The Importance of Fiber Quality and Starch Content for Nutrient Value of Corn Silage

Florida/Georgia Forage Day

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University of Illinois Extension
Increasing Forage Intake
(60 to 70% Total DMI)

- Reduce feed costs
- Sustainable on-farm resource
- Quality controlled by the dairy manager
- Healthy rumen environment
- Selection of high yield & high NDF digestible forage hybrids
- Reduce cereal grain use (human and fuel competition)
Whole-Plant Corn Silage

Grain ~40-45% of WPDM
- Avg. 30% starch in WPDM
- Variable grain:stover

Stover ~55-60% of WPDM
- Avg. 42% NDF
- Variable stover:grain

80 to 98% StarchD
- Kernel particle size
- Duration of silage fermentation
- Kernel maturity
- Endosperm properties
- Additives

40 to 70% IVNDFD
- Lignin/NDF
- Hybrid Type
- Maturity
- Additives

Variable peNDF as per chop length

Adapted from Joe Lauer, UW Madison Agronomy Dept.
Plant Dry Matter vs. Composition

Plant Composition 2008

Pioneer-ISU Collaborative Field Study
Using the Forage NDFD or uNDF
Forage NDF digestibility and cow performance

For every 1 percentage-unit increase in NDF digestibility:
- +0.40 lb/d DMI
- +0.55 lb/d 4%FCM
  (Oba and Allen, 1999)

>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)

- Overall, DMI increased by 1.4 lb/d and milk by 2.0 lb/d

Allocation of forage by production level gets more milk from fiber!
# Corn Silage Fiber Values

<table>
<thead>
<tr>
<th></th>
<th>DRY BASIS</th>
<th>AVERAGE</th>
<th>Normal Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADF</td>
<td>%DM</td>
<td>24.68</td>
<td>24.66</td>
</tr>
<tr>
<td>aNDF</td>
<td>%DM</td>
<td>38.85</td>
<td>41.00</td>
</tr>
<tr>
<td>aNDFom</td>
<td>%DM</td>
<td>37.90</td>
<td>40.10</td>
</tr>
<tr>
<td>NDFD 30</td>
<td>%NDF</td>
<td>51.93</td>
<td>53.87</td>
</tr>
<tr>
<td>NDFD 120</td>
<td>%NDF</td>
<td>61.58</td>
<td>71.54</td>
</tr>
<tr>
<td>NDFD240</td>
<td>%NDF</td>
<td>65.83</td>
<td>73.90</td>
</tr>
<tr>
<td>uNDFom30</td>
<td>%DM</td>
<td>18.22</td>
<td>18.20</td>
</tr>
<tr>
<td>uNDFom120</td>
<td>%DM</td>
<td>14.56</td>
<td>11.45</td>
</tr>
<tr>
<td>uNDFom240</td>
<td>%DM</td>
<td>12.95</td>
<td>10.50</td>
</tr>
</tbody>
</table>
179,753 Samples – 2014 Crop Year
Measured ranges in uNDF240
(source: Dairy One, May, 2015 newsletter)

- **Corn silage**
  - 8.7% of DM
  - Range: 2.0 to 25.5%

- **Legume silage**
  - 17.6% of DM
  - Range: 5.5 to 31.7%

- **Grass silage**
  - 15.5% of DM
  - Range: 2.3 to 44.8%

Tremendous variation in uNDF that we need to capture when formulating diets and predicting cow response!
Fast and slow NDF exists in all forage types (Allen, 2005, unpublished)

Slide courtesy of Dr. Mike Allen
3-Pool Model of NDF Digestion: Better Measure of Reality?

1) Indigestible NDF (uNDF240)
2) Fast NDF
3) Slow NDF

- Focus on 0, 30, 120, 240 hour
- Labs measure routinely now
- NIR more accurate than ADL
- Better characterize fiber digestion profile!
Importance of rumen digestion: Corn silage NDF (47-h in situ)
Wheat straw NDF (47-h in situ)
Rumen Fill Dynamics
Is there a max and min uNDF240 for high-performing cows?

Suggest:
- **0.25 to 0.45% of BW**
- Below range, inadequate rumen fiber
- Above range, rumen fill constraint
- Work in progress...
Use of uNDF

- Determines rumen fill from forage sources
- Guideline is 6.0 to 6.2 pounds of uNDF-30 (Holstein) and 5.0 lb uNDF-30 (Jersey)

**Holstein Example:**

30% ration NDF X 50 lb DMI X 40% uNDFD = 6.0 lb uNDF

This herd should be able to consume this level of dry matter intake based on uNDF ration levels
Forage Particle Measurements
Visualizing the Rumen Mat
# Penn State Separator Guidelines

<table>
<thead>
<tr>
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<th>Top</th>
<th>2nd</th>
<th>3rd</th>
<th>Bottom</th>
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<tbody>
<tr>
<td>TMR</td>
<td>10-15</td>
<td>&gt; 40</td>
<td>&lt; 30</td>
<td>&lt; 20</td>
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<tr>
<td>Haylage</td>
<td>&gt; 40</td>
<td>&gt; 40</td>
<td>&lt; 20</td>
<td>&lt; 5</td>
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<tr>
<td>Corn silage</td>
<td>5-15</td>
<td>&gt; 50</td>
<td>&lt; 30</td>
<td>&lt; 5</td>
</tr>
</tbody>
</table>

(3/4 TLC-Process)

TMR: Total Mixed Ration

Haylage

Corn silage

(as fed)
Corn Silage Processing
Poor job of processing
Rotap shaker showing 4.75mm screen and corn retained on the sieve
Kernel Processing Score

- ΔWorth 2 lb. Milk or 2 lb. Corn

RD Shaver UW-Madison
Shredlage vs. Conventional Processing

- My goal is to process the corn kernel properly
- Particle size is determined by TLC (3/4 inch to one inch seem optimal)
- Processing rolls wear out
- Shredlage guarantees kernel processing
- Cost: $35,000 unit vs. $10,000/+$2 per ton
Fecal Starch
Apparent digestibility of feed starch and fecal starch (%DM)

\[
y = -0.0176x + 0.9872
\]

\[R^2 = 0.7345\]
Dairy Fecal Starch %

- **Range**: 
  - <3%: 40% 
  - 3-5%: 21% 
  - >5%: 39%
- **UW Recommendations for Dairy**: 
  - No need to investigate further
  - Investigate individual feeds
- **883 Samples described as “dairy”**

Bar chart showing the distribution of dairy fecal starch percentages.
Milk response

• Fecal starch should be less than 4.5% represents total tract apparent digestibility of 90+ percent.

• If fecal starch can be reduced 1 unit (absolute decrease from 10% to 9%), milk production could increase 0.67 pound (dry matter intake remains constant).
Silage Fermentation Profile
# Recommended Fermentation Profile for Ensiled Feeds

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Legume/grass</th>
<th>Corn Silage</th>
<th>H.M. Corn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter (%)</td>
<td>35 to 50</td>
<td>30 to 35</td>
<td>70 to 75</td>
</tr>
<tr>
<td>pH</td>
<td>4.3 to 4.7</td>
<td>3.8 to 4.2</td>
<td>4.0 to 4.5</td>
</tr>
<tr>
<td>Lactic acid (%)</td>
<td>4.0 to 6.0</td>
<td>5.0 to 10.0</td>
<td>1.0 to 2.0</td>
</tr>
<tr>
<td>Acetic acid (%)</td>
<td>0.5 to 2.5</td>
<td>1.0 to 3.0</td>
<td>&lt;0.5</td>
</tr>
<tr>
<td>Propionic acid (%)</td>
<td>&lt;0.25</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
</tr>
<tr>
<td>Butyric acid (%)</td>
<td>&lt;0.25</td>
<td>&lt;0.10</td>
<td>&lt;0.10</td>
</tr>
<tr>
<td>Ethanol (%DM)</td>
<td>&lt;1.0</td>
<td>&lt;3.0</td>
<td>&lt;2.0</td>
</tr>
<tr>
<td>Ammonia (%CP)</td>
<td>&lt;12.0</td>
<td>&lt;8.0</td>
<td>&lt;10.0</td>
</tr>
<tr>
<td>Lactic/Acetate</td>
<td>&gt;2.5</td>
<td>&gt;3.0</td>
<td>&gt;3.0</td>
</tr>
<tr>
<td>Lactic (% total)</td>
<td>&gt;70</td>
<td>&gt;70</td>
<td>&gt;70</td>
</tr>
</tbody>
</table>
Inoculation Speeds Up Fermentation

- Untreated
- Inoculated

Better Fermentation with inoculation.
### Inoculants in Corn Silage

18 peer reviewed studies

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Inoculants</th>
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</thead>
<tbody>
<tr>
<td><strong>pH</strong></td>
<td>3.9</td>
<td>3.85</td>
</tr>
<tr>
<td><strong>Lactic acid (%)</strong></td>
<td>5.11</td>
<td>5.22</td>
</tr>
<tr>
<td><strong>Acetic acid (%)</strong></td>
<td>1.59</td>
<td>1.50</td>
</tr>
<tr>
<td><strong>DM recovery (%)</strong></td>
<td>86.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>89.9&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>DM digest (%)</strong></td>
<td>67.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>69.3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Milk (lb)</strong></td>
<td>70.4</td>
<td>71.7</td>
</tr>
</tbody>
</table>
Economics of Silage Inoculants

3% improvement in dry matter recovery

2% increase in digestibility

Benefit to cost ratio ($1 per ton)

• 3 : 1 on nutrient preserved

• 8 : 1 when fed to high producing cows
Corn Silage Hybrids

- **Conventional:** higher tonnage; higher milk/acre; higher starch
- **Brown Mid-Rib (BMR):** lower lignin, higher digestibility, lower tonnage
- **Leafy:** increase digestibility; no significant milk response
- **High Oil:** fed as silage does not reflect advantage
Selecting Corn Silage Varieties

*Using Wisconsin Milk2006 equation*

**Inputs:**
- Non-Fiber Carbohydrates (NFC)
- Starch levels and digestibility
- NDF digestibility and level
- Dry matter intake
- NEI (Mcal/lb DM)
- Moisture content and processing effects

**Outputs:**
- Pounds of milk per ton (quality emphasis)
- Pounds of milk per acre (quantity and quality emphasis)
### Table: Average Corn Silage Hybrid

<table>
<thead>
<tr>
<th>Trait(s)</th>
<th>GxE</th>
<th>Forage yield</th>
<th>NDF</th>
<th>NDFD</th>
<th>Starch</th>
<th>Milk2006</th>
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<tbody>
<tr>
<td>Normal</td>
<td>3398</td>
<td>7.8</td>
<td>47</td>
<td>59</td>
<td>30</td>
<td>3100 25000</td>
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<tr>
<td>Bmr</td>
<td>126</td>
<td>6.4</td>
<td>48</td>
<td>67</td>
<td>26</td>
<td>3300 21000</td>
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<tr>
<td>Leafy</td>
<td>240</td>
<td>8.1</td>
<td>48</td>
<td>59</td>
<td>27</td>
<td>3100 25000</td>
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<tr>
<td>CB</td>
<td>736</td>
<td>8.1</td>
<td>46</td>
<td>59</td>
<td>31</td>
<td>3100 26000</td>
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<tr>
<td>RR</td>
<td>339</td>
<td>7.8</td>
<td>47</td>
<td>58</td>
<td>30</td>
<td>3100 24000</td>
</tr>
<tr>
<td>CB,LL</td>
<td>331</td>
<td>8.2</td>
<td>47</td>
<td>59</td>
<td>30</td>
<td>3100 26000</td>
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<tr>
<td>CB,RR</td>
<td>395</td>
<td>8.0</td>
<td>46</td>
<td>59</td>
<td>32</td>
<td>3100 25000</td>
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<tr>
<td>CB,RW,RR</td>
<td>891</td>
<td>7.9</td>
<td>46</td>
<td>58</td>
<td>32</td>
<td>3100 25000</td>
</tr>
</tbody>
</table>

| LSD(0.05) | 0.6 | 2   | 1   | 4   | 100 | 2000 |

| Average   | 7403| 8.0 | 47  | 58  | 30  | 3100 25000 |

Lauer © 1994-2014
http://corn.agronomy.wisc.edu

Lauer, 1990-2010; UW ST trials= 266; n= 21,420
Take Home Messages

- Corn silage requires digestible fiber and high levels of fermentable starch
- Evaluate NDFD and uNDF values
- Testing for fecal starch, kernel processing score, and fermentation profile
- Agronomic considerations should be evaluated (hybrid selection, stacked genetics, and fungicide treatment)