What do the real experts (cows) say about corn silage fiber analysis?

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Corn silage as a forage

• Advantages over other forage crops
  – High yield
  – High energy (TDN) forage
  – Manure management options
  – Custom harvesting
What makes a better corn silage?

• High yield
• High digestibility
  – Grain (+)
  – Fiber (-)
  – Fiber digestibility (+)
• High intake potential
  – Fiber (-)
  – Fiber digestibility (+)
Milk 2006
Ranking CS by yield and quality

• Milk/acre: Yield, digestibility and intake
  ✓ Lauer (2009): correlation between corn silage yield and Milk_{2006}/acre = .97
  ✓ Average difference between top and bottom performing hybrids in UW trials is 3.7 tons DM/Acre
  ✓ 11,500 lb milk/acre difference between top and bottom performing hybrids
Milk 2006

• Milk/ton: Ranks CS by Quality (Digestibility and Intake)

Lauer (2009) correlation of silage traits with milk/ton:

• NDF  - 0.46
• NDFD  + 0.49
• Starch  + 0.48
• StarchD  + 0.30
Contributions to TDN by Corn Silage Components

\[ \text{TDN}_{1x} = \text{td NFC} + \text{td CP} + (\text{td FA} \times 2.25) + \text{td NDF} - 7 \]
• About 1/3 of the energy in corn silage is in the fiber fraction (digestible NDF)
• NFC fraction accounts for about ½ of the energy in corn silage
Energy from corn silage fiber is affected by:

- The amount of fiber (NDF)
- The digestibility of fiber (NDFD)

- Both are measurable characteristics of corn silage
- Both can be selected for in corn breeding programs
- Both are affected by harvest date, growing conditions and environment
## Corn Silage NDF values

<table>
<thead>
<tr>
<th>Data base</th>
<th>n</th>
<th>NDF, %</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRC 2001</td>
<td>1033</td>
<td>45</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td>Lab 1, 2009</td>
<td>&gt;15,000</td>
<td>43</td>
<td>5.6</td>
<td>37-48</td>
</tr>
<tr>
<td>Lab 2, 2009</td>
<td>&gt;20,000</td>
<td>42</td>
<td>4.8</td>
<td>32-52</td>
</tr>
<tr>
<td>Lab 3, 2009</td>
<td>&gt;10,000</td>
<td>43</td>
<td>4.6</td>
<td>19-65</td>
</tr>
<tr>
<td>UW Corn silage Hybrid evaluation</td>
<td></td>
<td>47</td>
<td>5.4</td>
<td></td>
</tr>
</tbody>
</table>

- Corn silages analyzed by commercial labs vary greatly in NDF content
- Variations in NDF content in the field are largely due to environment and management
NDFD and Dairy Performance

*The real experts (cows) report:*

- Increased IVNDFD correlated with higher milk production
- Milk response to IVNDFD through DMI, not improved total tract digestibility
- DMI and Milk responses appear to be greater in higher producing cows
Figure 1. Ranges of NDF digestibility for common forages. The NDF digestibility ranges and guidelines are based on a 48 h in vitro true dry matter digestibility assay. (Marshfield Soil and Forage Analysis Laboratory, University of Wisconsin-Madison: 2001 Nutrient Requirements of Dairy Cattle).
## NDFD affects Dairy Cow Performance

<table>
<thead>
<tr>
<th>Reference</th>
<th>Diets</th>
<th>NDF (% DM)</th>
<th>DMI (lb/d)</th>
<th>Milk (lb/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oba and Allen, 1999</td>
<td>iso-CS</td>
<td>31.6</td>
<td>+4.6</td>
<td>+6.2</td>
</tr>
<tr>
<td></td>
<td>bm3–CS</td>
<td>30.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oba and Allen, 2000</td>
<td>iso-CS</td>
<td>29.1</td>
<td>+4.0</td>
<td>+6.8</td>
</tr>
<tr>
<td></td>
<td>bm3–CS</td>
<td>28.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iso-CS</td>
<td>38.4</td>
<td>+3.1</td>
<td>+7.3</td>
</tr>
<tr>
<td></td>
<td>bm3–CS</td>
<td>37.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tine et al., 2001</td>
<td>iso-CS</td>
<td>32.0</td>
<td>+5.2</td>
<td>+6.8</td>
</tr>
<tr>
<td></td>
<td>bm3–CS</td>
<td>31.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Response to corn silage NDF and NDFD
(Ivan et al. 2005 JDS 88:244-254)

<table>
<thead>
<tr>
<th>Item</th>
<th>Low NDF</th>
<th>High NDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS NDF, %</td>
<td>49</td>
<td>53</td>
</tr>
<tr>
<td>CS NDFD&lt;sub&gt;48&lt;/sub&gt;</td>
<td>58</td>
<td>67</td>
</tr>
<tr>
<td>Diet NDF, %</td>
<td>31</td>
<td>33</td>
</tr>
<tr>
<td>DMI, lb/d</td>
<td>53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>56&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>3.5% FCM, lb/d</td>
<td>70&lt;sup&gt;a&lt;/sup&gt;</td>
<td>75&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a,b</sup> DMI and Milk yield were higher for cows fed High NDFD CS, P<0.05
The *real* experts (cows) agree:

A 1% increase in forage NDFD is associated with a 0.4 lb increase in intake and a 0.8 lb increase in 4% FCM yield.

(Oba and Allen, 1999)
The Challenge: NDFD values vary by lab

- **No standard method:** Scientists can’t agree on the most appropriate method

- **The Result:**
  - Should not compare NDFD values between labs
  - NDFD is limited to ranking corn silages
  - Can’t compare fiber digestibility of corn silage to alfalfa or grasses
Challenges with NDFD assays

Many different methods/modifications

*lignin*: calculated fiber digestibility

*in situ methods*

*in vitro methods*: Procedures differ by lab

Variation in in vitro lab methods

Rumen fluid is not a reagent

Incubation times

Grind size and type

*Don’t compare forages with NDFD results from different labs!*
Corn Silage NDFD values vary by method and lab (2009 forage data base summaries)

<table>
<thead>
<tr>
<th></th>
<th>NDF % of DM</th>
<th>NDFD24</th>
<th>NDFD30</th>
<th>NDFD48</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab 1</td>
<td>42</td>
<td>53</td>
<td>57</td>
<td>61</td>
</tr>
<tr>
<td>Lab 2</td>
<td>43</td>
<td>NR</td>
<td>58</td>
<td>64</td>
</tr>
<tr>
<td>Lab 3</td>
<td>43</td>
<td>16</td>
<td>24</td>
<td>42</td>
</tr>
<tr>
<td>Lab 4</td>
<td>43</td>
<td>42</td>
<td>53</td>
<td>62</td>
</tr>
</tbody>
</table>

- Labs use different methods to measure NDFD
- Labs report in vitro NDFD values at different times
- Use in vitro values to index forage within a lab
NDF digestibility values are useful for ‘indexing’ forages:
• Compare corn silages only
• Don’t compare values of different labs
*In vitro* estimates of fiber digestibility are not the same as *in vivo* measurements.

**In vitro/in situ systems**

- Ruminal
  - Batch
  - Forage characteristic

**In vivo measurements**

- Total tract
- Continuous fermentation
- Combination of forage, diet, and animal

Quick, relatively inexpensive ≠ Slow, expensive, impractical for routine analysis
Comparing corn silage and legume silage NDFD values
(2009 lab data base averages)

<table>
<thead>
<tr>
<th></th>
<th>NDFD 30</th>
<th></th>
<th>NDFD 48</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CS</td>
<td>AS</td>
<td>CS</td>
</tr>
<tr>
<td>Lab 1</td>
<td>57</td>
<td>48</td>
<td>61</td>
</tr>
<tr>
<td>Lab 2</td>
<td>54</td>
<td>43</td>
<td>59</td>
</tr>
<tr>
<td>Lab 3</td>
<td>52</td>
<td>52</td>
<td>62</td>
</tr>
</tbody>
</table>

In vitro lab tests suggest that corn silage fiber is more rapidly digested than legume silage fiber
What do the ‘real experts’ say?

<table>
<thead>
<tr>
<th>Legume/grass feeding trials</th>
<th>Mean</th>
<th>47.3 % of NDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>(20 trials, 64 observations</td>
<td>Range</td>
<td>31.1-66.2 % of NDF</td>
</tr>
<tr>
<td>In vivo NDF diet digestibility)</td>
<td>St. Dev</td>
<td>8.1</td>
</tr>
</tbody>
</table>

Cows report that NDF digestibility of legume/grasses are higher than fiber digestibility of corn silage.

<table>
<thead>
<tr>
<th>Corn Silage/Sorghum feeding trials</th>
<th>Mean</th>
<th>40.2 % of NDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>(25 trials, 81 observations,</td>
<td>Range</td>
<td>20.1-58.8 % of NDF</td>
</tr>
<tr>
<td>In Vivo NDF diet digestibility)</td>
<td>St. Dev.</td>
<td>8.8</td>
</tr>
</tbody>
</table>
Why don’t cows and labs agree?

In vitro ≠ in vivo

In vitro tests might overestimate rate of fiber degradation?

<table>
<thead>
<tr>
<th>Rate of NDF digestion</th>
<th>NDFD30</th>
<th>NDFD48</th>
<th>Estimated Digestibility in vivo</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 % per hour</td>
<td>42</td>
<td>56</td>
<td>38</td>
</tr>
<tr>
<td>6 % per hour</td>
<td>61</td>
<td>71</td>
<td>56</td>
</tr>
</tbody>
</table>
The bottom line

About 1/3 of the energy value of corn silage is associated with NDF

Corn silage hybrids vary in NDF and NDFD content

• NDF and NDFD are tools to compare corn silage hybrids
• Milk 2006 uses NDF and NDFD to compare hybrids

Limits of NDFD: Not all NDFD tests are the same

• NDFD values vary by lab (lignin, in situ tests, in vitro)
• Use NDF and NDFD (ie Milk 2006) to compare corn silages
• In vitro NDFD values for corn silage appear to overestimate fiber energy values
• Alfalfa and corn silage in vitro NDFD values are ‘apples to oranges’ comparisons
Web Resources

• UW Extension Forage Resources
  www.uwex.edu/ces/crops/uwforage/uwforage.htm

• UW Extension Corn Agronomy
  http://corn.agronomy.wisc.edu/Extension.htm

• UW Department of Dairy Science
  http://www.wisc.edu/dysci/