into the cows?
  - A. Increase ration nutrient density?
  - B. Increase DMI?

Ration Questions

- A large dairy sells a TMR to a neighboring small farm. Milk production on the large dairy is 78 lbs./cow/day while it is 86 lbs./cow/day on the small farm. How do you explain this?
- A high group of cows is averaging 120 lbs. of milk per day on a TMR "formulated" for 85 lbs. of milk. How do you explain this?
- A high group of cows is averaging 120 lbs. of milk per day but the top cow in the group is producing 180 lbs. of milk. How do you explain this?
What Do High Producing Herds Feed?

- 25 herds.
- Holstein herds fed TMR’s.
- Northeast and Midwest herds.
- Milk = 30,842 lbs./cow (28,031 to 36,729 lbs./cow).
- Milk fat, % = 3.75 (range = 3.21 to 4.26%).
- Milk true protein, % = 3.05 (range = 2.9 to 3.22).
- All rations run through the CNCPS 6.1 model.

Forages Fed and NDF

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Forage in Ration</td>
<td>52.9</td>
<td>45 – 62.8</td>
</tr>
<tr>
<td>Corn Silage, % of Ration DM</td>
<td>32.2</td>
<td>18.8 – 49</td>
</tr>
<tr>
<td>Corn Silage, % of Forage DM</td>
<td>62.1</td>
<td>35.2 – 80.9</td>
</tr>
<tr>
<td>Ration NDF, %</td>
<td>30.1</td>
<td>24.5 – 32.8</td>
</tr>
<tr>
<td>Forage NDF, % of Ration DM</td>
<td>22.9</td>
<td>19.75 – 28.2</td>
</tr>
</tbody>
</table>

Other Forages Fed

<table>
<thead>
<tr>
<th>Forage</th>
<th>Number of Herds</th>
<th>% of Total DM</th>
<th>% of Forages Fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>4</td>
<td>1.2</td>
<td>2.3</td>
</tr>
<tr>
<td>Dry Hay</td>
<td>12</td>
<td>3.47</td>
<td>6.5</td>
</tr>
<tr>
<td>Hay crop Silage</td>
<td>25</td>
<td>18.9</td>
<td>37</td>
</tr>
</tbody>
</table>

Ration Protein and Amino Acids

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, %</td>
<td>16.7</td>
<td>14.3 – 18.1</td>
</tr>
<tr>
<td>MP, g/day</td>
<td>3007</td>
<td>2501 – 3718</td>
</tr>
<tr>
<td>MP bacteria, % of total MP</td>
<td>46.3</td>
<td>38.9 – 52.6</td>
</tr>
<tr>
<td>Lysine, % of MP</td>
<td>6.5</td>
<td>5.87 – 6.94</td>
</tr>
<tr>
<td>Methionine, % of MP</td>
<td>2.16</td>
<td>1.76 – 2.55</td>
</tr>
<tr>
<td>Lysine: Methionine ratio</td>
<td>3.06:1</td>
<td>2.54:1 – 3.76:1</td>
</tr>
</tbody>
</table>
**Starch, Sugar and Fat**

<table>
<thead>
<tr>
<th>Item</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ration Starch, %</td>
<td>26.7</td>
<td>21.3 – 30.1</td>
</tr>
<tr>
<td>Ration Sugar, %</td>
<td>4.4</td>
<td>2.7 – 8.3</td>
</tr>
<tr>
<td>Ration Fat, %</td>
<td>5.3</td>
<td>4.2 – 6.6</td>
</tr>
</tbody>
</table>

**Energy Sources Fed**

- HMSC = 10
- Corn grain = 21
- Tallow = 9
- Whey = 6
- Molasses = 10
- Sugar = 4
- Whole cottonseed = 13
- Bypass fat = 20

**Protein Sources Fed**

- Corn gluten feed = 9
- Corn germ meal = 4
- Corn gluten meal = 2
- Distillers = 13
- Soybean meal = 14
- Roasted soybeans = 8
- Expeller SBM = 20
- Canola meal = 18
- Urea = 12
- Animal protein blends = 7
- Blood meal = 13
- RP methionine = 18

**Non-dietary Factors and Milk Production**

- 47 herds in NE Spain
- 3,129 cows
- All herds were fed the *same TMR*
- Mixed at the cooperative and delivered to each herd daily
- Feed *delivered* per cow ranged from 35.4 to 54.3 lbs. of DM

*Bach et.al., J. Dairy Sci. 91:3259-3267, 2008*
Herd Milk Production

What Were the Key Differences in These Herds?
- Age at 1st calving was negatively correlated with milk production
- Stalls/cow were positively related to milk
- Herds that pushed up feed produced 8.3 lbs. more milk
- Herds that had refusals produced 3.5 lbs. more milk.

These factors accounted for >50% of variation in milk production

Corwin Holtz - 2010
- 7 Big Management Areas That Make a Difference
  - 25% = Cow Comfort
  - 25% = Forage Quality
  - 15% = Transition/Dry Cow Mgmt.
  - 15 % = Reproduction
  - 10% = Routine
  - 5% = Social interaction
  - 5 % = Nutrition

- Holtz-Nelson Consulting Group

Feeding Management and Milk Production
- Sova et. al., JDS – 2013 -
  - 22 free-stall herds in Ontario.
  - Herd size = 162 cows.
  - Average group size = 83 cows.
  - Average days in milk = 187.
  - Average DMI = 54.5 lbs.
  - Average milk production = 75.5 lbs.
  - TMR’s were studied for 7 consecutive days.
  - If multiple feeding groups, used the highest producing group.
  - Feeds fed and refused were recorded and sampled daily.
Key Findings

- Feeding 2x versus 1 x =
  - Increase of 3.1 lbs. of DMI.
  - Increase of 4.4 lbs. of milk.
  - Decreased ration sorting.
- Every 2% group-level sorting of long particles was associated with a 2.2 lbs. per day decrease in milk.

  - Sova et al., 2013

Cow Comfort

- A 700 cow herd built a new free-stall barn to reduce cows/stall from 1.2 to 1.
  - Predicted milk response was 5-6 lbs./day.
  - Actual was 8-10 lbs. of milk.
- At Cornell, we moved from a 40 year old free-stall barn to a new, sand-bedded free-stall barn in 2013:
  - Resting time increased.
  - Time standing decreased.
  - Milk increased 7-9 lbs. with no ration change.
- Many other herds report increases of 5 – 12 lbs. of milk per cow when cow comfort is improved.

Feed bunk space affects where cows choose to eat (Rioja-Lang et al., 2012)

- Compared 76, 60, 46, and 30 cm of bunk space and preference for:
  - low-palatability feed alone
  - high-palatability feed next to a dominant cow
  - Y-maze testing to offer choices

<table>
<thead>
<tr>
<th>Space (cm)</th>
<th>HPF Dominant</th>
<th>Equal choice</th>
<th>LPF Alone</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>0</td>
<td>1</td>
<td>11</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>46</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>60</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>&gt;0.05</td>
</tr>
<tr>
<td>76</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>&gt;0.05</td>
</tr>
</tbody>
</table>

Optimizing Cow Behavior: On-Farm Concept

- Facility
  - stalls
  - floors
- Feed area
- Ventilation
- Grouping
- Stacking Density
- Time Budgeting & Natural Behaviors
- Resting
- Feeding
- Ruminating
- Productivity and Health
Feeding environment affects cow behavioral, productive, and efficiency responses

Relationship between resting and milk yield (Miner Institute data base)

\[ y = 49.2 + 3.7x \]
\[ r = 0.55 \]

Kentucky High Producing Herds
- Smith et. al., The Professional Animal Scientist – 2013.
- Surveyed 23 Kentucky dairy herds with > 22,000 lbs. of milk. Average milk = 23,736 lbs. (range = 22,028 to 27,687 lbs. milk).
- 65% of the herds were partial confinement and 35% were total confinement.
- Average number of cows = 191 (range 25 to 1,590).
- 74% of the herds milked 2x.

Kentucky Herds – Management Practices Adopted
- Regular forage testing = 100%.
- Fans, sprinkler or both = 91%.
- Rations balanced at least yearly = 87%.
- Separate far-off and close-up groups = 70%.
- Kernel processor = 70%.
- Electronic feed management program = 57%.
- Push up feed regularly = 52%.
Kentucky Herds – Feed Additives

- Use rumen buffers = 91%.
- Use yeast cultures = 78%.
- Use organic or chelated minerals = 65%.
- Use mycotoxin binders = 65%.
- Use bypass = 57%.
- Use ionophores = 57%.
- Use direct-fed microbials = 43%.
- Use anionic salts = 35%.

“What 1 Management Practice Has Contributed the Most to Your Current Level of Milk Production?”

- Attention to detail = 8 responses.
- Nutrition = 5 responses.
- Cow comfort = 4 responses.
- Quality forages = 4 responses.
- Record keeping = 3 responses.
- Genetics = 3 responses.
- Consistency = 2 responses.
- Many others had 1 response each.

Survey of Kentucky dairy herds.

Milking Frequency, % of Herds

<table>
<thead>
<tr>
<th>Survey</th>
<th>2x</th>
<th>3x</th>
<th>4x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michigan, 2006</td>
<td>39</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>Wisconsin, 2010</td>
<td></td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>New York, 2000</td>
<td>20</td>
<td>72</td>
<td>8</td>
</tr>
<tr>
<td>Kentucky, 2013</td>
<td>74</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Wisconsin, 2004</td>
<td>83</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>Wisconsin, 1997</td>
<td>33</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>

Number of Feedings/Day, % of Herds

<table>
<thead>
<tr>
<th>Survey</th>
<th>1</th>
<th>2</th>
<th>3+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minnesota, 2010</td>
<td>70</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>Wisconsin, 2010</td>
<td>20</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>New York, 2000</td>
<td>44</td>
<td>41</td>
<td>15</td>
</tr>
<tr>
<td>Wisconsin, 1997</td>
<td>20</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Wisconsin, 2004</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wisconsin consultant</td>
<td>67</td>
<td>22</td>
<td>11</td>
</tr>
</tbody>
</table>
### Number of Feed Pushups/Day, % of Herds

<table>
<thead>
<tr>
<th>Survey</th>
<th>0</th>
<th>1-3</th>
<th>3-6</th>
<th>&gt;6</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York, 2000</td>
<td>13</td>
<td>26</td>
<td>35</td>
<td>26</td>
</tr>
<tr>
<td>Wisconsin, 1997</td>
<td>17</td>
<td>67</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Wisconsin, 2004</td>
<td>33</td>
<td>17</td>
<td>17</td>
<td>33</td>
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<tr>
<td>Wisconsin, 2010</td>
<td>20</td>
<td>20</td>
<td>60</td>
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</tr>
<tr>
<td>Wisconsin consultant</td>
<td>11</td>
<td>11</td>
<td>56</td>
<td>22</td>
</tr>
</tbody>
</table>

### Phil Helfter – Norco Farm - 1999
- **“Nutrition is not the key to my success”**
- Northern NY herd.
- 800 cows.
- Consistently > 100 lbs. of milk per cow shipped.
- “If a cow gets sick, it’s my fault”

### J. Kollwelter WI- 2013
- I really believe by the year 2020 we should be able to push 50,000 pounds of milk.
- 210 cows, currently 40,280 lbs. milk.
- CI = 13.2, CR = 60%, AFC =22-23 months.
- “Nothing replaces walking the pens, looking at cows and being observant”
- “There are no secrets. Cow comfort, feeding a balanced ration, good genetics….all the information is out there”
- “I don’t push the cows – I just set them up to succeed”

### Gordie Jones - 2014
- Rules that still apply:
  - Cow comfort is first
  - Forage is king
  - And better forage is better
  - Preg rate means you keep cows
  - Dry cow program stops early fresh cow losses
- Milk quality is EVERYTHING
Dr. Herb Bucholtz – Michigan State - 2006

- "To achieve high per cow milk production, there are no magic ingredients or herd management techniques. It is a combination of overall excellent management of all aspects involved in feeding and managing the entire dairy herd."

Jim Barmore - 2006

- "Dairy producers need to spend more time on feeding management (feed delivery, feeding frequency, ration variation) vs. ration formulation. I see very few problems today in ration formulation and several opportunities for improvement in feeding management."

What Have We Learned?

- Ration nutrient specifications in high producing herds are “similar” to the nutrient profiles of many other herds.
- These herds use a wide variety of forages, feed ingredients and feed additives to obtain the final ration nutrient parameters.
- These herds generally tend to have more 1st lactation animals, a lower AFC, lower SCC, higher 21 day pregnancy rates and fewer fresh cow problems.

Summary

- My key points from working with and observing these herds:
  - They have comfortable cows.
  - High quality forages.
  - High and consistent DMI.
  - A "cow person" that observes and manages the cows on a daily basis.
Food Safety Modernization Act

2016 Virginia State Feed Association Convention &
Virginia Tech Dairy Nutritional Management "Cow" College
February 17, 2016
David Fairfield
National Grain and Feed Association

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Food Safety Modernization Act of 2011

- Signed into law on Jan. 4, 2011
- Greatly expands FDA’s authority to regulate the U.S. food supply
  - Mandates that FDA create a new *prevention-based regulatory system* to ensure the safety of food/feed products
  - Requires FDA to develop and issue more than 50 regulations and/or guidance documents

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### Subject of FSMA Rule

<table>
<thead>
<tr>
<th>Subject of FSMA Rule</th>
<th>Date Regs Issued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Good Manufacturing Practice (CGMPs) and Preventive Controls – Human Food</td>
<td>Aug. 30, 2015 (Sept. 17, 2015)</td>
</tr>
<tr>
<td>Current Good Manufacturing Practice (CGMPs) and Preventive Controls – Animal Food</td>
<td></td>
</tr>
<tr>
<td>Produce Safety Standards</td>
<td>Oct. 31, 2015 (Nov. 27, 2015)</td>
</tr>
<tr>
<td>Foreign Supplier Verification Programs</td>
<td>Oct. 31, 2015 (Nov. 27, 2015)</td>
</tr>
<tr>
<td>Accreditation of Third-Party Auditors</td>
<td></td>
</tr>
<tr>
<td>Sanitary Transportation of Food **</td>
<td>March 31, 2016</td>
</tr>
<tr>
<td>Food Defense/Intentional Adulteration **</td>
<td>May 31, 2016</td>
</tr>
</tbody>
</table>

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Applicability of FSMA Rules

- **Who’s In, Who’s Out ...**
  - FSMA rules generally apply to facilities required to register as a “food facility” with FDA under Bioterrorism Act requirements
  - Farms (operations meeting FDA’s definition of a “farm”) are exempt
  - Individual rules also specify certain exemptions and modified requirements
Farm means:
1) Primary production farm. A primary production farm is an operation under one management in one general (but not necessarily contiguous) physical location devoted to the growing of crops, the harvesting of crops, the raising of animals (including seafood), or any combination of these activities. The term “farm” includes operations that, in addition to these activities:
   i) Pack or hold raw agricultural commodities;
   ii) Pack or hold processed food, provided that all processed food used in such activities is either consumed on that farm or another farm under the same management, or is processed food identified in paragraph (3)(i)(B)(1) of this definition; and
   iii) Manufacture/process food, provided that:
      A) All food used in such activities is consumed on that farm or another farm under the same management; or
      B) Any manufacturing/processing of food that is not consumed on that farm or another farm under the same management consists only of:
         1) Drying/dehydrating raw agricultural commodities to create a distinct commodity (such as drying/dehydrating grapes to produce raisins), and packaging and labeling such commodities, without additional manufacturing/processing (an example of additional manufacturing/processing is slicing);
         2) Treatment to manipulate the ripening of raw agricultural commodities (such as by treating produce with ethylene gas), and packaging and labeling treated raw agricultural commodities, without additional manufacturing/processing; and
         3) Packaging and labeling raw agricultural commodities, when these activities do not involve additional manufacturing/processing (an example of additional manufacturing/processing is irradiation); OR

2) Secondary activities farm. A secondary activities farm is an operation, not located on a primary production farm, devoted to harvesting (such as hulling or shelling), packing, and/or holding of raw agricultural commodities, provided that the primary production farm(s) that grows, harvests, and/or raises the majority of the raw agricultural commodities harvested, packed, and/or held by the secondary activities farm owns, or jointly owns, a majority interest in the secondary activities farm. A secondary activities farm may also conduct those additional activities allowed on a primary production farm as described in paragraphs (1)(ii) and (iii) of this definition.
Applicability of FSMA Rules

1-2. Human Food and Animal Food CGMP and Preventive Controls

- Facilities “solely engaged” in storing grain and oilseeds exempt from requirements to implement CGMPs and preventive controls
- Different treatment for elevators handling “fruits” (i.e., lentils, kidney beans, pinto beans, lima beans, coffee beans, cocoa beans, peanuts, tree nuts and seeds for direct consumption [e.g., sunflower seeds])
- Elevators solely engaged in storing, handling such “fruits” exempt from CGMP requirements, but not exempt from the preventive controls and supply chain program requirements
- Grain millers, processors potentially covered by rules for human food and animal food
- Feed and pet food facilities covered by animal food rule

3. Foreign Supplier Verification Programs

- Applies to importers of grains and oilseeds, feed ingredients - could include a grain elevator

4. Accreditation of Third-Party Auditors

- Applies to foreign food in certain circumstances; i.e., high-risk designation by FDA or participation in Voluntary Qualified Importer Program (VQIP)

5. Sanitary Transportation of Food

- Will apply to grain elevators and feed facilities; will cover truck and rail transportation

6. Food Defense/Intentional Adulteration

- FDA proposed that animal food be exempt, human food covered

CGMPs and Preventive Controls for Animal Food

- PART 507—Current Good Manufacturing Practice, Hazard Analysis, and Risk-Based Preventive Controls for Food for Animals:
  - Subpart A: General Provisions
  - Subpart B: Current Good Manufacturing Practices (CGMPs)
  - Subpart C: Hazard Analysis and Risk-Based Preventive Controls
  - Subpart D: Withdrawal of a Qualified Facility Exemption
  - Subpart E: Supply-Chain Program
  - Subpart F: Requirements Applying to Records That Must Be Established and Maintained

Qualified Individual Requirements

- Individuals who manufacture, process, pack, or hold animal food subject to the rule are to be qualified to perform their assigned duties
- Each individual (including temporary, seasonal and contract personnel) must:
  1. Have the education, training, or experience (or a combination thereof) necessary to manufacture, process, pack, or hold safe animal food as appropriate to the individual's assigned duties; and
  2. Receive training in the principle of animal food hygiene and animal food safety, including the importance of employee health and personal hygiene, as appropriate to the animal food, and the facility
## Qualified Individual Requirements

- Rule does not specify the frequency of training, but FDA expects training to occur before working in production operations and periodic refresher training thereafter
- Rule requires that training records are to be maintained for at least two years
- Rule does not prescribe the content of training records

## CGMPs Requirements

- **CGMPs** – Required conditions and practices to ensure that animal feed/pet food will not become adulterated
  - **CGMPs establish new** requirements for animal feed/pet food facilities
    - All other applicable regulations still apply
    - BSE-Prevention requirements
    - 21 CFR Part 225 CGMPs
    - Others...

## CGMPs Requirements – Overview

- Establish requirements for following conditions/practices:
  - Personnel – cleanliness and training
  - Plant and grounds – maintenance, design, construction
  - Sanitation – housekeeping, cleaning, pest control
  - Water supply and plumbing – water quality, plumbing design, rubbish control
  - Equipment and utensils – maintenance, design, construction
  - Plant operations – labeling, inspection of raw materials, ingredients, protection against metal/foreign objects
  - Holding and distribution – storage and transportation
  - Holding and distribution of human food by-products for use as animal food

## Exempt from CGMPs

1. Farms
2. Establishments **solely engaged in the holding** and/or transportation of one or more raw agricultural commodities other than fruits or vegetables (e.g., grain elevators)
3. Establishments **solely** engaged in hulling, shelling, drying, packing, and/or holding nuts and hulls (without manufacturing/processing, such as grinding shells or roasting nuts)
4. Establishments **solely** engaged in ginning of cotton (without manufacturing/processing, such as extracting oil from cottonseed)
## Preventive Controls for Animal Food – Overview

- **Requires covered facilities to develop and implement a written animal food safety plan**
- **Plan to be developed/overseen by a “preventive controls qualified individual”**
  - *Preventive controls qualified individual* means a qualified individual who has successfully completed training in the development and application of risk-based preventive controls at least equivalent to that received under a standardized curriculum recognized as adequate by FDA (Food Safety Preventive Controls Alliance), or is otherwise qualified through job experience to develop and apply an animal food safety system.
- **Animal Food Safety Plan** to include a written hazard identification and analysis
  - Identify and evaluate *known or reasonably foreseeable hazards* – physical, chemical (radiological), biological, including those associated with intentional economic adulteration
  - Implement one or more *preventive controls* effective in preventing any hazard identified during the hazard evaluation as being a *hazard requiring a preventive control* from adulterating product

### IF a “hazard requiring a preventive control” is identified, then one or more “preventive controls” and “components to manage such controls” are to be implemented to ensure the hazard is controlled effectively. “Components to manage such controls” include, as appropriate to the preventive control:

- Monitoring
- Validation
- Verification
- Corrective actions and corrections
- Records
- Recall plan

- **All required activities within the animal food safety plan are to be documented and retained for at least two years; electronic records allowed**
- **Reassessment of animal food safety plan is required**
  - At least every three years – entire plan
  - More frequently if situations prescribed in the rule occur
Exempt from Preventive Controls

- Farms
- Facilities *solely* engaged in the storage of raw agricultural commodities (other than fruits and vegetables) intended for further distribution or processing, e.g., grain elevators
- Facilities *solely* engaged in the storage of unexposed packaged animal food that does not require time/temperature control to significantly minimize or prevent the growth of, or toxin production by, pathogens

Supply-Chain Program Requirements for Animal Food – Overview

- Applies to a covered facility that has identified a *hazard requiring a preventive control and* who relies on its “supplier” to control the hazard
- *Supply-chain-applied control* means a preventive control for a hazard in a raw material or other ingredient when the hazard in the raw material or other ingredient is controlled before its receipt

Supply-Chain Program Requirements for Animal Food – Overview

- *Supplier* means the establishment that manufactures/ processes the animal food, raises the animal, or grows the food that is provided to a receiving facility without further manufacturing/processing by another establishment, except for further manufacturing/processing that consists solely of the addition of labeling or similar activity of a *de minimis* nature

Who’s The Supplier?

- Grain Farmer
- Country Grain Elevator
- Terminal Grain Elevator
- Feed Mill
- Broker
- Grain Farmer
- Grain Farmer
Supply-Chain Program Requirements for Animal Food – Overview

**IF** a receiving facility has identified a hazard requiring a supply-chain-applied control, then the receiving facility is required to have a written supply-chain program to:

- Receive that raw material or ingredient only from approved suppliers
- Perform activities to verify that the supplier is adequately controlling the hazard

Compliance Dates for CGMPs and PCs

<table>
<thead>
<tr>
<th>Business Size</th>
<th>CGMPs Compliance Date</th>
<th>Preventive Controls Compliance Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Other than Small and Very Small</td>
<td>1 year – Sept. 19, 2016</td>
<td>2 years – Sept. 18, 2017</td>
</tr>
<tr>
<td>Small Business</td>
<td>2 years – Sept. 18, 2017</td>
<td>3 years – Sept. 17, 2018</td>
</tr>
<tr>
<td>Very Small Business</td>
<td>3 years – Sept. 17, 2018</td>
<td>4 years – Sept. 17, 2019</td>
</tr>
</tbody>
</table>

Business Sizes

- **Small Business**: A business employing fewer than 500 full-time equivalent employees. The rule specifies that when determining the number of full-time equivalent employees, the calculation is to include all employees of the business rather than be limited to the employees at a particular facility.
- **Very Small Business**: A business (including any subsidiaries and affiliates) averaging less than $2,500,000, adjusted for inflation, per year, during the 3-year period preceding the applicable calendar year in sales of animal food plus the market value of animal food manufactured, processed, packed, or held without sale (e.g., held for a fee or supplied to a farm without sale).

Compliance Dates for Supply-Chain Program

<table>
<thead>
<tr>
<th>Situation</th>
<th>Compliance date:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A receiving facility is a small business and its supplier will be subject to the CGMPs, but not the preventive control requirements, of the animal food preventive controls rule</td>
<td>The later of: September 17, 2018 or 6 months after the receiving facility’s supplier of that raw material or other ingredient is required to comply with this rule</td>
</tr>
<tr>
<td>A receiving facility is a small business and its supplier is subject to the animal food preventive controls rule</td>
<td>Six months after the receiving facility’s supplier of that raw material or other ingredient is required to comply with this rule</td>
</tr>
<tr>
<td>A receiving facility is not a small business or a very small business and its supplier will be subject to CGMPs, but not the preventive control requirements, of the animal food preventive controls rule</td>
<td>The later of: September 18, 2017 or 6 months after the receiving facility’s supplier of that raw material or other ingredient is required to comply with the CGMP requirements of this rule</td>
</tr>
<tr>
<td>A receiving facility is not a small business or a very small business and its supplier will be subject to the animal food preventive controls rule</td>
<td>Six months after the receiving facility’s supplier of that raw material or other ingredient is required to comply with this rule</td>
</tr>
</tbody>
</table>
## FDA Guidance Documents – In Process

- Current Good Manufacturing Practices
- Human Food By-Products for Use as Animal Food
- Hazard Analysis and Preventive Controls
- A Small Entity Compliance Guide that explains the actions a small or very small business must take to comply with the rule

## Food Safety Preventive Controls Alliance

- FDA-recognized hazard analysis and preventive controls training for food/feed industry and regulatory personnel -
  - Developed by subject-matter experts from government, industry, academia
  - Individuals successfully completing training will be “preventive controls qualified individuals”
  - Curriculum likely to be available in June
  - Likely will be a 20-hour course

## Food Safety Modernization Act

David Fairfield  
Senior Vice President, Feed Services  
National Grain and Feed Association  
Email: dfairfield@ngfa.org  
Phone: (712) 243-4035
Information Used to Monitor Our Robotic Milking Herd

Scott and Laura Flory
Hillside Farm
Dublin, VA

Hillside Farm

- Herd size – 230
- Facility- Freestall Barn with 4 Lely A-4's and Juno Feed Pusher
- Closed Loop Flush System with Sand Lane
- Automatic Calf Feeder and Growing Calf Barn
- RHA – 27,300 lbs/cow
Scope of Data

- 100 data points/cow/day
- Over 20,000 numbers collected in 24 hours herd wide
- One lactation = 500x amount of data as monthly test data

“It’s not information overload, it’s filter failure.”
- Clay Shirky
Rumination

- Herd Wide
- Within Management Groups
- Individual Animals
- Precedes all unfavorable circumstances

Milkings/Cow/Day

- Total Free Flow System
- Leads Milk Production
- Managed – Herd Wide, Groups, Individual Animals
Production/Components

- Focus on key management groups (i.e. Fresh Cows)
  - Production
  - Deviations over time
  - Fat/Protein Indication
  - Fat/Protein Ratio

Refusals

- Unrewarded visits to robot (i.e. too early)
- Indicator of energy status or animals comfort level and curiosity
- Managed by group status or herd only
Concentrate Intake

- Can be used to monitor herd, groups or individual animals
- Designed to follow production model

Rest Feed

- Measure of how much concentrate was unclaimed based on amount allowed per production table
- Controlled amount allowed to carry to next day
- Indicator of infrequent visits by individual animal
- Monitor as a percentage for herd basis

Fetch Cows

- List generated from:
  - Animals not milked in over 12 hours
  - Animals over 8 hours that aren't meeting their minimum average milkings based on production and stage of lactation
- The fewer the better
- Indicator of overall nutritional balance and herd health
Conductivity

- Per quarter/animal every milking
- Numerical value
- Tracking deviations from other quarters or individual history
- Time lag on down trends
- Observation:
  - Milk volume has effect
  - False Positives

Questions?
Monitoring Dairy Management Remotely

Patrick French, PhD, Dipl ACAN
How Can I Use This?

- File Storage
- File Sharing
  - Work
    - Rations
  - Home
    - Game Schedules
    - Photos
- Store Everything, Share Somethings
Class III Equivalent Milk (C3EM)

- C3EM = Calculated Milk Value / Class III * 100
- Class III Milk = [(Protein Price x 3.1) + (Other solids price x 5.9) x 0.965] + Fat Price x 3.5
- Calculate Milk Value =
  \[ \text{Protein lbs} \times \text{Protein Price} + [3.1 \times 3 = 9.3] \]
  \[ \text{Fat lbs} \times \text{Fat Price} + [3.6 \times 2 = 7.2] \]
  \[ \text{Other Solids lbs} \times \text{Other Solids Price} + [5.71 \times 0.4 = 2.28] \]
  \[ \text{PPD + Bonuses} - \text{Deductions} \]
- **KEY** - Standardized to constant prices
  - Avg Prot = $3, Fat = $2, Other = $0.40

Can You Manage What You’re Measuring?

Google Forms
Communicate like we’re in-person, although we’re miles away

Google+ FaceTime
skype ooVoo

business Bee
Right Quality vs High Quality Forages

Mary Beth Hall

U.S. Dairy Forage Research Center
USDA Agricultural Research Service

To do anything well (and repeatably), we need to understand what we are dealing with.

Mary Beth Hall

Forage In Dairy Cow Rations

Forage 50-60%
NonForage 40-50%

Forage quality sets limits for amount of forage fed and production. We must balance rations without breaking rules.

You can’t push a cow to produce…..

…..But you can get the obstacles out of her way so she can.

Forage In Dairy Cow Rations

14 herds, 28,600 - 36,960 kg RHA
Shaver and Kaiser, 2011
What Do Forages Do?
- Nutrients to meet requirements
- Physical form for healthy gut function
- They are & make good use of farm resources
- Recycles manure, reduces erosion

Which Is High Quality Forage?
- Alfalfa
- Grass
- Straw
- Corn Silage

Which Is The Best Screwdriver?

What Is “Quality”?
- “Quality”: how a feed complements the rest of the ration to meet cow needs.
- Not High or Low, but Right Quality
- What fits the need?
  - Composition
  - Digestibility
  - Form
  - Amount
Form: Physically Effective Fiber

- Enhances rumen function
- Increases rumination
- Reduces rumen acidosis
- Rumen retention & passage
- Allows rations to work

Affected by particle size, digestion, density, hydration, "softness" ......

Fine    Medium    Coarse

For the record, only cows can tell you whether there's enough effective fiber in the ration.

As usual, we're the only ones who know what's going on....

Cows have very few hobbies, so they sort their feed. Use moist rations. Particle size?
At least 50% of all cows not sleeping, drinking, or eating should be chewing their cuds. Manure, ok.

Not good. Not normal. We broke the rules.

Fecal Particle Size

Good ruminal retention = better digestion

Reduced ruminal retention = poorer digestion
**Fiber Digestibility**

- Highly variable
- Crop variety, maturity, growing conditions, ...
- Determines available nutrients

**30 hour NDF digestibility**

<table>
<thead>
<tr>
<th>Grass</th>
<th>Corn silage</th>
</tr>
</thead>
<tbody>
<tr>
<td>74%</td>
<td>56%</td>
</tr>
<tr>
<td>91%</td>
<td>96%</td>
</tr>
<tr>
<td>67%</td>
<td>44%</td>
</tr>
</tbody>
</table>

Where digestibility or rate is determined

**Digested**

- Hall and Mertens, 2012

**Fiber Digestibility**

How rapidly digestible a feed is affects
- How quickly a cow gets the nutrients
- How quickly feed breaks down & leaves the rumen

So....

Will a rapidly fermenting forage probably have more or less effective fiber value than one that ferments more slowly?

**Measuring NDF Digestibility**

In any type of analysis, there is some variability.

Often, the more steps, or for a biological assay, there’s more variability.

- Hall and Mertens, 2012
### NDFD Precision

<table>
<thead>
<tr>
<th>Sample</th>
<th>30 h NDFD Range Mean</th>
<th>95% Probability Limits</th>
<th>Repeatability</th>
<th>Reproducibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>39.1 - 58.5</td>
<td>9.5</td>
<td>10.2</td>
<td></td>
</tr>
<tr>
<td>Corn Silage</td>
<td>43.8 - 62.6</td>
<td>10.7</td>
<td>15.6</td>
<td></td>
</tr>
<tr>
<td>Grass</td>
<td>33.4 - 73.9</td>
<td>8.7</td>
<td>14.6</td>
<td></td>
</tr>
</tbody>
</table>

Very good for ranking samples within lab.

Hall and Mertens, 2012

### Composition

**Water Soluble Carbohydrates**
- Fresh forages/hays
- Temperate grasses
- Almond hulls
- Bakery waste
- Beet & citrus pulps
- Molasses
- Whey products

**Starch**
- Grain silages
- Corn, sorghum
- Small grains
- Bakery waste
- Wheat midds
- Potatoes

**Soluble Fiber**
- Legume forages
- Beet & citrus pulps

**Fiber**
- Forages
- Crop residues
- Nonforage fiber sources
- Wheat middlings
- Corn gluten feed

**Protein**
- Legume forages
- Soy & Canola
- Corn gluten meal

### Eaten Doesn’t Mean Digested

- Coarse corn meal

- Poorly chopped/processed corn silage

### Body Condition Changes

**OK?**
- Depending on days in milk....

**Too Thin.**
Forage: Current Recommendations

- Composition
- Physical form
- Digestibility

<table>
<thead>
<tr>
<th>Forage NDF</th>
<th>Dietary NDF</th>
<th>Dietary NFC</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>25</td>
<td>44</td>
</tr>
<tr>
<td>18</td>
<td>27</td>
<td>42</td>
</tr>
<tr>
<td>17</td>
<td>29</td>
<td>40</td>
</tr>
<tr>
<td>16</td>
<td>31</td>
<td>38</td>
</tr>
<tr>
<td>15</td>
<td>33</td>
<td>36</td>
</tr>
</tbody>
</table>

- NDF from Forage as 0.9 to 1% of body weight (Mertens)
- 75% NDF from forage

\[ \text{(In)Digestibility and Intake} \]

There's only so much undigestible material a cow can fit in her rumen/gut!
Undigestible feed limits intake.
NDF is the least digestible part of the diet.
Bigger pieces of feed cannot pass until they are digested & ruminated to reduce their size.

\[ \text{Conrad et al., 1964, J. Dairy Sci. 47:54} \]

How Much Can You Feed?
Starting Point: 28% NDF in the ration
Allowable fNDF = 28% x 75% from forage = 21%
Allowable Forage = Allowable NDF% / Forage NDF%

<table>
<thead>
<tr>
<th>Forage NDF</th>
<th>Diet %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straw</td>
<td>80%</td>
</tr>
<tr>
<td>Barley Silage</td>
<td>55%</td>
</tr>
<tr>
<td>Alfalfa Silage</td>
<td>45%</td>
</tr>
<tr>
<td>50:50 Barley:Alf</td>
<td>50%</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>45%</td>
</tr>
</tbody>
</table>

Formulating For NFC

- 5% WSC
- 25% starch
- 7% soluble fiber
- Allowable starch relative to amount of forage/effective fiber?

\[ \text{Hall and Van Horn, 2001} \]
Moldy Feed / Mycotoxins

What is the costs of preventably sick cows?

Spoilage

Sorting This Out On The Farm

- Balance first with forages. They dictate the ration's base.
- Aim to meet cow fiber & energy needs within bounds of present recommendations.
- ... Then work with the cows to figure out the details.

Things you can evaluate
- Digestibility and composition
- Particle size & sorting
- Rumination and manure evaluation
- Intake, performance, and feed efficiency
- Body condition score change

Questions?

U. S. Dairy Forage Research Center
www.ars.usda.gov/mwa/madison/dfrc
Proteins & Carbohydrate in Rumen Fermentation

Mary Beth Hall

U.S. Dairy Forage Research Center
USDA Agricultural Research Service

Proteins do WHAT!?!?!

When cows don’t perform like we think they should, the cows are not the ones who are wrong. What were we missing?

Feed Digestion In The Rumen

Carbohydrate fermentation drives microbial protein production. More carbohydrate fermentation = more organic acids and lower pH.

NFC & RDP and NDF Digestibility

Carbohydrate fermentation drives microbial protein production. More carbohydrate fermentation = more organic acids and lower pH. NFC at 0.3% of BW

Heldt et al., 1999

<table>
<thead>
<tr>
<th>NFC at 0.3% of BW</th>
<th>0.031% of BW as RDP</th>
<th>0.122% of BW as RDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>60%</td>
<td>52.5%</td>
</tr>
<tr>
<td>Fructose</td>
<td>41.9%</td>
<td>45.1%</td>
</tr>
<tr>
<td>Sucrose</td>
<td>41.9%</td>
<td>45.1%</td>
</tr>
<tr>
<td>Starch</td>
<td>59.3%</td>
<td>62.3%</td>
</tr>
<tr>
<td>Glucose</td>
<td>51.2%</td>
<td>54.1%</td>
</tr>
<tr>
<td>Fructose</td>
<td>68.1%</td>
<td>71.3%</td>
</tr>
<tr>
<td>Sucrose</td>
<td>68.1%</td>
<td>71.3%</td>
</tr>
</tbody>
</table>
Starch: Rates Subject To Change?

- Fermentation rates were increased at higher dietary starch levels.
- Change greater for rapid than slow rate.
- Greater protein degradability in HMSC affecting kd?
- Basis for rapidly fermented grains being "touchy"?

Oba and Allen, 2003
Starch P<0.001, Corn P<0.001, Starch x Corn P<0.01

Protein & Rumen pH

NFC x RUP for Sugar v Citrus P = 0.02
Hall et al., 2010

Carbohydrate, Protein & pH

Rapidly Avail. NSC High Low RANSC: RDP High Low High Low
DM Intake, lb/d 55.0 54.8 58.7 55.7

Protein Changes VFA?

- Sometimes, even when protein looks adequate, when we increase rumen degradable protein unexpected things happen…
- Urea fertilized pasture grass with 4x daily drench of dextrose and maize flour.

Composition High N Low N
CP% 17.6 13.2
NDF% 46.0 45.7
WSC% 22.0 27.1

Hall et al., 1993

Aldrich et al., 1993

Aldrich et al., 1993

Carruthers and Neil, 1997

2/19/16 U.S. Dairy Forage Research Center
2/19/16 U.S. Dairy Forage Research Center
2/19/16 U.S. Dairy Forage Research Center
2/19/16 U.S. Dairy Forage Research Center
Changes in Digesta Amounts Before and After Feeding

Protein, Intake, & Lactic Acid

Changes in Digesta Amounts Before and After Feeding

Protein Changes Microbial Yield

NSC:DIP & Microbial Protein

Increases in protein supply gave increased microbial YIELDS at each amount of carbohydrate in vitro.

Protein Changes Microbial Yield

NSC:DIP & Microbial Protein

Hall, 2013

Hall, 2013

Hall, 2013

Argyle and Baldwin, 1989

Hoover and Stokes, 1991
Protein supplementation changed yield of microbial protein from carbohydrate. How???

How Microbes Process NFC
Carbohydrates that microbes utilize rapidly.
- glucose
- fructose
- sucrose
- lactose
- raffinose
- fructan
- starch

Carbohydrates that microbes utilize rapidly:
- glucose
- fructose
- sucrose
- lactose
- raffinose
- fructan
- starch

Readily Available Carbohydrates ➔ Organic acids ➔ Microbes + Gas ➔ Glycogen

When microbes have more N they store less glycogen.

Residual Glucose, mg

Glucose: Glycogen C, mg

Max 12-13% of glucose to glycogen

p-values
- N 0.94
- H < 0.01
- NH 0.93
- SED 2.0

Maxima
- N 0.03
- SED 0.04
- L0 v H 0.02
- T v U 0.04

Accumulated Glycogen C, mg

Accumulated Glycogen C, mg

Hann, 2012

Hann, 2012
**Glucose: Microbial N, mg**

- Values

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Maxima</th>
<th>SED</th>
<th>Lo v Hi</th>
<th>T v U</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>0.04</td>
<td>0.03</td>
<td>0.03</td>
<td>0.05</td>
</tr>
</tbody>
</table>

- Not just a peptide response.

**Counterbalancing**

**More Glycogen**
- More energy to make glycogen
- Less energy for microbe growth
- Dampen pH drops
- Slows the fermentation
- Another SI "starch" source?

**Less Glycogen**
- Make more microbes (?)
- Make more lactate (less energy?)
- Greater ruminal digestion?
- Change passage (?)

**What Microbes Do With Energy**

**IF, microbes have all the nutrients they need:**
- Stay Alive
- Make More Microbes

**IF, something is lacking:**
- Stay Alive
- Make Some Microbes
- Make Glycogen
- Waste Energy

**Rumen degradable protein affects:**
- How rapidly carbohydrates are fermented in the rumen
- The efficiency of microbial growth
- Total microbe production
So What?
Feed efficiency starts in the rumen.
This fits in the big picture of what we need to do to keep the cow productive, more efficient, and healthy.

So What?

[Image]

WSC & Rumen Microbes

In vitro fermentation with mixed rumen microbes, repeated sampling from vials.

Hmmm. Would less degradable protein help on low rumen pH?

Ok, now don’t go overfeeding protein to us! Maybe get the timing and proportions a bit tighter?

Summary
- Degradable protein affects carbohydrate use by rumen microbes, their efficiency, and potential nutrient supply.
- Don’t go and overfeed protein!!! Adjust timing for rapidly available protein relative to rapidly available carbohydrate?
- Rumen products need to be delivered to cow to be useful. How will kp affect net results?
- We have more to learn.
Give microbes nitrogen, and they will grow more cells. This gives microbes an immediate use for the energy rather than storing substrate for later.

Testing Protein Amount & Type
- Glucose as the carbohydrate substrate
- LoN: 12% less N from peptides
- HiNU: N added back with urea
- HiNT: N added back with Tryptone (peptides)
- Microbial N, glycogen, VFA, Glc
Cell growth supported by N reduces glycogen syn & energy spilling; more ATP for growth, more efficient: Lactic acid?

¼ to ½ of ATP may be used for glycogen synthesis. Lactic acid production will reduce ATP production.

Effect of increased ruminally degradable protein amount or timing

Microbial Efficiency Implications

Cell growth supported by N reduces glycogen synthesis & energy spilling; more ATP for growth, more efficient. Lactic acid? 

¼ to ½ of ATP may be used for glycogen synthesis. Lactic acid production will reduce ATP production.

Effect of increased ruminally degradable protein amount or timing
FSMA Hazard Analysis

• FSMA final rule requires each registered facility to have a written hazard analysis for chemical, physical and microbiological hazards, including the following:
  – Frequency/Probably and Severity
  – Experience
  – Scientific reports
  – Known illness and frequency
  – And the impact of the following:
  • (1) The formulation of the animal food;
  • (2) The condition, function, and design of the facility and equipment;
  • (3) Raw materials and other ingredients;
  • (4) Transportation practices;
  • (5) Manufacturing/processing procedures;
  • (6) Packaging activities and labeling activities;
  • (7) Storage and distribution;
  • (8) Intended or reasonably foreseeable use;
  • (9) Sanitation, including employee hygiene; and
  • (10) Any other relevant factors such as the temporal (e.g., weather-related)
    • And nature of some hazards (e.g., levels of some natural toxins).
FSMA Hazard Analysis

- Is that enough?
- Can you do it?
- More than a HACCP program requires
- AFIA is partnering with the University of Minnesota’s Center for Animal Health and Food Safety to do a generic HA for the feed industry
- Will be available in late October.

FSMA Hazard Analysis

- All AFIA members will receive CAHFS report with details on how to use
- Must have your PCQI review it and make it facility specific and add your mill’s experience
- Have invited NGFA to join the project
- This will save each facility considerable resources, as doing a hazard analysis will be expensive
- Funded by AFIA’s foundation--IFEEDER

VFD changes: final rule

Animal Drugs Expected to be VFD Drugs

- Apramycin (not marketed)
- Avilamycin (new VFD)
- Chlortetracycline
- Erythromycin (not marketed)
- Florfenicol (already VFD)
- Hygromycin B
- Lincomycin
- Neomycin
- Oleandomycin (not marketed)
- Virginiamycin

- Oxytetracycline
- Penicillin
- Streptomycin
- Sulfadimethoxine:Ormetoprim
- Tilmicosin (already VFD)
- Tylosin
- Sulfamerazine
- Sulfamethazine
- Sulfafquinoxaline

List of affected products:
http://www.fda.gov/AnimalVeterinary/SafetyHealth/AntimicrobialResistance/juducible/animalDrugsExpectedToBeVFDDrugs.htm
VFD: The Process

Veterinarian (retains original)

Producer

Feed Distributor

Sends "intent to distribute letter"

FDA

Drug Supplier

Sends "acknowledgement letter"

VFD: The Coming Changes

• FDA issued Guidance for Industry documents #209 and #213 that tells drug sponsors to change from growth promotion, feed efficiency and milk production claims to therapeutic/prevention claims in three years (by Dec. 2016)

• This requires data submission and approval or updates to the claims—likely will remove claims

• There are about 16 chemical entities and 280+ uses affected, not including current VFD drugs.

VFD: The Coming Changes

• These drugs would come under the control of a veterinarian via VFD

• This would include many feed drugs except dewormers, carbadox, bambermycins, ionophores, bacitracin and a few others

• AFIA has focused on the VFD process and the administrative changes needed to assist in an orderly transition

• VFDs will be required for each use of a drug, including for FFA and 4-H use

VFD: Practical Issues

• Original VFD form is retained by the veterinarian and copies to the producer and feed distributor

• Faxes (and limited electronic) VFDs are allowed

• Phone-in VFDs are not allowed

• Feed mills can deliver smaller amounts than on VFD and save rest for later

• Delivering a VFD to the farm before the producer has a VFD form is problematic
VFD: Current Challenges (cont’d.)

- More VFD approvals increases paperwork load and review times for feed mills
- AFIA says say feed mills put at disadvantage when producer customer cannot be served appropriately due to incorrect forms
- Storing VFD drugs prior to use and prior to receiving the VFD is a problem for producers
- AFIA is addressing this issue with FDA

VFD: Concerns

- The following concerns have arisen:
  - Scanned VFDs from the veterinarian must be printed and filed unless the feed distributor has a FDA registered computer (21 CFR, Part 11)
  - Veterinarians must complete a “Veterinarian’s Intention Statement”
  - Will allow faxes and pdfs without hard copies, must print, date and file

VFD: Affirmation Statements

Veterinarian must mark one of the following on each VFD form:
1. "This VFD only authorizes the use of the VFD drug(s) cited in this order and is not intended to authorize the use of such drug(s) in combination with any other animal drugs."

VFD: Affirmation Statements

Veterinarian must mark one of the following on each VFD form:
2. "This VFD authorizes the use of the VFD drug(s) cited in this order in the following FDA-approved, conditionally approved, or indexed combination(s) in medicated feed that contains the VFD drug(s) as a component." [List specific approved, conditionally approved, or indexed combination medicated feeds following this statement.]
VFD: Affirmation Statements
Veterinarian must mark one of the following on each VFD form:

3. "This VFD authorizes the use of the VFD drug(s) cited in this order in any FDA-approved, conditionally approved, or indexed combination(s) in medicated feed that contains the VFD drug(s) as a component." (Sec. 558.6(b)(6)).

VFD: Generic Drug Use
Generics may be used if the drug or tradename is listed and the veterinarian doesn’t object.

VFD: The Future Challenges
• How will this happen: all drugs VFD overnight, phase-in???
• Will drug sponsors save these changes and release all the new drugs at once?
• Will FDA require training for vets?
• Will there be a list of trained vets?
• Where will more vets come from?
• Will there be enforcement against vets?

VFD: The Future Challenges
• We are addressing all these issues with FDA
• We hope FDA is amenable to an orderly phase in as there may be the same approved drugs not requiring a VFD with the new approval that requires a VFD in the marketplace.
• FDA will likely require “stickering” of old premix bags to note that use of these premixes after 2017 will require a VFD
• Will FDA allow those to be exhausted?
**VFD: Timeline**
- October 1, new VFD rule effective
- October 31, new VFD form must be implemented
- Summer/Fall 2016, drug sponsors contacting feed companies with label changes
- January 1, 2017, must cease all growth promotion claims and hopefully can use old premixes but must have a valid VFD
- Will likely allow some time exhaust supplies: AFIA is doing a survey

**VFD: Next Steps**
- Most drug sponsors seem to be removing the production claims and leaving the therapeutic claims and will contact feed companies
- If data need to be submitted, then review will take longer for the change and resulting drug will not have a generic for some years

**VFD: Next Steps**
- FDA told AFIA that these changes must take place January 1, 2017 for new and old drug premixes
- We urged CVM to put out a notice industry-wide
- All old premixes will require a VFD after Jan. 1
- AFIA will be collecting data on amount of premixed in feed mills soon and in November 2016 and possibly six months after that
- This will be the basis of extension requests

**Questions/Discussion**
Challenges and Opportunities in the Beef Industry

2015
Tight supplies drive CME live cattle to 6th straight yearly gain

2015 TRENDS: High cattle prices, weather-dependent grain prices predicted by economist

Continued record prices amid tight beef supplies in 2015

TheCityWire.com: Cattle prices will be high in 2015

Land prices peaking; cattle still on the rise

Experts: 2015 Cattle Prices May Be Higher Than 2014

Fed Market
Adapted from USDA:AMS

CHALLENGE: MARKET
LOOKING AHEAD TO 2016

Jan 1 Beef Cow Inventory (mil cows)
Adapted from USDA:NASS

18-year contraction = 6.2 million cows

Beef Cows (mil head)

10-Year Cycle

Jan 1 Feeder Cattle Supply Outside Feedlots
(000 head)
Adapted from USDA:NASS / USDA:ERS

Average Annual Cattle Prices (S. Plains)
Source: LMIC

500-600lb Steer Calves
700-800lb Feeder Steers
Fed Steers
Live Cattle Futures: High/Low/Close
February 12, 2016 / Adapted from CME

Feeder Cattle Futures: High/Low/Close
February 12, 2016 / Adapted from CME

Feedyard vs. Cow/Calf Inventory Returns
Annual Basis / Adapted from LMIC

CHALLENGE: VOLATILITY
**Weekly Change: 13-Week Moving Average ($/head)**

Adapted from USDA-AMS / CME

**Ag Commodities New Model of Complexity**

- **Risk On!**
- **Risk Off!**
- **Policy!**
- **External Events!**

**Remember The Story? Dustin Johnson, PGA Championship 2010**

**Challenge: Risk**

1. Danger
   Therefore, need to seek protection

2. Opportunity
   Perspective of missing out
   (more later….)
Protecting Against External Risk

- Lock in margins
- Refinance long-term debt
- Pay down debt!
- Increase working capital reserve
- Carefully, conservatively evaluate expansion opportunities (is it a cash trap?)
- Manage costs!

```
• Managing risk includes the willingness to give up some upside potential to protect against downside risk.
```

Kansas Farm Management Assoc.
Profitability Comparison Among Operations

<table>
<thead>
<tr>
<th></th>
<th>High 1/3</th>
<th>Mid 1/3</th>
<th>Low 1/3</th>
</tr>
</thead>
<tbody>
<tr>
<td># of cows</td>
<td>166</td>
<td>104</td>
<td>98</td>
</tr>
<tr>
<td># of calves</td>
<td>126</td>
<td>83</td>
<td>89</td>
</tr>
<tr>
<td>Avg wt of calves sold</td>
<td>609</td>
<td>608</td>
<td>531</td>
</tr>
<tr>
<td>Sale price ($/cwt)</td>
<td>$165</td>
<td>$158</td>
<td>$162</td>
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<tr>
<td>Gross income</td>
<td>$972</td>
<td>$933</td>
<td>$817</td>
</tr>
<tr>
<td>Feed costs</td>
<td>$290</td>
<td>$437</td>
<td>$477</td>
</tr>
<tr>
<td>Pasture cost</td>
<td>$162</td>
<td>$137</td>
<td>$151</td>
</tr>
<tr>
<td>Total</td>
<td>$901</td>
<td>$1,109</td>
<td>$1,314</td>
</tr>
<tr>
<td>Net return ($/head)</td>
<td>$71</td>
<td>$(176)</td>
<td>$(497)</td>
</tr>
</tbody>
</table>

*Research suggests that while both production and price do impact profit, they are much less important in explaining differences between producers than costs.*

Large Commercial Producer
Purchasing Priority Behavior

Adapted from University of Purdue

```
Large Commercial Producer
Purchasing Priority Behavior
```

<table>
<thead>
<tr>
<th>Performance Price Relationship</th>
<th>Performance Price Relationship</th>
<th>Price Performance Relationship</th>
<th>Other Combined: Price/Rel/Perf Rel/Price/Perf</th>
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<tbody>
<tr>
<td>Animal Health Products</td>
<td>Feed</td>
<td>40%</td>
<td>30%</td>
</tr>
</tbody>
</table>

```
OPPORTUNITY: BUSINESS!!
```

- What’s the market going to be?
- Doing what we’ve always done
- The right question:
  - What’s the business environment telling us?
  - How will we construct our business management decisions around those signals?
  - Where do new opportunities lie?
General Customer Demands
James Womack and Daniel Jones: Lean Solutions: How Companies and Customers Can Create Value and Wealth Together, c. 2005

1. Solve my problem completely
2. Don’t waste my time
3. Provide exactly what I want
4. Deliver value where I want it
5. Supply value when I want it
6. Reduce the number of decisions I must make!!

General Attitudes Among Consumers (% respondents)
Adapted from Sullivan, Higdon & Sink - FoodThink

Feel Food Companies are Transparent about Production Practices
Feel Agriculture Industry is Transparent
Want to know more about where their food comes from
Want food industry take more action in educating people on how food is...
Think it’s important to understand how their food is produced

“Two out of three consumers think it’s very or somewhat important to understand how their food is produced.”
“*And 66 percent want to see more action from the food industry to educate people on how food is produced.”
The Power of the Post Recession Consumer
John Gerzema and Michael D’Antonio, Strategy + Business

• "Say hello to a lifestyle more focused on community, connection, quality and creativity."
• "People are returning to old-fashioned values to build new lives of purpose and connection."
• "They also realize that how they spend their money is a form of power, and are moving from mindless consumption to mindful consumption increasingly taking care to purchase goods and services from sellers that meet their standards and reflect their values."

NEW EMPHASIS

MARKET DIFFERENTIATION!!
BEAT THE COMMODITY TRAP

BOTH!! QUALITY AND STORY!!
Change in requirements / focus / emphasis over time

<table>
<thead>
<tr>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>External fat</td>
<td>Overall uniformity</td>
<td>Overall uniformity</td>
<td>Traceability</td>
<td>Food safety</td>
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<tr>
<td>Seam fat</td>
<td>Overall palatability</td>
<td>Marbling</td>
<td>Tenderness</td>
<td>Instrument grading</td>
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<tr>
<td>Overall palatability</td>
<td>Tenderness</td>
<td>Marbling</td>
<td>Market signals</td>
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<tr>
<td>Marbling</td>
<td>Segmentation</td>
<td>Weight and size</td>
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<tr>
<td>Cut weights</td>
<td>External fat</td>
<td>Carcass weights</td>
<td></td>
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</tr>
<tr>
<td>Cattle genetics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Consumers want narrative with food purchases
New tack needed on food literacy
Honest dialogue facilitates survival
Ignoring reality of consumer sentiment will be costly

Speer | Agriclear
Customer-Centric Thinking: Reverse Traditional Value Chain

- Traditional approach:
  • Start with core competencies (production) and then move downstream through marketing channels and finally to the consumer.
- Consumer-centric approach
  • Bottom-up: start with the customer and then adapt the value chain accordingly.

Become A Food-Producer Partner!!!

Shelf-Centered Collaboration

- The overarching goal is for each function and each business in the value chain to think end-to-end about the entire network of participants, from the first supplier to the end consumer.
- [by doing so] they can now contribute to making the entire value chain more effective and responsive.

2015 Video Sale Average Premium ($/cwt)

<table>
<thead>
<tr>
<th></th>
<th>Heifers</th>
<th>Steers</th>
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<tbody>
<tr>
<td>SAV</td>
<td>7.83</td>
<td>1.90</td>
</tr>
<tr>
<td>NHTC</td>
<td>9.03</td>
<td>7.73</td>
</tr>
<tr>
<td>VNB</td>
<td>5.81</td>
<td>1.83</td>
</tr>
<tr>
<td>GAP</td>
<td>10.95</td>
<td>8.53</td>
</tr>
<tr>
<td>Organic</td>
<td>42.77</td>
<td>24.52</td>
</tr>
</tbody>
</table>

OPPORTUNITY: BEEF QUALITY - KEY TO PROSPERITY

“The path to sustainable, profitable growth begins with creating more promoters [happy customers] and few detractors [unhappy customers]. It’s that simple and that profound.”

What Went Wrong?
Per Capita Meat Expenditures: Beef vs. Pork/Poultry
(Adapted from USDA:ERS)

What Went Wrong?
Per Capita Meat Expenditures: Beef vs. Pork/Poultry
(Adapted from USDA:ERS)

Beef Was Working In A Commodity Mindset
"Where We’ve Been"

• Traditional Supply Chain
  – Adversarial relationships
  – Win-lose negotiations
  – Short term focus
  – Primary emphasis on cost
  – Little concern for added value
  – Limited communication
  – Volatile
  – Unresponsive

Beef Was Losing Market Share

• Health
• Convenience
• Price / value
• Era of increasing consumer empowerment!
• Quality / Taste!!!!!

Weekly Combined Prime / Choice %
Trendline = 52-week Moving Average, Adapted from USDA-AMS
Effects of UpGrading to Improve Odds of Favorable Eating Experience
Adapted from Tatum, 2015 – Recent Trends: Beef Quality, Value and Price

Comprehensive Cutout Price Spreads (Versus Select) – 26-week moving averages
Adapted from USDA:AMS

FINAL DEMAND: ECONOMIC GAME CHANGER
20 years of work = Enhanced beef quality and consistency
More responsive precision and efficiency of product delivery to various consumer segments.

Bottom-line: improved customer satisfaction that’s anchoring spending in these challenging times.

Quarterly All-Fresh Retail Beef Demand Index
Adapted from Kansas State Univ
OPPORTUNITY:

Beat the Commodity Trap

- Deterioration: low-cost players disrupt the status quo
- Can’t match low-end rival
  - Economies of scale
  - Cost structure
  - Experience curve
  - Even if you could, simply accelerates the deterioration when low-end discounter uses its muscle to punish the challenger
- Turn the trap to your advantage:
  - “Contain the low-end players market power to the low end.”

What NOT To Do!

MONEY

Emotion

2016 Virginia State Feed Association & Nutritional Management "Cow" College
What To Do!

Invest time AND resources into obtaining objective information and performing disciplined review!

Complacency Is Not An Option

PRESERVE THE CORE / STIMULATE PROGRESS

If an [industry] is to meet the challenges of a changing world, it must be prepared to change everything about itself except [its basic] beliefs...

The only sacred cow in an organization should be its basic philosophy of doing business.

Introduction to AgriClear

AgriClear is a transformational web-based platform that connects North American Cattle Producers. Marketers can now securely list, transact, and be assured of payment from their computer, phone, or tablet.
Benefits of AgriClear

☑ Cost Savings
Lower cost structure at $6/head/side, with no listing fee.

☑ Expanded Marketplace
Access to a broad network of verified North American buyers and sellers.

☑ Attribute Based Marketing
Provides greater ability to capture more value from your genetic and/or management inputs.

☑ Payment Assurance
Market across North America with financial certainty. Sale proceeds are paid in advance by the buyer, and held until both parties confirm satisfactory completion of the contract.

Counter-Party Risk

What happens if the guy you’ve known for 20 years in the ag community – you’ve always known he’s good for it – what if one day he’s not good for it?

How will that affect your business?
Don’t let someone else’s financial problems become your problems.

QUESTIONS / COMMENTS?

Nevil Speer, PhD, MBA
Managing heat stress in transition cows and calves

*Department of Animal and Dairy Science, University of Georgia; †Department of Animal Sciences, University of Florida

Heat stress reduces milk production of early lactating cows

Tao and Dahl, Unpublished

Heat stress reduces milk production of mid and late lactation cows

Weng and Tao, Unpublished

Reduction in DMI accounts for 50% decrease in milk production in mid-lactation

Rhoads et al., 2009
Reduction in DMI accounts for ALL decrease in milk production in early-lactation

Heat-stressed mid-lactating cows have blunted adipose tissue mobilization and increased whole body glucose utilization

Heat stress blunts fat mobilization in early lactating cows

Cooling during the ENTIRE dry on DMI
Cooling during mid to late lactation on DMI

- CL: Cooling
- NON-CL: Non-Cooling

Cooling effect: \( P < 0.001 \)
Cooling*Week: \( P < 0.001 \)
Cool: 26.71 kg/d; Non-Cool: 21.56 kg/d

Heat stress exaggerates the decrease in DMI from lactating to dry

- Cooling
- Heat stress

TRT: \( P = 0.07 \)

Heat stress doesn't affect blood metabolites and insulin of dry cows

Heat stress doesn't affect fat mobilization of dry cows

Ahmed and Dahl, unpublished

Lamp et al., 2015
Heat stress doesn't affect glucose tolerance of dry cows

-14 d relative to calving

Heat stress increases protein mobilization of dry cows

Adapted from Lamp et al., 2015

Cooling during the ENTIRE dry on milk yield (Multiparous cows)

Diff: 4 kg/d (12.2%)

Adapted from Tao and Dahl, 2013

Cooling during the Close-up on milk yield (Multiparous cows)

Diff: 2.2 kg/d (5.8%)

Adapted from Wang et al., 2010

Adapted from Gomes et al., 2014

Adapted from Karimi et al., 2015

Average
Cooling during the late gestation on milk yield (~ 1 month, Heifers)

- Wang et al., 2010
- Gomes et al., 2014
- Average

Diff: 1.4 kg/d (6.2%)

Cooling during the late gestation on milk yield decreases MY

Tao et al., 2011

Cooling improves mammary growth in the late dry period

- 20 Day Relative to Calving
  - P < 0.05
  - ** P < 0.01

H&E - Mammary gland alveoli number

Preliminary Data: Cooling increases alveoli number

Laporta and Dahl, Unpublished
Late gestation heat stress decreases estrone sulfate

Collier et al., 1982

Mammary gland development during the dry period

Collier et al., 1982

Heat stress may alter mammary involution in early dry period

Hypothesis: Heat stress impairs mammary involution

Collier, et al., 1982; 2008; Tao et al., 2011, 2013

Collier et al., 1982
Heat stress blunts mammary autophagy during the early dry period

Heat stress impairs lymphocyte proliferation

Heat stress impairs IgG responses against ovalbumin challenge

Heat stress impairs neutrophil function

Wohlgemuth et al., 2015

do Amaral et al., 2011

Gomes et al., 2014

do Amaral et al., 2011
Calving season on cow health (up to 60 DIM)

- Calving in summer
- Calving in winter

Adapted from Thompson and Dahl., 2012

Prepartum cooling increases metritis

- Heat Stress
- Cooling

Exp 1: Heat Stress 39/119, Cooling 54/123
Exp 2: Heat Stress 2/74, Cooling 8/73

Adapted from Thompson et al., 2014

Prepartum cooling increases metritis

- No cooling
- Evaporative cooling

Farm 1: Heat Stress 119, Cooling 123
Farm 2: Heat Stress 107, Cooling 101
Overall: Heat Stress 226, Cooling 224

Santos et al., 2014

Prepartum cooling is the key

- Most effective approach
- Slight reduction in body temperature can have strong impact on subsequent lactation
Prepartum cooling slightly reduces cow body temperature

Cooling during lactation largely reduces body temperature

Reduction in body temperature when dry improves subsequent milk yield

Summary – Heat stress during the dry period on cow
- Impairs mammary growth during the dry period
- Decreases milk production in the next lactation
- Alters metabolic responses during transition
- Compromises immune function during transition
- Cooling dry cow is the key
Maternal heat stress on calf

Late gestation heat stress decreases birth weight

Adapted from Tao and Dahl, 2013

Maternal heat stress on calf

Late gestation heat stress affects calf body weight

In utero heat-stressed calf had higher ability to absorb glucose

Glucose clearance to glucose infusion

Adapted from Collier et al., 1982b; Wolfenson et al., 1988; Avendaño-Reyes et al., 2006; Adin et al., 2009; do Amaral et al., 2009; do Amaral et al., 2011; Tao et al., 2011; Tao et al., 2012; Monteiro et al., 2012; Monteiro et al., 2013; Tao et al. 2013; Monteiro et al., 2015.

Average Calf birth weight, kg

Heat Stress

Cooling

Diff: 4.7 kg (12.5%)

Glucose clearance to glucose infusion

Trt effect: P = 0.16

Trt*Time effect: P < 0.01

** P < 0.01, * P < 0.05

Day 8

Day 29

Day 57

In utero heat-stressed calf had higher ability to absorb glucose

Monteiro et al., 2013
In utero heat-stressed calf had insulin resistance – less insulin mediated glucose entry to tissue.

Monteiro et al., 2015, JAM

Monteiro, Dahl and Tao, Unpublished
Preliminary data: Maternal heat stress decreases AEA

Laporta and Dahl, Unpublished

Maternal heat stress affects lymphocyte function of calves

Tao et al., 2012

Maternal heat stress decreases calf survival

Monteiro and Dahl, unpublished

Maternal heat stress decreases offspring’s milk production

Monteiro, et al., 2013
Summary – Heat stress during the dry period on calf

- Impairs fetal growth and lowers birth weight
- Compromises immune function before weaning
- Decreases milk production in the first lactation

Acknowledgements
Feed and Diet Composition Varies
Knowing why it varies and what to do about it can prevent lost milk

Bill Weiss
Normand St-Pierre

Buckeyes enjoy visiting Virginia

Goals of Feed Sampling/Analysis

1. Getting the right number
   - Value that approximates the mean over at least several days

2. Getting an estimate of variance
   - Why should you care?

Why do we care about SD?

1. Economic value of feeds
2. Ration formulation specs
3. Risk management
To reduce risk of acidosis, increase the mean NDF (safety factor) for variable diet.

- Farm with consistent forage (SD 1.3)
- Farm with poor consistency (SD = 2.1)

Multiple databases are available:

- Dairy One
  - www.dairyone.com
  - CORN SILAGE, Accumulated Crop Years: 5/1/2000 - 4/30/2014
  - N > 210,000

<table>
<thead>
<tr>
<th>DM, %</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDF, %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Starch, % | All variances are not created equal

- Year
- Soil
- Hybrid
- Harvest
- Sampling
- Lab
OSU Project: Quantify variation in feed composition on dairy farms

- Silage sampled daily (14 d, 11 farms OH, VT)
- 47 farms from across US (20 from OH)
- Feeds sampled monthly (12 months)

Our “perfect” map

🌟 = region with cooperating farm

The Data Set (corn and hay silage)

- 11 farms
- 14 consecutive days
- 2 samples/day
- 2 assays/sample
- 504 numbers for each nutrient

**Corn silage**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Mean (%)</th>
<th>SD</th>
<th>Value for NDF (day 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>37.0%</td>
<td>5.23</td>
<td></td>
</tr>
<tr>
<td>NDF</td>
<td>39.1%</td>
<td>4.03</td>
<td>6.0</td>
</tr>
<tr>
<td>Starch</td>
<td>32.8%</td>
<td>4.33</td>
<td></td>
</tr>
</tbody>
</table>
Partitioning Variation

Total Variation = Farm to farm variation + Sampling variation + Analytical variation + True day to day variation

Farm to farm is major source of variation in silages

% of Total Variance

DM     NDF  Starch   Ash      DM    NDF    Ash     CP

Farm     True Day    Sampling    Analytical

Corn Silage

Hay Crop Silage

Sampling Non-Forages on Farms

All wet feeds tested WCGF, WBG, WDG
HM corn

Farm was significant source of variation

Dry corn, SBM, DCGF canola meal, whole cottonseed

Farm was NOT a significant source of variation

DDGS

Farm was OFTEN not an important source of variation

NEWS flash!

Farm to Farm Variation is Huge

1. You need to sample silage from each client’s farm
2. Don’t use a book value
3. But this is not true for all feedstuffs
Within Farm SD (14 days)
Variation is still large

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Corn silage</th>
<th>Haycrop Silage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>DM, %</td>
<td>37.0</td>
<td>1.7</td>
</tr>
<tr>
<td>NDF, %</td>
<td>39.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Starch, %</td>
<td>32.8</td>
<td>2.3*</td>
</tr>
<tr>
<td>CP, %</td>
<td>7.6</td>
<td>0.3</td>
</tr>
</tbody>
</table>

* On 5 out of 14 days, starch would be <30.5 or >35.1%

Average Ranges for Corn and Alfalfa Silage (over 12 months)

TMR Sampling:
Useful tool or random number generator?

1. Extreme sampling challenge
   - heterogeneous particles
     - shape, density, nutrients

2. Added sources of variation
   - Feeder
   - Mixer

3. Lower sampling/assay costs (vs. feeds)
All particles are not created equal

How do you reduce sampling error (or how do you reduce its impact)?

1. Use good sampling technique
2. Take duplicate samples

Good Sampling Practices

1. Mix as much as possible BEFORE sampling
2. Take progressively smaller subsamples
3. Use good handling procedures
4. Develop SOP for sampling
5. Evaluate SOP by multiple samples
Take progressively smaller subsamples

Don’t Die Getting A Sample

'Borrowed' Images

Good Sampling Technique

Use procedures that reduce particle bias in the sample
Starch and NDF in different particle fractions of processed corn silage

<table>
<thead>
<tr>
<th></th>
<th>NDF</th>
<th>Starch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>54%</td>
<td>13%</td>
</tr>
<tr>
<td>DM Basis</td>
<td>38%</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>29%</td>
<td>53%</td>
</tr>
</tbody>
</table>

How do you reduce sampling error (or how do you reduce its impact)?

1. Use good sampling technique
2. Take duplicate independent samples

The value of duplicate samples (corn sil)

Mean = 36.5% (all)
SD(a) = 2.6   SD(b) = 1.9   SD(m) = 1.4
Does Variation Affect Cows?

4 experiments conducted at OARDC to examine this question

DM, LCFA, fNDF, CP

Does a transient change in silage DM affect cows? (McBeth et al., J. Dairy Sci. 2013)

DM% of silage can abruptly change

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Control, Re-Balanced, Unbalanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>As-Fed Forage:Concentrate</td>
<td></td>
</tr>
<tr>
<td>DM Forage:Concentrate</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nutrient Composition of Diets, % of DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM%</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>66.2</td>
</tr>
<tr>
<td>fNDF%</td>
</tr>
<tr>
<td>Starch%</td>
</tr>
<tr>
<td>CP%</td>
</tr>
</tbody>
</table>

UNB and Re-BAL reflect diets during wet bouts only
Weiss, St-Pierre  |  Ohio State University

2016 Virginia State Feed Association & Nutritional Management "Cow" College 2/18/16

**21 day period averages** (diets differed on only 6 days)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Unbal</th>
<th>Re-Bal</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI (lbs/day)</td>
<td>70</td>
<td>72</td>
<td>74</td>
</tr>
<tr>
<td>Milk yield</td>
<td>90</td>
<td>90</td>
<td>90</td>
</tr>
</tbody>
</table>

**As-Fed Intake, Deviation from Control**

<table>
<thead>
<tr>
<th>Treatment, Deviation from Control</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>UnBal</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-Bal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note the lag at the start and end of the bouts

**Effect of Abrupt Addition of Wetted Silage**

- Wetted Silage
- Normal silage

Feed delivery was increased

**Does extreme variation in fNDF affect cows?** (Yoder et al., J. Dairy Sci. 2013)

Things Happen
High day to day variation in fNDF had little effect on average production

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, lbs/day</td>
<td>53.9</td>
<td>53.4</td>
</tr>
<tr>
<td>Milk, lbs/day</td>
<td>94.2</td>
<td>94.8</td>
</tr>
<tr>
<td>Milk (mature) lbs/d</td>
<td>106.2</td>
<td>105.6</td>
</tr>
<tr>
<td>Milk fat, %</td>
<td>3.49</td>
<td>3.51</td>
</tr>
</tbody>
</table>

Feed offered was adjusted so daily refusal was usually ~5%

Overreacting Treatment

Changing % forage in response to a new analysis (every 5 days) that was either above or below true population mean NDF

 Avg fNDF = 25%  
Alfalfa:grass silage ratio varied
5 days of a ‘bad’ diet didn’t do much?

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>OverReact</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, lbs/d</td>
<td>53.9</td>
<td>55.2*</td>
</tr>
<tr>
<td>Milk, lbs/d</td>
<td>94.2</td>
<td>95.9</td>
</tr>
<tr>
<td>Milk, lbs/d (multi)</td>
<td>106.2</td>
<td>106.5</td>
</tr>
<tr>
<td>Milk fat, %</td>
<td>3.49</td>
<td>3.54</td>
</tr>
</tbody>
</table>

Over 10 days both diets are equal

DMI, Over-react, deviation from Control

Is Day to Day Variation in Diet Composition Bad?

Maybe (but it may be good)

1. Can ‘controlled’ variation be used to reduce costs?
2. Can ‘controlled’ variation be used to increase production?

No matter what, don’t feed a bad diet for too long
Conclusions

1. Sampling is a substantial source of within farm variation in silages and TMR
2. High sampling error = low confidence in single sample: **USE MEANS!**
3. Time can be important source of variation
   - know how much your feeds vary
   - don’t over-smooth
   - don’t change too quickly

Diet Variation in Cows

Substantial, short term variation (DM, fat, CP, fNDF) did not affect cows when cows were allowed to eat

**Take Home Message**
Increase feed delivery rates when you suspect high day to day variation in diet composition

Diet Variation in Cows

Longer term (>2 days) feeding of unbalanced diet has affected cows

**Take Home Message**
Before re-formulating, make sure the feeds really have changed but don’t wait too long

This project was supported by National Research Initiative Comp. Grant No. 2009-55206-05242 from the USDA National Institute of Food and Agriculture.