Fibre is complicated!

Understanding aNDF, aNDFom, NDFD, uNDFom in forage analysis reports

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NDF

• NDF is meant to measure
  • Hemicellulose
  • Cellulose
  • Lignin

• Unfortunately, there are many different NDF methods.
  • NDF solution by itself does not remove:
    • Protein within the NDF matrix
    • Soil/silica contamination

Review

• aNDFom used in model now
  • "a" represents the presence of sodium sulfite and α-amylase
  • Removes protein within the matrix
  • Removes starch (very important with corn silages or high starch feeds)
  • "om" represents being expressed as organic matter
    • NDF residue is ashed to remove soil contamination that is not soluble in NDF solution
      • 0.5 to >10 units difference
Impact of ash correction

• aNDF concentration DECREASES

• NFC and soluble fiber content INCREASES
  • NFC = 100 – CP – Fat – Ash – aNDFom
  • Soluble fiber = NFC – silage acids – lactic acid – other organic acids – sugar – starch

• Thus, ME and MP allowable production INCREASES due to greater NFC/soluble fiber!

Lignin relationship with NDF digestibility

• 2.4 factor to calculate CHO C is NOT constant
• BMR corn silage hybrids, 3 to 5
• Conventional hybrids 2 to 7
• Alfalfa 1.9 to 3.2
  • (with 80% between 2.2 and 2.8)
• Grasses 1.5 to 5.5
  • (with immature grasses varying from 1.9 to 7.5).

aNDFom – uNDF = pdNDF

uNDF

• Very confusing topic
  • uNDF is the proportion of NDF that was not digested
  • uNDF stated by itself is meaningless
  • Must also state the number of hours the in vitro was run
    • E.g.
      • uNDF-30
      • uNDF-120
      • uNDF-240

uNDF is determined with different time points for forages vs. non-forages
Corn silage example: uNDF

2 time-points + 240 hours

Use 240 hr in vitro instead of a fixed relationship to estimate undigested NDF in the rumen.

率 = 0%, uNDF = 9.9% NDF

For comparison:
2.4 * 3% lignin/42% NDF = 17% unavailable NDF

Rate = 0%, uNDF = 9.9% NDF

Corn silage example: fast pool

Larger fast pool appears to result in:
- Faster eating
- Faster ruminal disappearance
- Higher intakes
- More ruminal buoyancy

P1 (Fast Pool)
Rate = 11% / hr
P1 = 72% NDF

Corn silage example: slow pool

Larger Slow and uNDF pools:
- More "ballast"
- Greater chewing and rumination
- Lower intake
- Slower eating speed

P2 (Slow Pool)
Rate = 2%, P2 = 18.1% NDF
Corn silage example: P1+P2+uNDF

What does this tell us?

- Simple vensim model created to show NDF flow through rumen
  - Assumed 1,680 g aNDFom consumed every 6 hrs
    - Equal to 28% aNDFom diet at 24 kg DMI
    - 60% fast pool with 15%/hr kd
    - 20% slow pool with 2%/hr kd
    - 20% u pool with 0%/hr kd
  - Kp set at 1.5%/hr
  - Simulated over 480 hrs

Steady state about 4,250 g u
Fast and slow pool in rumen

What if only fed 1 meal?

Fast and slow pools 1 meal

99% degraded

57% degraded
NDF in rumen

Other components to consider

• Particle size of u240
  • Given that u240 has 0 kd, the only way it ‘disappears’ from rumen is via passage rate
  • Typically must be < 1.18 mm to pass
• Species of plant
  • Grasses vs legumes particle size degradation is different
    • Legumes break more into ‘cubes’ whereas grasses as ‘strings’

Stage of maturity

• Finnish data
  • Grass silages (timothy and meadow fescue mix)
• Harvested at:
  • 1st cut early (June 5)
  • 1st cut late (June 17)
  • 2nd cut early (July 29)
  • 2nd cut late (Aug 12)

Comparison

<table>
<thead>
<tr>
<th>Composition</th>
<th>1st Early</th>
<th>1st Late</th>
<th>2nd Early</th>
<th>2nd Late</th>
<th>2nd early vs 1st early</th>
<th>2nd late vs 1st late</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter</td>
<td>91.8</td>
<td>93.2</td>
<td>102%</td>
<td>90.2</td>
<td>91%</td>
<td>98%</td>
</tr>
<tr>
<td>CP</td>
<td>15.5</td>
<td>12.7</td>
<td>82%</td>
<td>15.7</td>
<td>11.6%</td>
<td>74%</td>
</tr>
<tr>
<td>uNDFom</td>
<td>49.8</td>
<td>58.8</td>
<td>118%</td>
<td>51.3</td>
<td>53.8%</td>
<td>105%</td>
</tr>
<tr>
<td>uNDF288 %DM</td>
<td>5.0</td>
<td>9.7</td>
<td>194%</td>
<td>6.0</td>
<td>9.3%</td>
<td>155%</td>
</tr>
<tr>
<td>uNDF288 % NDF</td>
<td>10</td>
<td>16</td>
<td>164%</td>
<td>12</td>
<td>17%</td>
<td>148%</td>
</tr>
<tr>
<td>uNDF288 in rumen BW</td>
<td>0.24</td>
<td>0.37</td>
<td>0.30</td>
<td>0.41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What is this telling us?

- Standard quality numbers (CP, aNDFom, RFV) do not tell the entire story when it comes to intake potential and forage quality.
- Seasonal effects are as important as stage of maturity
- In this study, longer particles of 2nd cut had slower kd and longer rumen retention
  - Too bad we do not have the uNDF30.

Does it really matter?

- Dataset of over 65,000 feeds from Dairyland
  - aNDFom
  - lignin
  - u30, 120 240
  - Plus other data points
  - Forages include
    - Alfalfa (hay and silage)
    - Grasses
    - Small grain silages
    - Straw
    - BMR and conventional corn silage
    - And more

Modified TDN equation from NRC 2001

- Replaced the lignin/NDF surface area relationship that estimates u with u240
- Used a variable pdNDF digestibility (very high, high, medium, low)
- Where appropriate, calculated starch kd based on 7 hr starch
  - Modified digestible NFC as:
    - Non-starch NFC: 99% digestible (based upon CNCPS calculations)
    - Starch NFC: used calculated rate, 6% kp, 75% intestinal digestibility
- Doing this gets carbohydrate side of TDN equation closer to CNCPS method

Overall TDN distributions
Relationship between NRC 2001 TDN and modified TDN equation (AMTS TDN)

Correlations of AMTS TDN, NRC TDN, RFV and RFQ.

Correlation between u240 and lignin x 2.4 and NRC 2001 surface area

Relationship between Lignin x 2.4, uNRC, and u240
Correlations between d30, u120, u240 % NDF

New approach

- We have observed that the uNDF240 %BW is a wide range
  - Miner data: ~0.33%
  - Univ of Bologna data: ~0.5%
  - German: 0.19%
  - Irish pasture: 0.15%
  - On-farm observations: 0.24 to 0.45%
- Why?
  - The results would suggest this is related to
    - forages being used
    - aNDFom of the forages combined with species and relative sizes of fast, slow, and u pools
- I did NOT calculate the fast and slow pools for this data set. Rather, using Excel, calculated slope of 0 to 30 hr, 30 to 120 hr and 120 to 240 hr uNDFom as a proxy

Alfalfa Hay

- Poor correlations

Grass Hay

- Low correlation for 120 to 240 slope
- Significant correlation for 30-120 with aNDFom
  - As aNDFom increases, the slope gets larger indicating a large shift from 30 to 120 hr
  - So increasing slow pool size!
Tritcale silage
- Same behavior as grass
- All small grain silages showed similar behavior and correlations.

What are these saying?
- U240 %BW does NOT have a magical benchmark value in relation to DMI
- Alfalfa is basically ‘fast’ and ‘u’ (leaves and stems)
- Grasses and small grain silages shift pdNDF pools as aNDFom increases
- Evaluating diets using only u240 can result in unintended results
  - Drops in DMI
  - Drops in milk
- For now, use these as ‘internal farm’ benchmarks
  - However, if a forage source is changed (e.g. alfalfa to grass), these benchmarks will not work.
So what would the ‘ideal’ forage look like?

- Low in
  - Protein
  - Ash
  - Fatty acids
  - Minerals
  - uNDFom240
  - uNDFom120 (low to moderate)

- Moderate to High in
  - Sugar
  - aNDFom
  - NDFD30

In other words

- What we want is a forage that is
  - high in fermentable carbohydrates while
  - low to moderate in crude protein
  - Harvested quickly
  - Stored under excellent management
  - And fed at the correct particle size

- In other words: as close to pasture quality as we can while maintaining economic yields
  - Typically best as 1st cutting, harvested early!

So how can we use all this information?

- Forage selection
  - Especially if purchasing forage, Analyze forages for uNDF (30, 120 and 240 hr) and select based upon these values
  - If growing forages,
    - Select for digestibility if possible
    - Harvest to maximize digestibility as part of quality
    - Store to maintain quality
      - Silage management

Continued

- Forage allocation
  - Many farms struggle with this concept
    - May be a limitation due to storage system
    - May be a ‘mental block’ of having two to three forages being used at any given time
  - Allocate based upon overall quality AND NDFD
    - Highest digestibility to fresh and high producing cows
    - Do not want to limit intake due to rumen fill
    - Heifers and dry cows either need to be fed lower digestibility (more fill) ad libitum or if only high quality forages available, limit feed
Investigating the Relationship between Corn Silage Fiber Digestibility and Rainfall, Growing Degree Days and Soil Group

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uNDFom Results

- A trend was observed for uNDFom where
  - A hydrological class soils were lower in uNDFom vs other soil classes (LSMean 9.9 units difference, p=0.002)
  - Significant difference in uNDFom by year (LSMean 19.9 units difference, p=0.001)
    - Year 1 lower than Year 2
  - BMR samples were significantly lower in uNDFom compared with conventional hybrids (LSMean 6.6 units difference, p=0.018)

aNDFom and Starch results

<table>
<thead>
<tr>
<th>Year</th>
<th>Average</th>
<th>St. Dev</th>
<th>Average</th>
<th>St. Dev</th>
<th>Average</th>
<th>St. Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>aNDFom (NDFM)</td>
<td>40.9</td>
<td>3.5</td>
<td>36.9</td>
<td>4.5</td>
<td>39.1</td>
<td>4.4</td>
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<tr>
<td>Starch (NDFM)</td>
<td>35.7</td>
<td>4.4</td>
<td>37.3</td>
<td>4.2</td>
<td>35.3</td>
<td>4.6</td>
</tr>
<tr>
<td>DM</td>
<td>34.7</td>
<td>4.8</td>
<td>36.3</td>
<td>3.6</td>
<td>35.5</td>
<td>4.4</td>
</tr>
</tbody>
</table>

UNDFom, %aNDFom – Digestible aNDFom

<table>
<thead>
<tr>
<th>Term</th>
<th>Estimate</th>
<th>Std Error</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMR vs. Conventional</td>
<td>-7.10</td>
<td>0.84</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>June GDD50</td>
<td>-0.17</td>
<td>0.02</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>July GDD50</td>
<td>0.29</td>
<td>0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>May Precipitation</td>
<td>10.09</td>
<td>0.41</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>July Precipitation</td>
<td>-4.75</td>
<td>0.34</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>August Precipitation</td>
<td>-12.98</td>
<td>0.58</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Conclusions

- Soil type and hybrid significantly influence aNDFom, aNDFdom, and uNDFom
- Rainfall and temperature (GDD50) significantly influence aNDFom, aNDFdom, and uNDFom
  - Timing of Rainfall and GDD50 significantly shift digestible aNDFom and uNDFom
  - August rainfall had the largest impact
- Same results regardless of year
- Implications for timing irrigation and planting date
Conclusions

• aNDFom should be utilized
• Agronomic and Environmental factors have very large influence on aNDFom digestibility
• Cows have a limited rumen capacity for slow and unavailable aNDFom
• Forage management begins with the soil and continues through
  • Nutrient management (fertilization plan)
  • Species and hybrid selection
  • Harvest and storage management
  • Formulation
  • Feeding
• High levels of milk production require high quality forage

Thank-you