Assessing the Feeding Value of your Corn Silage

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Veterinary Medicine Teaching and Research Center
Tulare, CA
Corn Silage in TMR

2.2 to 10.7 kg/day in lactating cows - *Castillo* (2012)

7.1 to 23.1% of the DM in high producing cows - *UCDavis Peter Robinson* (2007)
Does all corn silage have the same feeding value?
Quality of the Forage Crop

Various factors affect the quality of the forage standing in the field:

Hybrid

Agronomic Practices

Growing Conditions
Quality of the Ensiled Crop

Various factors affect the quality and quantity of the ensiled forage:

**Harvest**

**Storage**

**Feedout**

After ensiling, the quality of the ensiled crop may not correlate with the quality of the forage standing in the field.
How can we assess if corn silage 1 has a superior feeding value than silage 2?
Taking a representative sample

In the field

At the silage pit
Nutrient Analysis
What are the lab assays that you are most interested in?

Question to Nutritionists from California and Pacific South West ARPAS UCCE Dairy Nutritionist Survey - Daniel H. Putnam, 2011

1. Starch
2. NDFD
3. NDF
4. DM, IVDDM, Ash

*DM was consider very important for quality and yield estimations
DRY MATTER
Dry Matter

Desirable dry matter: 30 to 36%

Low Dry Matter Silages:
1. Low starch
2. High seepage losses
3. Poor fermentation (high production of fermentation acids)
4. Less susceptible to aerobic spoilage

High Dry Matter Silages:
1. High starch
2. Lower NDF and starch digestibility
3. Hard to pack
4. More susceptible to aerobic spoilage

<table>
<thead>
<tr>
<th></th>
<th>Silage 1</th>
<th>Silage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>45.4</td>
<td>26.6</td>
</tr>
</tbody>
</table>

Which silage is less likely to heat up in the feedbunk?
Which silage provides the most nutrients based on wet weight?
STARCH
Starch

Starch (%) in corn silage samples from California dairies (n=126)

```
Mean = 34.3
Range = 14.5 – 45.7
```

Type of Hybrid
Growing Conditions
Chopping Height
Dry Matter at Harvest

**Starch analysis were done with a modified lab assay**
Starch Digestibility

Macro-protective coats of the seeds – *kernel*

Micro-protective coats of starch granules within the seeds – *prolamin type*

Maturity at harvest
Chop length
Kernel processing

Storage length
Type of corn endosperm
Kernel Processing

Kernel processing improves the whole plant value by breaking all the corn kernels and reducing the presence of large cob pieces.

** In CA, 5-15% of the dairy producers do not kernel process because of harvest costs (Collar and Silva-del-Rio, 2010)

Processing corn silage increases milk production up to 1.7 to 2.5 lbs/cow/d when corn silage represents 30 to 40% of the ration.

It is normal to find 2 to 3% of the kernel DM consumed in feces. If large amounts of kernels are found in feces, then kernel processing may have been inadequate.
Kernel Processing

Guidelines for kernel processing evaluation on-farm (Mertens, 2005):
- 90 - 95% cracked
- 70% smaller than ¼ of a kernel
- Nicking and crushing is not enough

Kernels separated from fodder with a bucket of water (Courtesy of Dr. Limin Kung)
**Kernel Processing**

**Corn Silage Processing Score**

Coarse Fraction > 4.75mm (0.18 in):
- **Fiber** will stimulate chewing activity.
- **Starch** will be poorly digested.

<table>
<thead>
<tr>
<th>Starch (%) passing through the coarse screen</th>
<th>Ranking</th>
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<tbody>
<tr>
<td>&gt; 70%</td>
<td>Optimum</td>
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<tr>
<td>50 - 70%</td>
<td>Average</td>
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<tr>
<td>&lt; 50%</td>
<td>Inadequate Processing</td>
</tr>
</tbody>
</table>
Corn Silage Processing Score

Cumberland Lab, 2009 - 2011 (n=1131)

- 42% Inadequately Processed
- 51% Adequately Processed
- 7% Optimally Processed
Starch Micro-Coat

Prolamin micro-coats of the starch granules within the endosperm.

Starch heavily imbedded in prolamin-protein complex

Starch less encapsulated by prolamin-protein complex.

(Gibbon et. al., 2003)
Effect of storage period on prolamin-zein proteins in high moisture corn.

Hoffman et al. (2010)
Why new corn silage doesn’t feed as well?

Forage from a single field (n=2)
Samples were vacuum sealed and kept in an environmentally controlled room
Samples were removed every 30 days and kept frozen until analysis

<table>
<thead>
<tr>
<th>Time (mo.)</th>
<th>DMD12</th>
<th>DMD30</th>
<th>NDFD30</th>
<th>STRD12</th>
<th>ttSTRD</th>
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<tbody>
<tr>
<td>0</td>
<td>37.4%</td>
<td>42.5%</td>
<td>29.2%</td>
<td>69.3%</td>
<td>91.6%</td>
</tr>
<tr>
<td>1</td>
<td>37.9%</td>
<td>43.2%</td>
<td>30.9%</td>
<td>70.6%</td>
<td>92.5%</td>
</tr>
<tr>
<td>3</td>
<td>38.8%</td>
<td>44.3%</td>
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<td>72.5%</td>
<td>94.1%</td>
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<tr>
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<td>45.1%</td>
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</tr>
<tr>
<td>11</td>
<td>40.5%</td>
<td>46.4%</td>
<td>39.2%</td>
<td>73.9%</td>
<td>96.9%</td>
</tr>
</tbody>
</table>

Monthly change (0-6 mo.) | 0.50% | 0.70% | 1.20% | 0.60% | 1.80% |

DMD = dry matter digestibility at 12 or 30 hours
NDFD30 = digestibility of NDF fraction at 30 hours
STRD12 = starch digestibility at 12 hours
ttSTRD = total tract starch digestibility

Chris Hallada, Vitta Plus - Hoards Dairyman, Nov 2009
What can you do to maximize the starch available for rumen microbes?

- Harvest at the crop at the correct DM
- Kernel process the crop properly
- Start feeding at least 3 - 6 months after storage
NDF Digestibility
What is NDF?

NDF is the residue obtained after the plant material is washed with a neutral detergent solution (NDF) that leaves the cell wall matrix.

- Polyphenolic acids linked to hemicellulose by ether or ester bonds.
- Limits digestion of the Lignin-Hemicellulose-Cellulose complex.
Why NDF Digestibility is important?

- Fiber is the lowest digesting component in feeds.
- Diets containing high digestible fiber allow for more intake and milk.
- Increase NDF Digestibility of forages by 1% (Mertens, 2006):
  - 0.2 lb of DMI
  - 0.28 lb of FCM

Factors affecting NDF Digestibility:
- Maturity, Growing Conditions,
- Crop Management, Hybrid, Ensiling Time

Conventional (top) vs BMR (bottom) corn
Why new corn silage doesn’t feed as well?

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Effective Fiber from Corn Silage
Effective Fiber from Corn Silage

Corn silage particle length should be long enough to supply effective fiber for optimal rumen function and adequately short to favor packing and fermentation.

TLC adjusted based on DM and kernel processing.

<table>
<thead>
<tr>
<th>DM</th>
<th>TLC</th>
<th>Roller Setting</th>
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<tr>
<td>&lt; 33%</td>
<td>0.75 – 0.90 in.</td>
<td>Open</td>
</tr>
<tr>
<td>33-38%</td>
<td>0.75-0.90 in.</td>
<td>0.12 in.</td>
</tr>
<tr>
<td>38%</td>
<td>0.5 in.</td>
<td>Close rolls</td>
</tr>
</tbody>
</table>

(https://www.livestocktrail.uiuc.edu/dairynet/paperDisplay.cfm?ContentID=615)

If ensiled corn is the only roughage source at the dairy, it is recommended to chop long to ensure enough effective fiber in the ration.
Evaluate Forage Particle Length

<table>
<thead>
<tr>
<th></th>
<th>3/4 TLC Processed</th>
<th>3/8 TLC Unprocessed</th>
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<tr>
<td>Top</td>
<td>5-15</td>
<td>3-8</td>
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<tr>
<td>Second</td>
<td>&gt;50</td>
<td>45-60</td>
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<tr>
<td>Third</td>
<td>&lt;30</td>
<td>30-40</td>
</tr>
<tr>
<td>Bottom</td>
<td>&lt;5</td>
<td>&lt;5</td>
</tr>
</tbody>
</table>
Effective Fiber from Corn Silage

Corn Shredlage
Cross-grooved processing rolls
Greater proportion of coarse stover particles

http://www.shredlage.com/
Experimental Design
Corn Silage DM=35%
Conventional: 0.74 inch TLC and 0.12 in roll opening
Shredlage: 1.18 inch TLC and 0.10 in roll opening
Experimental unit: 14 pens (n=8).
50% of the TMR was corn

Results Shredlage vs Conventional:
Dry Matter Intake (1.4 lb/d; P < 0.08)
Fat Corrected Milk (100.1 vs 97.8 lb/d; P < 0.08)
Fat Corrected Milk by time interaction (P <0.03)

Ferraretto and Shaver, 2012
http://www.uwex.edu/ces/crops/uwforage/Shredlage-FOF.pdf
Fermentation Acids
Fermentation Acids

pH 3.7 - 4.2
Lactic acid 4-7%
Acetic acid 1-3%
Ethanol 1-3%
Fermentation Acids

**pH 3.7 – 4.2**

- Indicates the acid level of silage.
- Needs to be low for silage to reach the stable phase.
- It does not inform about how fast the stable phase was reached.

**High pH is undesirable and could be explained by:**
- High dry matter silage
- Incomplete fermentation – sampling too early
- Poor packing
- Moldy silages
- Silages containing manure
Fermentation Acids

Lactic acid 4 - 7%
65-70% of total silage acids

- Lactic acid is a strong acid responsible for most of the drop in silage pH.
- A fermentation that produces lactic acid results in the lowest dry matter losses during storage.

Low lactic acid could be explained by:
- High dry matter silage
- Incomplete fermentation – sampling too early
- Poor packing
- Moldy silages
- Silages containing manure
- Aerobic exposure that degrades lactic acid
Fermentation Acids

**Acetic acid 1 – 3 %**

Acetic acid is a less desirable end-product than lactic acid. It is a weaker acid and fails to effectively decrease silage pH. High acetic acid results in silage DM losses and low DM intake (unless by *L. Bucheneri*).

**High acetic acid is undesirable and could be explained by:**
- Wet silages
- Prolonged fermentation:
  - Slow filling
  - Poor packing
Fermentation Profile

**Ethanol 1 – 3 %**

Ethanol indicates excessive metabolism by yeasts.
Dry matter losses are usually greater.
These silages are more prone to aerobic stability problems.

High Ethanol can be explained by:
- Poor packing
- High DM
Microbial Quality
Microbial Quality

Insufficient lactic acid production results in a high silage pH that facilitates the growth of potential pathogenic organisms.

Mold and Yeast
Clostridia
Listeria monocytogenes
Clostridium botulinum
Neospora caninum
Salmonella
Which silage provides the most nutrients based on wet weight?

<table>
<thead>
<tr>
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<th>Silage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>45.4</td>
<td>26.6</td>
</tr>
<tr>
<td>%DM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>2.4</td>
<td>5.1</td>
</tr>
<tr>
<td>Starch</td>
<td>45.7</td>
<td>21.5</td>
</tr>
<tr>
<td>NDF</td>
<td>26.9</td>
<td>47.6</td>
</tr>
<tr>
<td>NDFD</td>
<td>41.1</td>
<td>45.4</td>
</tr>
<tr>
<td>CP</td>
<td>7.9</td>
<td>8.8</td>
</tr>
<tr>
<td>Fat</td>
<td>3.5</td>
<td>2.4</td>
</tr>
</tbody>
</table>
Microbial Quality - Yeast

High when > $10^6$ CFU of yeast per gr of silage (ethanol, alcohols, CO2, VFA, lactate)

48% in CA
65% in WI

(Dairyland Lab WI, 2007-2009)
Microbial Quality - Molds

High when $>10^6$ CFU of mold per gr of silage (decreases palatability, poor dry matter recovery)

18% in CA
30% in WI

(Dairyland Lab WI, 2007-2009)
Penicillium, Fusarium and Aspergillus are mycotoxin producers.

(Dairyland Lab WI, 2007-2009)
How can we integrate all this information?
MILK2006, University of Wisconsin
Index method to estimate milk production from corn silage based on crop yield and nutrient availability

Pricing corn silage, University of Minnesota
Corn silage price adjusted by starch and NDFD

Pricing corn silage, University of Wisconsin
Spreadsheet to calculate corn silage price
Determines a value with an average of NDF and Lab NDFD. For example, the average NDF is 59 and the lab NDFD is 48.

2-Inputs for assays to calculate starch digestibility

Starch digestibility is a calculated value with minimum set at 0.76 and maximum set at 0.98. If available and desired, either Kernel Processing Score (KPS), Degree of Starch Access (DSA),
**MILK2006**

**University of Wisconsin Corn Silage Evaluation System**

Randy Shaver, Dept. of Dairy Science  
Patrick Hoffman, Dept. of Dairy Science  
Joe Lauer, Dept. of Agronomy  
Jim Coors, Dept. of Agronomy

Sample values entered here must correspond to lab average and incubation time information entered in "UserInputGuide" Worksheet cells G25 and G27.

<table>
<thead>
<tr>
<th>Field ID</th>
<th>Lab ID</th>
<th>Kernel Processed</th>
<th>KPS</th>
<th>DSA</th>
<th>IS-IV</th>
<th>DM %</th>
<th>CP % DM</th>
<th>NDF % DM</th>
<th>NDFD % DM</th>
<th>Starch % DM</th>
<th>Ash % DM</th>
<th>Fat % DM</th>
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Kernel processed
# Starch Digestibility

The image shows a spreadsheet titled "University of Wisconsin Corn Silage Evaluation System." It contains data related to corn silage analysis, including fields, lab IDs, kernel processed, and various nutritional values such as DM, CP, NDF, NDFD, and Starch. The spreadsheet is used for inputting data and calculating various outputs. The note on the spreadsheet indicates that sample values entered must correspond to lab averages and incubation time information entered in "UserInputGuide" worksheet cells G25 and G27.

The spreadsheet includes columns for Field ID, Lab ID, Kernel Processed, and other nutritional values. The table structure is as follows:

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The bottom of the image highlights the term "Starch Digestibility."
# MILK2006

## University of Wisconsin Corn Silage Evaluation System

### Randy Shaver, Dept. of Dairy Science
### Patrick Hoffman, Dept. of Dairy Science
### Joe Lauer, Dept. of Agronomy
### Jim Coors, Dept. of Agronomy

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**DM**
### University of Wisconsin Corn Silage Evaluation System

**Randy Shaver, Dept. of Dairy Science**  
**Patrick Hoffman, Dept. of Dairy Science**  
**Joe Lauer, Dept. of Agronomy**  
**Jim Coors, Dept. of Agronomy**

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### University of Wisconsin Corn Silage Evaluation System

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**NDF**
# University of Wisconsin Corn Silage Evaluation System

**Milk 2006**

**Randy Shaver, Dept. of Dairy Science**  
**Patrick Hoffman, Dept. of Dairy Science**  
**Joe Lauer, Dept. of Agronomy**  
**Jim Coons, Dept. of Agronomy**

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**Optional Starch Digestibility Tests**

- DM %
- CP %
- NDF %
- NDFD %
- Starch %
- Ash %
- Fat %

**Critical Data Entry**

Sample values entered here must correspond to lab average and incubation time information entered in "UserInputGuide" Worksheet cells G25 and G27.

**Calculated**

- TDN-1x % DM
- NE\textsubscript{L}-3x Mcal/lb DM
- Milk per Ton Index
- Milk per Acre Index

---

**NDFD**
### University of Wisconsin Corn Silage Evaluation System

**Milk 2006**  
Randy Shaver, Dept. of Dairy Science  
Patrick Hoffman, Dept. of Dairy Science  
Joe Lauer, Dept. of Agronomy  
Jim Coors, Dept. of Agronomy

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#### Optional Starch Digestibility Tests
- Lab Value: 76.6, 0.73, 3546, 24822
- Calculated: #VALUE!, #VALUE!, #VALUE!, #VALUE!

#### Calculated Outputs
- TDN-1×: 76.6, 0.73, 3546, 24822
- Milk per Ton Index: 3248, 22735
- Milk per Acre Index: #VALUE!, #VALUE!, #VALUE!, #VALUE!
# University of Wisconsin Corn Silage Evaluation System

Randy Shaver, Dept. of Dairy Science  
Patrick Hoffman, Dept. of Dairy Science  
Joe Lauer, Dept. of Agronomy  
Jim Coors, Dept. of Agronomy

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Sample values entered here must correspond to lab average and incubation time information entered in "UserInputGuide" worksheet cells G25 and G27.

## Ash

- Ash % DM
- Ash % DM

Additional columns include:
- TDN-1x % DM
- NEI-3x % DM
- Moa/llb DM
- Milk per Ton Index
- Milk per Acre Index
- Milk per lb Index

Calculated values are shown in the corresponding columns.
# University of Wisconsin Corn Silage Evaluation System

Randy Shaver, Dept. of Dairy Science  
Patrick Hoffman, Dept. of Dairy Science  
Joe Lauer, Dept. of Agronomy  
Jim Coors, Dept. of Agronomy

**Optional Starch Digestibility Tests**

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**Field Measure**

- TDN 1x % DM
- NE_{l-3x} % DM
- Mecal/lb DM
- Milk per Ton Index
- Milk per Acre Index

**Critical Data Entry**
- Required Inputs
- Calculated Outputs

*Sample values entered here must correspond to lab average and incubation time information entered in "UserInputGuide" Worksheet cells G25 and G27.*

Fat
### University of Wisconsin Corn Silage Evaluation System

**MILK2006**

**Randy Shaver, Dept. of Dairy Science**

**Patrick Hoffman, Dept. of Dairy Science**

**Joe Lauer, Dept. of Agronomy**

**Jim Coors, Dept. of Agronomy**

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**Tons/acre**
### University of Wisconsin Corn Silage Evaluation System

**Milk 2006**

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Jim Coors, Dept. of Agronomy

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- **TDN**: Total Digestible Nutrients
- **NEI**: Net Energy for Intrauterine Growth
- **Milk per Ton**: Milk production per ton of feed
- **Milk per Acre**: Milk production per acre of feed

---

**MILK2006**

**TDN**  
**NEI**  
**Milk per Ton**  
**Milk per Acre**
It is very useful to compare hybrids because it combines silage yield and nutrient composition of the crop.

The information on the energy value of the crop is only as good as the input that is entered into the spreadsheet calculation.
Traditionally, corn silage price was calculated as:

\[
7-10 \times \text{bushel} \quad \text{price of a ton of corn} \\
\text{price of corn} \quad \text{silage at 35\% DM}
\]

**New Approach:** gives value to starch and fiber content (Linn, 2002).

**Base Price + Starch Adjustment + NDFd Adjustment**

**Starch adjustment**
\[
(\% \text{starch} - 29\%) \times (0.5 \text{ bu/starch}) \times (\text{corn price } \$/\text{bu})
\]

**NDFD adjustment**
\[
(\% \text{NDFd}) \times (0.6 \text{ lb milk/NDFd}) \times (\text{milk price } \$/\text{lb})
\]
Starch Adjustment = ((% starch (DM basis) – 29%) x .5 bushels) x corn $/bushel
Example - 26% starch and corn price of $2.40/bushel
Adjustment = ((26 – 29) x 0.5) x $2.40 = -$3.60/ton silage DM

NDF digestibility Adjustment
Example 59% NDF digestibility (48 hour in vitro) and milk at $13.50/cwt
Adjustment = 59% x .6 x .1350 = $4.78/ton silage DM

Base price - established based on planting, seed, agronomic and harvest costs
Example - $20/ton at 33% DM = $60.60/ton DM

$/ton of corn silage DM = Base + Starch Adjustment + NDF dig Adjustment.
= $60.60 + (-$3.60) + $4.78
= $61.78/ton DM or $20.39/ ton at 33% DM
Animals do no require feeds but the nutrients within that fed. The value of a feed should be calculated based on the nutrients that it contains.

**Hedonic price**
The unit price of nutrients within a feedstuff is calculated based on the commodity prices in a given market.
The feeding value of the forage standing in the field may not correlate with the ensiled forage.

Animal acceptability and production performance is related to multiple factors: nutrient content, nutrient digestibility, physical form, quality of fermentation and microbial quality.
Questions?

Silage pit in the Central Valley (late 1930’s)
Photo Courtesy of Alan George, retired UCCE Farm Advisor in Tulare County