Keys to making Quality Silage

Dr. Noah Litherland
Dairy Extension Specialist
Oklahoma State University
(405) 744-6058
noah.litherland@okstate.edu
Today’s Discussion

• Principles of silage making
• Quality control measures
• Evaluation Methods
• 11 steps to making good silage and making your silage pay ($)
Ensiling is a method of feed preservation....

- Which is based on removal of oxygen
- To promote fermentation of sugars into lactic acid by lactic-acid bacteria
- Causing an increase in acidity (a ↓ in pH)
- Which inhibits further silage degradation by:
  - Plant enzymes
  - Undesirable bacterial species (clostridia, yeast and mold)
4-Stages Fermentation Process

1. Aerobic fermentation (pre-seal and days following post-seal)
2. Anaerobic fermentation
3. Storage (stable phase)
4. Feed out (ready after ~ 30 days)
Fermentation

1. **Aerobic Stage**
   - Aerobic bacteria/plants use up oxygen, release CO₂ and H₂O, temp rises
   - Anaerobic conditions are established and additional sugars produced from starch hydrolysis
Fermentation

2. **Anaerobic Stage**
   - Lactic acid bacteria ferment sugars and produce organic acids (lactic acid)
   - pH is reduced to ~ 4.2
3. Storage Phase

- Temps stabilize, and bacteria continue to produce lactic acid (10-30 d)
- Production of hazardous silo gases (NO₂)
Fermentation

4. **Feed out**
   - Should be quick and efficient
   - Silage additives like acetic or propionic acid can be used to reduce decomposition
<table>
<thead>
<tr>
<th><strong>Silage Statistics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry matter content</strong></td>
<td>32-42%</td>
</tr>
<tr>
<td><strong>Moisture content</strong></td>
<td>68-58%</td>
</tr>
<tr>
<td><strong>Length of cut</strong></td>
<td>¼ - ¾ inch</td>
</tr>
<tr>
<td><strong>Time required for fermentation</strong></td>
<td>21 days</td>
</tr>
<tr>
<td><strong>Density in upright silo</strong></td>
<td>40-45 lbs/cu ft</td>
</tr>
<tr>
<td><strong>Density in wagon, freshly chopped</strong></td>
<td>20-25 lbs/cu ft</td>
</tr>
</tbody>
</table>
Silage bags

Corn Silage Bunker

Upright Silo
Correct Moisture and Silo Type

- Recommended moisture content for corn silage.

<table>
<thead>
<tr>
<th>Structure</th>
<th>% Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunker/ Pile</td>
<td>65-70</td>
</tr>
<tr>
<td>Bag</td>
<td>60-70</td>
</tr>
<tr>
<td>Upright Concrete</td>
<td>62-67</td>
</tr>
<tr>
<td>Upright O$_2$ Limiting</td>
<td>50-60</td>
</tr>
</tbody>
</table>
Importance of Correct Moisture

- **Too Wet** (< 70% moisture)
  - Seepage
  - Clostridial fermentation
  - Higher pH and greater DM losses
Importance of Correct Moisture

• **Too Dry**
  – Results in poor packing
  – Poor fermentation and heating
  – Greater spoilage and poor bunk life
  – Lower starch and fiber digestibility
Harvest at 35% Dry Matter
"Grab Test” to Determine the DM Content of Forages

<table>
<thead>
<tr>
<th>Description of Forage Ball</th>
<th>Approximate DM Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holds its shape but has considerable free juice</td>
<td>Less than 25%</td>
</tr>
<tr>
<td>Holds its shape Hand is moist There is little free juice</td>
<td>25-30%</td>
</tr>
<tr>
<td>Expands slowly, with no free juice</td>
<td>30-40%</td>
</tr>
<tr>
<td>Springs out and falls apart rapidly</td>
<td>More than 40%</td>
</tr>
</tbody>
</table>
### Chemical comp, and buffering capacity of typical forages

<table>
<thead>
<tr>
<th></th>
<th>Water Soluble CHO</th>
<th>Crude protein (% DM)</th>
<th>Ration wsc/cp</th>
<th>Buffering capacity (mEq/kg DM)</th>
<th>“Aptitude” for silage preservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>80-300</td>
<td>80-100</td>
<td>1.0-3.0</td>
<td>150-300</td>
<td>High</td>
</tr>
<tr>
<td>Grasses</td>
<td>35-300</td>
<td>100-160</td>
<td>0.4-1.8</td>
<td>250-550</td>
<td>Intermediate</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>20-150</td>
<td>140-200</td>
<td>0.1-0.75</td>
<td>350-650</td>
<td>Low</td>
</tr>
</tbody>
</table>
Fermentation Analysis: A Tool for Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Corn Silage (30-40%)</th>
<th>Legume Silage (45-55%)</th>
<th>Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>3.7 – 4.2</td>
<td>4.7 – 5.0</td>
<td>Lower is 😊</td>
</tr>
<tr>
<td>Lactic Acid (%)</td>
<td>4 – 7</td>
<td>2 – 4</td>
<td>Higher is 😊</td>
</tr>
<tr>
<td>Acetic Acid (%)</td>
<td>1 – 3</td>
<td>0.5 – 2.0</td>
<td>Lower is 😊</td>
</tr>
<tr>
<td>Propionic acid (%)</td>
<td>&lt;0.1</td>
<td>&lt;0.1</td>
<td>Lower is 😊</td>
</tr>
<tr>
<td>Butyric acid (%)</td>
<td>0</td>
<td>0</td>
<td>Lower is 😊</td>
</tr>
<tr>
<td>Ethanol (%)</td>
<td>0.2 – 2.0</td>
<td>0.5</td>
<td>Lower is 😊</td>
</tr>
<tr>
<td>Ammonia-N (% of CP)</td>
<td>&lt;10</td>
<td>&lt;12</td>
<td>Lower is 😊</td>
</tr>
</tbody>
</table>
Commercial Forage Testing Labs Performing Fermentation Analysis

Cumberland Valley Analytical Services
Maugansville, Maryland
Contact: Ralph Ward (301) 790-1980

Dairy One
Ithaca, New York
Contact: Paul Sirois (607) 257-1272

Rock River Laboratories
Watertown, Wisconsin
Contact: Don Meyer (920) 261-0446

Dairyland Laboratories
Arcadia, Wisconsin
Contact Dave Taysom (608) 323-2123
Mycotoxin Risks in Dairy Cattle

What’s Really in this stuff?
Spoiled Silage Reduced intake and Digestibility in Steers

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>75:25</th>
<th>50:50</th>
<th>25:75</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM intake (lb/day)</td>
<td>17.5</td>
<td>16.2</td>
<td>15.3</td>
<td>14.7</td>
</tr>
<tr>
<td>OM digestibility (%)</td>
<td>75.6</td>
<td>70.6</td>
<td>69.0</td>
<td>67.8</td>
</tr>
<tr>
<td>CP digestibility (%)</td>
<td>74.6</td>
<td>70.5</td>
<td>68.0</td>
<td>62.8</td>
</tr>
<tr>
<td>NDF digestibility (%)</td>
<td>63.2</td>
<td>56.0</td>
<td>52.5</td>
<td>52.3</td>
</tr>
</tbody>
</table>
Mycotoxin Contaminated Feeds

• Drought and heat stressed grain crops are susceptible.
• May lead to animal health risks.
• Include:
  – Aflatoxin
    • Legal limit in milk of 0.5 ppb
    • At risk if total ration DM > 20 ppb
  – Zearalenone
  – T-2
  – Deoxynivalenol (DON)
If You Feed This Stuff Expect

• Reduced feed intake or feed refusal
  – Poor performance
• Reduced nutrient absorption and impaired nutrient metabolism
  – Poor growth
• Altered hormonal levels
  – Reduced reproduction
• Suppressed immune system
  – Increased health risk to disease
• Depressed rumen fermentation
  – Lower digestion and feed efficiency
Mycotic Abortion

• Caused by mycotoxins
  – ~3-10% of all abortions (?)

• Toxins in moldy feed enter the bloodstream and the pregnant uterus
  – Abortions and infertility may result if the “toxic elements” infect the placenta
  – Thickening of the cotyledon/caruncal junction
Solutions?

• **Add a mycotoxin binder**
  – Clay (bentonite)
  – Indigestible CHO

• **Test feeds regularly**
  – Difficult to obtain a “good” sample
  – Commercial lab or *Reveal* for Alflatoxin

• **If you must use contaminated feed…**
  – Blend with high quality feed
Top 11 Ways to Improve Silage Quality

1. **Harvest at the right time**
   a. Cut in the morning if conditions are wet
   b. Cut in the afternoon if drying conditions are good (harvest the next day)
   c. Afternoon mowing produces the lowest pH in alfalfa
   d. Harvest at one-third to one-half milk line
   e. Dry matter of 30-36%
   f. Kernels should be soft
   g. Consider kernel processing (breaks cobs)
Top 11 Ways to Improve Silage Quality

2. Use a conditioning mower to increase drying in the field
Top 11 Ways to Improve Silage Quality

3. Ensile the forage when it has the proper moisture content (35% DM)

• 30 - 40% for bunker silos
• 35 - 50% for tower silos
• 40 - 50% for wrapped round bales
Top 11 Ways to Improve Silage Quality

4. Correct setting on chopper knives
   • TLC (Theoretical Length of Cut)
   • Enhances sugar availability for fermentation.
   • Facilitates silo compaction!!
   • At least 20% of the particles should exceed 1” in length to ensure effective fiber
Particle Size Guidelines

- Penn State Shaker Box
  Corn silage ¼ to 3/8” TLC
  Top <5
  Middle >50
  Bottom <50
  Haylage
  Top >20
  Middle >40
  Bottom <40
Top 11 Ways to Improve Silage Quality

5. Filling a silo should be a continuous process with delays no longer than overnight.
   • The last load of the day should be packed particularly well to reduced oxygen penetration overnight.
Top 11 Ways to Improve Silage Quality

6. Avoid contamination of the silage mass from soil.
   • Avoid mud or manure on tires from packing tractor (tends to contain high levels of clostridia)
   • Watch the height of cut
     – Especially true for drought years
Top 11 Ways to Improve Silage Quality

7. Pack the silage as much as possible to expel oxygen and favor growth of lactic acid bacteria.

**Thumbrule:** packing density should be 50-60 lb/ft³
Densely Packed Silo in Southern Oklahoma
Spoilage on the Edge Due To Poor Compaction
Top 11 Ways to Improve Silage Quality

8. Judiciously use additives to improve fermentation

- **Four categories:**
  - Bacterial inoculants (lactic-acid producers)
  - Enzymes (Digest fiber and provide substrate)
  - Substrates sources (energy for lactic acid bacteria)
  - Inhibitors (acids that sterilize silage)
Silage Inoculants

- Improve fermentation
- Achieve a lower pH more quickly
- Minimizes secondary fermentation at feed out
- Apply while chopping or at bagging

**Rule of thumb:**
- Need 90 billion live lactic acid bacteria per ton of forage.
9. Properly Seal the Silo!!!!!
   • Prevents oxygen from entering
   • Encourages proper fermentation
   • Prevents loss of dry matter
   • Minimizes risk of mold, yeast, and bad bacteria (clostridium)
   • Properly covering is worth $60-100/h
Covering Bunker Silos

• Polyethylene Sheet (6 mil) or thicker
• Suck the air out? (shrink wrap)
• Weight the plastic down with 20-25 tires per 100ft$^2$ of surface area.
• Weight down edges
• Seal up holes (check frequently)
Well Covered Bunker
**Covered Vs. Uncovered Average Losses and Quality Changes**

<table>
<thead>
<tr>
<th></th>
<th>Temp (°C)</th>
<th>DM Loss (%)</th>
<th>pH</th>
<th>Lactic acid (% DM)</th>
<th>CP (% DM)</th>
<th>ADF (% DM)</th>
<th>SP (%CP)</th>
<th>ADIP (% CP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covered</td>
<td>36.7</td>
<td>4</td>
<td>4.9</td>
<td>3.2</td>
<td>21</td>
<td>39</td>
<td>20</td>
<td>28</td>
</tr>
<tr>
<td>Uncovered</td>
<td>53.9</td>
<td>32</td>
<td>6.8</td>
<td>1.7</td>
<td>22</td>
<td>47</td>
<td>16</td>
<td>37</td>
</tr>
</tbody>
</table>
Top 11 Ways to Improve Silage Quality

10. Allow fermentation to take place
   • Do not open the silo for at least 3-4 weeks
   • Allow for fermentation to reach its stabilization phase.
“New” Silage Slump

- Cows do not perform as well as expected.
- **Attributed to:**
  - Reduced starch digestibility
  - Hard and dry kernels in unprocessed silage
  - Problem resolves itself as kernels have a chance to absorb silage moisture
Top 11 Ways to Improve Silage Quality

11. Keep the face fresh and clean
   • Remove 4 to 8 inches of silage daily
     – So the rate of dry matter removal is greater than the rate of oxygen penetration at the face
     – Helps to have the right size bunker!
Notice the Clean Bunker Face
Take home Messages

- Need correct TLC ¼ to 3/8 chop
- Need correct moisture (35%)
- Ensile quickly
- Pack until your sick of it...then pack some more!
- Cover the bunker or you’ll be sorry!
- Keep the face clean at feed out
- http://agebb.missouri.edu/dairy/feed/index.htm
### Capacity of Corn Silage in Trench or Bunker Silos

<table>
<thead>
<tr>
<th>Bottom Width (ft)</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>16</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>3.1</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>4.6</td>
<td>5.9</td>
<td>7.1</td>
<td>9.6</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>6.1</td>
<td>7.7</td>
<td>9.3</td>
<td>12.6</td>
<td>16.0</td>
</tr>
<tr>
<td>50</td>
<td>7.6</td>
<td>9.6</td>
<td>11.6</td>
<td>15.6</td>
<td>19.8</td>
</tr>
<tr>
<td>60</td>
<td>11.5</td>
<td>13.8</td>
<td>18.6</td>
<td>23.6</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
<td>16.1</td>
<td>21.6</td>
<td>27.4</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
<td>18.3</td>
<td>24.6</td>
<td>31.0</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
<td>30.6</td>
<td>38.6</td>
<td></td>
</tr>
</tbody>
</table>