Using Forage Fiber Analyses to Get the Most from Your Cows

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Where is Miner Institute?
William H. Miner Agricultural Research Institute
William Miner stated nearly a century ago:

“Agriculture is the fundamental occupation.”

“No other occupation is so vitally important to the human race, nor requires such a wide range of practical and technical knowledge…”
Forage Fiber Concepts

Physically effective fiber and digestible fiber must be in balance

Greater intake
More milk and components
Rumen health
What Forage Fiber Analyses Should We Use ... What Do They Mean to the Cow?
Characterizing Forage Fiber Quality

- NDF, Lignin/NDF
- NDF digestibility
  - In vitro “artificial rumen” ≠ in vivo
  - 24, 30, 48 hours?
- Indigestible NDF
  - Needed for measuring rate of digestion
  - (Lignin x 2.4) or 240 hours?
- Physically effective NDF

Stem cross-section
How Do We Use NDF Digestibility Measurements?

- Relative ranking by NDFD
  - Hybrid/cultivar selection
  - Benchmarking
- Troubleshooting feeding problems
- Allocation of forages
- Adjust forage energy values
- Use in nutritional models for ration formulation
- Optimize forage inclusion in diet
Crude Protein DOES NOT Predict Forage Digestibility (Van Soest, 1994)

<table>
<thead>
<tr>
<th>Fraction</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude protein, %</td>
<td>0.24</td>
</tr>
<tr>
<td>ADF, %</td>
<td>-0.79</td>
</tr>
<tr>
<td>NDF, %</td>
<td>-0.81</td>
</tr>
<tr>
<td>L/NDF, %</td>
<td>-0.90</td>
</tr>
</tbody>
</table>

➢ L/NDF or L/ADF most accurately predicts DMD
Target L/NDF Ratios

- **Alfalfa**
  - Range: 11-20%
  - Goal: <15%
- **Corn silage**
  - Range: 3-9%
  - Goal: <6%
- **Grass silage**
  - Goal: <9%

Digestion in the rumen

Lignin="plant plastic"
Measured NDFD or Estimation from Lignin?

<table>
<thead>
<tr>
<th>NDF, %</th>
<th>Lignin, %</th>
<th>30-h NDFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>45.0</td>
<td>3.52</td>
<td>?</td>
</tr>
<tr>
<td>45.0</td>
<td>3.26</td>
<td>?</td>
</tr>
<tr>
<td>45.0</td>
<td>3.32</td>
<td>?</td>
</tr>
<tr>
<td>45.1</td>
<td>3.18</td>
<td>?</td>
</tr>
<tr>
<td>45.0</td>
<td>3.43</td>
<td>?</td>
</tr>
</tbody>
</table>

- Corn silage data set from Van Amburgh (2005)
- Similar relationships from 36.5 to 51.8% NDF
**Measured NDFD or Estimation from Lignin?**

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<tbody>
<tr>
<td>45.0</td>
<td>3.52</td>
<td>46.0</td>
</tr>
<tr>
<td>45.0</td>
<td>3.26</td>
<td>48.4</td>
</tr>
<tr>
<td>45.0</td>
<td>3.32</td>
<td>54.4</td>
</tr>
<tr>
<td>45.1</td>
<td>3.18</td>
<td>55.0</td>
</tr>
<tr>
<td>45.0</td>
<td>3.43</td>
<td>67.3</td>
</tr>
</tbody>
</table>

- Corn silage data set from Van Amburgh (2005)
- Similar relationships from 36.5 to 51.8% NDF
Note “fast” and “slow” pools in these digestion curves (Allen, 2005, unpublished)

- For many forages, digestion curves are ~parallel from 24 to 48 h
- Can use several time points for benchmarking
- Pick one and be consistent
Current Measurement of Fiber Digestion ...

- Measure NDF and lignin
- Measure NDF digestion at 30, 120, and 240 hours of in vitro fermentation
- Predict:
  - Indigestible NDF
  - Overall rate of NDF digestion
  - Fast and slow NDF digestion
- iNDF + slow NDF determine rumen fill
- Closer to reality? Closer to what cows are telling you?
Corn silage NDF and NDF digestibility at Miner Institute

BMR CS: 40.0% NDF
Conv CS: 38.5% NDF

BMR CS: 56.1% NDFD
Conv CS: 41.0% NDFD
Haycrop silage NDF and NDF digestibility at Miner Institute

HCS: 50.4% NDF
HCS DC: 62.6% NDF

HCS: 57.2% NDFD
HCS DC: 46.1% NDFD

Haycrop Silage NDF%
Getting the Greatest Response from Your Cows to Higher Forage-Fiber Digestibility
Rumen Fill Dynamics
High forage NDF digestibility increases maximum forage (Mertens, 2009)

High NDFD forages allow us to feed more NDF from forage
How high can you go?

Depends on digestibility

(Mertens and Huhtanen, 2007)

- Forage mix of 25% alfalfa (40% NDF):75% grass (55% NDF)

<table>
<thead>
<tr>
<th>Target milk (lb/d)</th>
<th>77</th>
<th>88</th>
<th>99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass 48-h NDFD 60%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forage, % of diet</td>
<td>61</td>
<td>54</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>+10%</td>
<td>+9%</td>
<td>+7%</td>
</tr>
<tr>
<td>Grass 48-h NDFD 76%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forage, % of diet</td>
<td>71</td>
<td>63</td>
<td>55</td>
</tr>
</tbody>
</table>

How high can NDF digestibility go?

65-80% for grasses
50-60% for legumes
How Much Forage is Being Fed to Dairy Cows? (Chase, 2012)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>I</th>
<th>N</th>
<th>Pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk (lb)</td>
<td>80</td>
<td>90</td>
<td>75</td>
<td>90</td>
<td>85</td>
<td>90</td>
<td>100</td>
<td>85</td>
<td>49</td>
</tr>
<tr>
<td>% Forage</td>
<td>58</td>
<td>58</td>
<td>59</td>
<td>59</td>
<td>67</td>
<td>58</td>
<td>82</td>
<td>57</td>
<td>100</td>
</tr>
<tr>
<td>F-NDF, % of BW</td>
<td>0.93</td>
<td>1.06</td>
<td>1.04</td>
<td>0.96</td>
<td>1.16</td>
<td>0.88</td>
<td>1.00</td>
<td>1.02</td>
<td>1.80</td>
</tr>
</tbody>
</table>

- How much Forage-NDF can a dairy cow consume?
  - 0.90% of BW minimum
How much NDF can be consumed?

- 1.10% of body weight
- 1.53% with high-bmr corn silage
- 1.80% with pasture

Grass vs legume

We’ve underestimated the Intake Potential of forage-NDF
Grass versus legume digestion in the rumen

- Extent of NDF digestion greater for grasses
- NDF digestion rate faster for alfalfa

Grass management goal
Response to forage digestibility varies by milk production level.

So target its use!
Forage Digestible NDF and Performance (Oba and Allen, 1999)

For every 1 percentage-unit increase in NDF digestibility:
- +0.40 lb/d DMI
- +0.53 lb/d milk
- +0.55 lb/d 4% FCM

>40% corn silage in diet:
- +0.26 lb/d DMI
- +0.31 lb/d 3.5% FCM (Jung et al., 2010)
Response to High-NDFd Corn Silage by Milk Production Level

(Ivan et al., 2004)

- Allocate high NDFd forages to highest producing cows and fresh cows
Milk production level and response to bmr (24-h NDFD 56%) vs grass (24-h NDFD 53%; Miner Inst., unpublished)

Mycogen F2F444 and 1st cut grass silage (ADF=32.5, NDF=51.1, CP=17.6%)
Physically Effective NDF

Fraction of NDF that...

- stimulates chewing
- contributes to rumen digesta mat formation and consistency
Physical Effectiveness Factor (pef) and peNDF: A Quick Review

- **pef** = physical effectiveness factor
  - 1.18-mm screen with dry sieving
  - 3.18- or 4.76-mm sieve on farm
  - New PSPS has 4.0-mm sieve (NASCO)
  - Ranges from 0 to 1.0

- **peNDF** = **pef** x NDF%
Physical effectiveness factor (%) measured by chewing versus sieving

<table>
<thead>
<tr>
<th>Technique</th>
<th>Coarse</th>
<th>Medium</th>
<th>Fine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab dry sieving 1.18-mm</td>
<td>63.3</td>
<td>59.9</td>
<td>55.0</td>
</tr>
<tr>
<td>On-farm as-fed 3.18-mm</td>
<td>61.0</td>
<td>58.0</td>
<td>56.0</td>
</tr>
<tr>
<td>Cow chewing response</td>
<td>65.4</td>
<td>57.0</td>
<td>53.7</td>
</tr>
</tbody>
</table>

- Cow is the ultimate measure of effectiveness!
- Chewing response = sieving measurement of physical effectiveness
Physically effective fiber and FCM/DMI (Grant, 2008, unpublished)

- 21-24% recommended
- Function of: CHO fermentability & feeding management

12 studies using vertical dry sieving (standard procedure)
# PSPS Particle Distribution Recommendations (DM basis)

<table>
<thead>
<tr>
<th>Screen (mm)</th>
<th>Corn silage</th>
<th>Haylage</th>
<th>TMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;19.0</td>
<td>5±3</td>
<td>15±5</td>
<td>5±3</td>
</tr>
<tr>
<td>19-8.0</td>
<td>55±10</td>
<td>60±15</td>
<td>40±10</td>
</tr>
<tr>
<td>8.0-1.18</td>
<td>40±10</td>
<td>30±10</td>
<td>40±10</td>
</tr>
<tr>
<td>Pan</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>≤20</td>
</tr>
</tbody>
</table>

(Kononoff, 2004)

- Assesses chop length, TMR size distribution, sorting
Size isn’t everything ....
Greater fiber digestibility enhances forage fragility (Cotanch et al., 2008)

60 min/d TCT
Δ 25% NDFD
Δ 35% Fragility

Fragility %

NDFD24 %

BMR, high quality HCS

Straws

BMRCS  CS  HCS  SGS  Straw
Rumen pH for cows fed bmr or conventional corn silages in TMR

- Particle size does not tell entire story!
Cow Management Environment?
When Forage NDF Digestibility and peNDF are in Balance …

- Higher rumen pH and fibrolytic bacteria
- Greater microbial protein production
- Improved milk components
- DMI & milk yield increase
- Peak milk & persistency increase
- SCM/DMI increases
- Less body weight loss in early lactation
- Better body condition & better reproduction

**Profit increases!**
Thank You