Corn Silage Evaluation: MILK2000 Challenges & Opportunities With MILK2006

Professor Randy Shaver
Department of Dairy Science
University of Wisconsin - Madison
University of Wisconsin - Extension
Whole-Plant Corn Silage

Grain ~40-45% of WPDM
- Avg. 28% starch in WPDM
- Variable grain:stover

Stover= ~55-60% of WPDM
- Leaves = 15% of DM
- Stem = 20-25% of DM
- Cob+Shank+Husk= 20% of DM

80 to 98% starch digestibility
- Kernel maturity
- Kernel particle size
- Endosperm properties

40 to 70% NDFD
- lignin/NDF

Adapted from Joe Lauer, UW Agronomy
NRC (2001) Dairy TDN

\[ TDN \ 1-X = \]
\[ tdCP + (tdFA \times 2.25) + tdNDF + tdNFC - 7 \]
Why measure NDFD \textit{in vitro} vs. calculating via lignin?

- Lignin wet chem assay difficult & its calibration with NIRS has been poor
- Lignin to NDFD equation is theoretically based
- Lignin explains only about half of the \textit{in vitro} NDFD variation
  - Stover NDF & lignin contents $\uparrow$ & NDFD $\downarrow$ with maturity, while WP NDF & lignin contents are constant or $\downarrow$ as grain\% increases
Relationship between lignified NDF and *in vitro* NDFD for corn & alfalfa forages

- **Alfalfa**
  - R² = 0.56

- **Corn Silage**
  - R² = 0.54

- **Lignin, % of NDF**
  - Corn silage: 3-9%
  - Alfalfa: 11-20%

*Allen, 2003*
30-h NDFD (adapted from Allen, 2003) vs. NDF digestibility calculated using NRC-01 lignin equation

<table>
<thead>
<tr>
<th>Whole-Plant Lignin, % DM</th>
<th>Calculated NDFD</th>
<th>30-h NDFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>62</td>
<td>60</td>
</tr>
<tr>
<td>3.1</td>
<td>57</td>
<td>45</td>
</tr>
<tr>
<td>4.2</td>
<td>53</td>
<td>30</td>
</tr>
</tbody>
</table>
### Measured NDFD or Estimated from Lignin?

<table>
<thead>
<tr>
<th>NDF, %</th>
<th>Lignin, %</th>
<th>Calc. NDFD</th>
<th>30-h NDFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>45.0</td>
<td>3.52</td>
<td>56</td>
<td>46.0</td>
</tr>
<tr>
<td>45.0</td>
<td>3.26</td>
<td>57</td>
<td>48.4</td>
</tr>
<tr>
<td>45.0</td>
<td>3.32</td>
<td>57</td>
<td>54.4</td>
</tr>
<tr>
<td>45.1</td>
<td>3.18</td>
<td>57</td>
<td>55.0</td>
</tr>
<tr>
<td>45.0</td>
<td>3.43</td>
<td>56</td>
<td>67.3</td>
</tr>
</tbody>
</table>

- Corn silage data set from Van Amburgh (2004)
- Similar relationships from 36.5 to 51.8% NDF

Adapted from: Rick Grant, NRAES Silage Conf., 2006
The incubation time-point debate

- **48-hr.**
  - Reflects maintenance intake for use in NRC summative equation
  - Less influenced by lag & rate, so possibly lower COV

- **30- or 24-hr.**
  - 30-h more closely related to ruminal retention time
  - 30-h was used in most cow trials
  - Faster lab turn-around
  - Better lab efficiency at 24-h?
The incubation time-point debate

- **MILK2000**
  - 48-h

- **MILK2006**
  - 48-h default, with 30-h or 24-h User Defined Option

- Lab average NDFD required
  - NDFD DMI adjustment =
    \[(\text{avg. NDFD} - \text{NDFD}) \times 0.26\]
  - NDFD adjustment for summative TDN<sub>1x</sub> equation
Adapted from Coors (data from Justen, 2004).
Variation in “normal “ corn silage NDF digestibility calculated using NRC-01 lignin equation and table data

<table>
<thead>
<tr>
<th>Whole-Plant Lignin, % DM</th>
<th>Calculated NDFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 (2stdev)</td>
<td>65</td>
</tr>
<tr>
<td>1.8 (1stdev)</td>
<td>61</td>
</tr>
<tr>
<td>2.6 (avg.)</td>
<td>59</td>
</tr>
<tr>
<td>3.4 (1 stdev)</td>
<td>56</td>
</tr>
<tr>
<td>4.2 (2stdev)</td>
<td>56</td>
</tr>
</tbody>
</table>
NDFD -- MILK2000 vs. MILK2006

**MILK2000**
- A 1%-unit change in NDFD from lab average NDFD changes DMI 0.37 lb (Oba and Allen, 1999, JDS)
- Double counting of TDN & DMI changes related to changes in NDFD
  - Tine et al. (2001, JDS) and Oba and Allen (1999, JDS)
  - At production levels of intake, NDFD has minimal impact on NE_L content but does impact NE_L intake primarily thru its impact on DMI
- Calculation of NE_L-3x from TDN_1x as per NRC (1989)

**MILK2006**
- NDFD used for calculating NE_L-3x adjusted for impact of NDFD on DMI (Oba and Allen, JDS, 1999)
- Calculation of NE_L-3x from TDN_1x via DE and ME as per NRC (2001)
Corn Silage NDFD% vs. NE\textsubscript{L3x}

Calculated assuming corn silage with 35% DM proc., 27% starch, 45% NDF, and 58% avg. NDFD.
Corn Silage NDFD% vs. Milk per Ton

Calculated assuming corn silage with 35% DM proc., 27% starch, 45% NDF, and 58% avg. NDFD

Milk Production Comparison:
- MILK2000
- MILK2006
NRC (2001) Dairy TDN

\[\text{TDN 1-}X = \text{tdCP} + (\text{tdFA} \times 2.25) + \text{tdNDF} + \text{tdNFC} - 7\]
NRC (2001) Dairy TDN

\[ td\text{NFC} = NFC\% \times 0.98 \times PAF \]

<table>
<thead>
<tr>
<th>PAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn grain, ground dry</td>
</tr>
<tr>
<td>Corn grain, ground high moisture</td>
</tr>
<tr>
<td>Corn silage, normal</td>
</tr>
<tr>
<td>Corn silage, mature</td>
</tr>
</tbody>
</table>
Schwab-Shaver Energy Equation

\[
\text{TDN}_{1-x} = \text{DIG}_{\text{CP}} + \text{DIG}_{\text{FA}} + \text{DIG}_{\text{Starch}} + \text{DIG}_{\text{NSTNFC}} + \text{DIG}_{\text{NDF}} - 7
\]
Predicted Starch Digestibility

Adapted from Schwab et al., 2003.
Differences in calculation of \textit{tdNFC}

Based on corn silage with 41\% NFC & 28\% starch

<table>
<thead>
<tr>
<th>WP DM %</th>
<th>NRC-01 $tdNFC%$</th>
<th>Schwab et al., 2003 $tdStarch&amp;NSTNFC%$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unprocessed</td>
<td>Processed</td>
</tr>
<tr>
<td>30</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>35</td>
<td>38</td>
<td>39</td>
</tr>
<tr>
<td>40</td>
<td>35</td>
<td>36</td>
</tr>
<tr>
<td>45</td>
<td>35</td>
<td>34</td>
</tr>
</tbody>
</table>
Calculated assuming corn silage with 27% starch, 45% NDF, and 58% NDFD

Corn Silage WP DM% vs. TDN₁x

MILK2006
Corn Silage WP DM% vs. Milk per Ton

Calculated assuming corn silage with 27% starch, 45% NDF, and 58% NDFD

Unprocessed

Processed

Ib. Milk/ton CS DM

30 35 40 45 30 35 40 45

WP DM%
Evaluating Starch Digestion in Ruminants.......... 

In Vivo...... Total Tract Collections & Digesta Markers Cannulae (Rumen, Duodenum, Ileum)

Macro In Situ.... Rumen cannulae
Incubation time?
Starch-Feeds cannot be fine ground
Post-Ruminal Enzymatic?

In Vitro.... Rumen fluid
Incubation time?
Starch-Feeds cannot be fine ground
Post-Ruminal Enzymatic?
Corn Silage Processing Score
Mertens, USDFRC & Dairyland Labs, Arcadia, WI

- Ro-Tap Shaker
  - 9 sieves (0.6 thru 19 mm) and pan
  - Analyze for starch on 4.75 mm & greater sieves

% of starch passing 4.75 mm sieve | CSPS
---|---
>70% | Optimum
70% to 50% | Average
< 50% | Poor
Kernels and Large Fragments Were Retained on > 4.75-mm Sieves
Corn Silage KPS vs. TDN$_{1x}$

Calculated assuming corn silage with 40% DM 27% starch, 45% NDF, and 58% NDFD.
Degree of Starch Access (DSA)
Blasel, Hoffman and Shaver, J AFST, 2006

- Adaptation of food industry assay “Degree of Starch Gelatinization”
- Detects particle size, moisture, and vitreousness differences in corn samples
- Appears to offer better characterization of processed corn silage samples than KPS
- DSA can be related to total tract starch digestion
  - More animal validation data needed
- Pilot study of assay across labs in progress
Mean Particle Size, $\mu$m

Particle Size $P<0.0001$

Degree of Starch Access, % of starch

Blazel et al., 2005
Dry Matter P<0.0001

$r^2 = 0.76$

Blazel et al., 2005
DSA vs. Total Tract Starch Digestibility from Literature Sources

\[ y = 0.198x + 76.9 \]

\[ R^2 = 0.73 \]

Difference worth 3 lb. milk
Calculated assuming corn silage with 27% starch, 45% NDF, & 58% NDFD.
MI LK2006: Starch Digestion
User Defined Options

- Default
  - WP DM & Kernel Processing Regressions
- KPS
- DSA
- Ruminal in situ plus post-ruminal in vitro
$TDN_{1x}$ Simulation -- Input Extremes

LQ 45% DM unproc., 20% starch, 54% NDF, and 46% NDFD

HQ 30% DM proc., 34% starch, 36% NDF, and 70% NDFD

- MILK2006
  - TDN %: 56.2

- MILK2000
  - TDN %: 57.3

HQ 30% DM proc., 34% starch, 36% NDF, and 70% NDFD
  - TDN %: 76.3

HQ 30% DM proc., 34% starch, 36% NDF, and 70% NDFD
  - TDN %: 79.9
Milk per Ton Simulation -- Input Extremes

LQ 45% DM unproc., 20% starch, 54% NDF, and 46% NDFD

HQ 30% DM proc., 34% starch, 36% NDF, and 70% NDFD

lb. Milk/ton CS DM

4256
3617
2418
2242

MILK2000
MILK2006
Milk per Ton -- High NDF, NDFD vs. Low NDF, NDFD
Ivan et al., JDS, 2005

LF 26% starch, 49% NDF, 58% NDFD
HF 22% starch, 53% NDF, 67% NDFD
Milk per Ton -- High NDF, NDFD vs. Low NDF, NDFD

Ivan et al., JDS, 2005

HF 22% starch, 53% NDF, 67% NDFD

LF 26% starch, 49% NDF, 58% NDFD

Calculated from animal data

MILK2000

297

MILK2006

132

168
Treatment differences for model-predicted milk per ton versus milk per ton from in vivo data

Calculated from 10 JDS papers with 13 comparisons
Treatment differences for model-predicted milk per day versus milk per day in vivo data

Calculated from 10 JDS papers with 13 comparisons
UW Correlations

\( n = 3727 \text{ treatment means} \)

<table>
<thead>
<tr>
<th>r-values</th>
<th>Milk per Ton DM 2006</th>
<th>Milk per Ton DM 2000</th>
<th>Milk per Ton DM 1995</th>
<th>Milk per Ton DM 1991</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDF</td>
<td>-0.46</td>
<td>-0.40</td>
<td>-0.94</td>
<td>-0.99</td>
</tr>
<tr>
<td>Starch</td>
<td>0.48</td>
<td>0.44</td>
<td>0.75</td>
<td>0.74</td>
</tr>
<tr>
<td>NDFD</td>
<td>0.49</td>
<td>0.70</td>
<td>0.16</td>
<td>-0.10</td>
</tr>
<tr>
<td>StarchD</td>
<td>0.30</td>
<td>0.21</td>
<td>-0.25</td>
<td>-0.27</td>
</tr>
</tbody>
</table>
**UW Correlations**

\[ n = 3727 \text{ treatment means} \]

<table>
<thead>
<tr>
<th>r-values</th>
<th>Milk per Acre 2006</th>
<th>Milk per Acre 2000</th>
<th>Milk per Acre 1995</th>
<th>Milk per Acre 1991</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM Yield tons/acre</td>
<td>0.97</td>
<td>0.97</td>
<td>0.88</td>
<td>0.85</td>
</tr>
<tr>
<td>Milk per Ton DM</td>
<td>0.23</td>
<td>0.20</td>
<td>0.52</td>
<td>0.61</td>
</tr>
</tbody>
</table>
Relationship between milk per acre and milk per ton of corn hybrids in South Central WI during 2002.
Visit UW-Madison Dairy Science Department’s Website

http://www.wisc.edu/dysci/