Forage Storage: Life after Harvest
Michelle Chang-Der Bedrosian, PhD
Forage Technical Specialist

Outline
• What happens during storage?
• How can we use storage to make milk?
• When storage goes wrong!

How to Get It Right
• Start with the right harvest conditions
• Use the best inoculant possible
• Pack until you have achieved the right density
• Cover perfectly
• Good storage is key

Phases of Ensiling:
- **Aerobic Phase**: Begins once the silo is covered and oxygen is gone; Also known as “spoilage”
  • Crop is still respiring, using sugars and proteins
  • Aerobic bacteria are alive and well, and they use sugars and protein; produce heat
  • Fermentation cannot begin until oxygen is gone
- **Anaerobic Phase**: Begins once the silo is covered and oxygen is gone; Continues so long as oxygen is absent
- **Feedout**: Oxygen

Aerobic Phase

Anaerobic Phase

Feedout

Oxygen

pH

Acids
Stored silage may look stagnant...

Effect of Storage Time on the pH of Corn Silage

Changes in pH reflect changes in lactic acid

Fiber digestibility doesn’t change during storage

Starch digestibility increases during storage
Effect of Days of Ensiling on Starch Digestion in Corn Silage

What does starch mean to the cow?

- A rich source of energy for production and metabolism (substrates for VFA and therefore energy for milk production)
- Provides energy for microbial metabolism
- However, rapidly fermentable, so holds potential to decrease rumen pH quickly

How does starch decrease pH?

- Starch → Lactic acid, propionic acid, other acids
- VFA decreases pH
Starch Digestion in Ruminants

- **Rumen**
  - Microbial Fermentation
  - VFA
  - Propionate
  - Glucose via liver
  - Microbial Protein

- **Small Intestine**
  - Microbial Fermentation
  - VFA
  - Less Efficient

- **Hind Gut**
  - Microbial Fermentation
  - VFA
  - Glucose
  - Microbial Protein

Microbial Fermentation

- **VFA**
- **Propionate**
- **Glucose via liver**
- **Microbial Protein**

Digestion (Enzymatic)

- **Glucose**
- **Less Efficient**

**Greater Proportion of Starch Digested in the Rumen**

<table>
<thead>
<tr>
<th>Potential Advantages</th>
<th>Potential Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>More energy from VFA</td>
<td>Low rumen pH issues</td>
</tr>
<tr>
<td>Microbial protein</td>
<td>Acidosis</td>
</tr>
<tr>
<td>Greater TTStarch-D</td>
<td>DMI</td>
</tr>
<tr>
<td>More energy for the cow</td>
<td>Fiber digestion</td>
</tr>
<tr>
<td></td>
<td>Decreased Fat %</td>
</tr>
<tr>
<td></td>
<td>Laminitis</td>
</tr>
</tbody>
</table>

**Potential Advantages**
- More energy from VFA
- Microbial protein
- Greater TTStarch-D
- More energy for the cow

**Potential Disadvantages**
- Low rumen pH issues
- Acidosis
- DMI
- Fiber digestion
- Decreased Fat %
- Laminitis

**Greater Proportion of Starch Digested in Small Intestine**

<table>
<thead>
<tr>
<th>Potential Advantages</th>
<th>Potential Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>More energetic efficiencies</td>
<td>Less microbial protein</td>
</tr>
<tr>
<td>Performance benefits hard to document</td>
<td>Reduced total tract starch digestion or total energy</td>
</tr>
<tr>
<td>Glucose use by gut tissue</td>
<td></td>
</tr>
<tr>
<td>Less rumen pH issues</td>
<td></td>
</tr>
</tbody>
</table>

**Potential Advantages**
- More energetic efficiencies
- Performance benefits hard to document
- Glucose use by gut tissue
- Less rumen pH issues

**Potential Disadvantages**
- Less microbial protein
- Reduced total tract starch digestion or total energy

**We are actually feeding rumen bacteria**

- Starch must be accessible by bacteria in the rumen
  - Pericarp
  - Protein/starch matrix

- Factors that limit the access to starch
  - Pericarp
  - Protein/starch matrix
**The Protein/Starch Matrix**

- Starch must be accessible by bacteria in the rumen
- Factors that limit the access to starch:
  - Pericarp
  - Prolamin/starch matrix
- Starch is embedded in a prolamin protein matrix that hinders access to starch
- The amount and complexity of this prolamin protein matrix increases with maturity and varies with hybrid
- Starch-D decreases 0.86 percentage units for each unit increase in prolamin protein content (as a percent of starch)

**There is a Strong Correlation Between Soluble Protein and Starch-D**

Der Bedrosian et al., 2012

**Proteolysis of the Protein/Starch Matrix During Storage Results in Increases in Starch-D**

Prior to ensiling  
After 240 d of ensiling

**Starch Digestibility vs Sol CP—General Benchmarks**

<table>
<thead>
<tr>
<th>Soluble CP, % of CP</th>
<th>Kernel Protein Status</th>
<th>Starch Digestion Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 30 %</td>
<td>Minimal Degradation</td>
<td>Slow</td>
</tr>
<tr>
<td>30-40 %</td>
<td>Protein Degradation Starting</td>
<td>Slow-Moderate</td>
</tr>
<tr>
<td>40-50 %</td>
<td>Moderate Protein Degradation</td>
<td>Moderate</td>
</tr>
<tr>
<td>50-60 %</td>
<td>Extensive Protein Degradation</td>
<td>Moderate-Fast</td>
</tr>
<tr>
<td>60 %</td>
<td>Proteins Degraded</td>
<td>Fast</td>
</tr>
<tr>
<td>&gt; 70 %</td>
<td>Proteins Fully Degraded</td>
<td>Fast</td>
</tr>
</tbody>
</table>

Corn Silage
Starch Digestion Rates (kd) are a function of surface area.

Starch surface area is altered by:
1. Mechanical reduction
2. Particle Decay

2 - Fermentation = Particle Decay

1. Mechanical processing (MPS) = i.e. Kernel processing

2. Particle Decay

Particle Decay – Electron Microscope [Hoffman et al., 2010]
In Summary, have the conversation:

**What is the minimum amount of time to store silage before feeding?**

- Corn Silage: 3 months
- Alfalfa Silage: 3 weeks

Where will you put the new feed to ensure there is 3-4 months of carryover?

Time of storage is more important than processing score.

Check the silo for holes... Kung, 2004
Feed out with only one face...

Keep Plastic Down at the Feeding Face

Thank you!