Inoculants for improving the preservation of corn and Bermudagrass forages

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IFAS

UNIVERSITY of FLORIDA
The Foundation for The Gator Nation
# Haylage / Silage Production Phases

<table>
<thead>
<tr>
<th></th>
<th>Before fermentation</th>
<th>Fermentation (front end)</th>
<th>Feedout (Back end)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Activity</strong></td>
<td>Cutting &amp; packing or baling</td>
<td>Storage of silage</td>
<td>Opening &amp; feeding</td>
</tr>
<tr>
<td><strong>Oxygen status</strong></td>
<td>Present</td>
<td>Absent (minimal)</td>
<td>Present</td>
</tr>
<tr>
<td><strong>Processes</strong></td>
<td>Plant respiration</td>
<td>Sugar fermentation (acids produced decrease pH)</td>
<td>Aerobic spoilage by molds and yeasts</td>
</tr>
<tr>
<td><strong>Problems</strong></td>
<td>Nutrient losses</td>
<td>Shrinkage (DM losses)</td>
<td>Heating</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Rapidly exclude oxygen from forage</td>
<td>Prevent oxygen entry into bunker/bale</td>
<td>Minimize oxygen entry</td>
</tr>
<tr>
<td><strong>Methods</strong></td>
<td>Pack well and cover or wrap promptly</td>
<td>Check for and seal holes</td>
<td>Feedout rapidly, maintain silo face</td>
</tr>
</tbody>
</table>
Silage bacteria battle

- Major ‘germ’ warfare occurs during ensiling

- **GOOD GUYS** vs. **BAD GUYS**
  - Homofermenters
  - Heterofermenters
  - Yeasts, Molds, Clostridia
## Types of Fermentation

<table>
<thead>
<tr>
<th>Type</th>
<th>Substrate (Microbe)</th>
<th>Product</th>
<th>Nutrient Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homo-fermentative</td>
<td>Glucose (L. plantarum)</td>
<td>2 x Lactic acid</td>
<td>Very Low</td>
</tr>
<tr>
<td>Hetero-fermentative</td>
<td>Glucose (L. buchneri)</td>
<td>1 x Lactic &amp; acetic acids, ethanol &amp; CO₂</td>
<td>Low</td>
</tr>
<tr>
<td>Secondary fermentation</td>
<td>Lactic acid (Clostridia)</td>
<td>Butyric acid + CO₂</td>
<td>High</td>
</tr>
<tr>
<td>Aerobic spoilage</td>
<td>Glucose, lactic acid (Yeasts &amp; molds)</td>
<td>Ethanol, CO₂</td>
<td>V. high</td>
</tr>
</tbody>
</table>
Poor fermentation causes

- DM, energy, and gas losses (wasted $$$$)
- Protein degradation
- Production of hazardous compounds:
  - Oxides of nitrogen
  - Foul smelling, intake depressing butyric silage
  - Toxic biogenic amines
Poor bunk life (aerobic spoilage) causes:

- Shrinkage – DM losses
- Heating by yeasts and molds
- Energy and nutrient losses
- Reduced animal performance
- Diseases (bloody gut, aspergillosis)
- Growth of pathogenic bacteria
- Mycotoxin production
USING INOCULANTS TO IMPROVE SILAGE QUALITY
Inoculants

- **What are they**
  Special bacteria added to dominate the natural plant bacteria population and improve silage quality

- **Types**
  1. *Homolactic* inoculants
  2. *Heterolactic* inoculants
  3. *Combo* inoculants
1. Homolactic inoculants

- Added to improve silage ‘fermentation’
- Typically contain *Lactobacillus plantarum* or *Pediococcus* bacteria
- Increase the acid production rate by fermenting sugars to lactic acid
- Rapidly reduce pH and prevent poor fermentation
- Minimize nutrient, DM and gas losses
Effect of *L. plantarum* (LP) on alfalfa silage

![Graph showing the effect of *L. plantarum* (LP) on alfalfa silage.](image)

- **Lactic acid, %**
- **pH**

**Time (days)**
- 1
- 3
- 5
- 7
- 56
Effect of *L. plantarum* on protein degradation

Control

LP

NH₃-N, % DM

Time (days)

1 3 5 7 56
Effectiveness of homolactic inoculants

(Muck & Kung, 1997)
2. Heterolactic inoculants

- Aim to improve bunk life
- Best ones contain *Lactobacillus buchneri*
- Produce less lactic acid and more acetic acid than homofermenters
- Acetic acid kills yeasts and molds that reduce bunk life
- Hence, *L. buchneri* inoculants improve bunk life
- Others with *Propionibacterium* are less effective
Effect of different inoculants on bunk life (aerobic stability)  
(Ranjit & Kung, 2000)

Aerobic stability (hours)

- Control: 27 hours
- LB - low: 36 hours
- LB - High: >900 hours
- LP - 1: 32.8 hours
- LP - 2: 33 hours
- Store-mate: 38 hours

LB = L. buchneri
LP = L. plantarum
3. Combo inoculants

- Aim to improve fermentation and bunk life

- Contain both:
  - homolactic bacteria
    (e.g. L. plantarum or Pediococcus pentosaceus)
  
  and

  heterolactic bacteria
  (e.g. L. buchneri)
Combo inoculant effects on spoilage organisms (Log cfu/g)

(Critical level that causes spoilage 100,000)

Huisden et al., 2009
Combo inoculant effects on bunk life (hours)

Huisden et al., 2009
Inoculant effects on corn silage made in Ag bags

- **Treatments:**
  - Control
  - Buchneri 500 Combo inoculant (B500)

- Four Ag bags were filled with 35 tons of silage for each treatment

- Measured quality, losses, and heating every week for 5 weeks after bags were opened

Queiroz et al., 2010
Inoculant effects on amounts of good and spoiled silage

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>B500</th>
<th>SE</th>
<th>Treat.</th>
<th>Treat. x time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Good silage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount, lb DM/day</td>
<td>343</td>
<td>352</td>
<td>2.12</td>
<td>0.23</td>
<td>0.65</td>
</tr>
<tr>
<td>Percentage</td>
<td>92.2</td>
<td>96.6</td>
<td>1.08</td>
<td>0.004</td>
<td>0.71</td>
</tr>
<tr>
<td><strong>Spoiled silage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount, lb DM/day</td>
<td>28</td>
<td>12</td>
<td>1.53</td>
<td>0.002</td>
<td>0.49</td>
</tr>
<tr>
<td>Percentage</td>
<td>7.8</td>
<td>3.4</td>
<td>1.08</td>
<td>0.004</td>
<td>0.71</td>
</tr>
</tbody>
</table>
Inoculant effects on nutrient losses in spoiled silage

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Inoculant</th>
<th>SE</th>
<th>Treat</th>
<th>Treat x time</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP lb/day</td>
<td>2.0</td>
<td>0.50</td>
<td>0.20</td>
<td>0.03</td>
<td>0.39</td>
</tr>
<tr>
<td>ADF, lb/day</td>
<td>5.6</td>
<td>1.8</td>
<td>0.54</td>
<td>0.04</td>
<td>0.51</td>
</tr>
<tr>
<td>NDF, lb/day</td>
<td>9.0</td>
<td>3.0</td>
<td>0.88</td>
<td>0.04</td>
<td>0.51</td>
</tr>
<tr>
<td>Ash, lb/day</td>
<td>0.3</td>
<td>0.07</td>
<td>0.03</td>
<td>0.03</td>
<td>0.30</td>
</tr>
<tr>
<td>Gross energy, kcal/day</td>
<td>1842</td>
<td>433</td>
<td>402</td>
<td>0.02</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Queiroz et al., 2010
Inoculant effects on spoilage indicators

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>B500</th>
<th>SE</th>
<th>Treat</th>
<th>Treat. x time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeasts and molds, log cfu/g</td>
<td>4.62</td>
<td>2.59</td>
<td>0.65</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>Average ensiling temp.(°F)</td>
<td>73</td>
<td>72</td>
<td>0.7</td>
<td>0.09</td>
<td>NA</td>
</tr>
<tr>
<td>Bunk life (h)</td>
<td>9.5</td>
<td>14.7</td>
<td>10.6</td>
<td>0.71</td>
<td>0.35</td>
</tr>
<tr>
<td>Silo face temperature (h)</td>
<td>97</td>
<td>95</td>
<td>1.22</td>
<td>3.3</td>
<td>0.99</td>
</tr>
<tr>
<td>Max. aerobic temp (°F)</td>
<td>86</td>
<td>84</td>
<td>3.4</td>
<td>0.52</td>
<td>NA</td>
</tr>
<tr>
<td>Sum of feedout temp. (°F)</td>
<td>129</td>
<td>122</td>
<td>17.2</td>
<td>0.89</td>
<td>NA</td>
</tr>
</tbody>
</table>

Queiroz et al., 2010
## Inoculant effects on spoilage and performance of dairy cows

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>BPII</th>
<th>LB</th>
<th>B500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic stability, h</td>
<td>95.20a</td>
<td>85.13a</td>
<td>177.75b</td>
<td>77.50a</td>
</tr>
<tr>
<td>Spoilage losses, % DM</td>
<td>24.9</td>
<td>27.4</td>
<td>20.2</td>
<td>22.2</td>
</tr>
<tr>
<td>DMI, lb/day</td>
<td>43</td>
<td>46</td>
<td>44.8</td>
<td>43.2</td>
</tr>
<tr>
<td>Milk yield, lb/day</td>
<td>69.0</td>
<td>73.6</td>
<td>74.1</td>
<td>68.6</td>
</tr>
</tbody>
</table>

Arriola et al., 2011
Effect of different inoculants on bermudagrass haylage

- **Treatments**
  - Control
  - Biotal II plus *(combo with Propionibacteria)* *(BPII)*
  - Silage inoculant *(homolactic)* *(SI)*
  - Buchneri 500 *(combo with Buchneri)* *(B500)*
  - Silo King *(homolactic)* *(SK)*

- Each treatment was applied to 8, 900-lb bales

Arriola et al., 2010
Inoculant effects on pH

Arriola et al., 2010

Days ensiled
## Inoculant effects on spoilage organisms in bermudagrass haylage

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>B500</th>
<th>BPII</th>
<th>SI</th>
<th>SK</th>
<th>SEM</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yeast</strong>s, log cfu/g</td>
<td>1.0</td>
<td>1.0</td>
<td>1.2</td>
<td>1.0</td>
<td>1.0</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Molds</strong>s, log cfu/g</td>
<td>4.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.35&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.81&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>2.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.60&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.0</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Clostridia</strong>s, log cfu/g</td>
<td>2.42&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.90&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.81&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.85&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>1.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.4</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Coliforms</strong>s, log cfu/g</td>
<td>1.7</td>
<td>1</td>
<td>1.4</td>
<td>1.7</td>
<td>1.4</td>
<td>0.9</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Arriola et al., 2010
Inoculant effects on bunk life of bermudagrass haylage

Arriola et al., 2010
COMPARISON OF NINE ADDITIVES FOR IMPROVING SILAGE QUALITY.

Queiroz, O.C.M., Arriola, K.G., and Adesogan, A.T.

University of Florida
Animal sciences department
Treatments

1. Control
2. L. plantarum MTD1 (Ecosyl / ADM)
3. L. plantarum PA-28 & K-270 (Biomax 5, Chr Hansen)
4. L. buchneri (Lallemand)
5. Acetic acid bacteria (New)
6. Gluconabacter (New)
7. Sodium benzoate (Chemical)
8. Acid mix (Silage savor, Kemin)
9. L. Plantarum, E. faecium and P. pentosaceus (Siloking, Agri King)
Effect of additives and inoculants on bunk life
Inoculants are also useful for:

- Wet forage
- Rainfall forages at ensiling
- Low sugar forages
- High buffering capacity forages
- High lactate forages (only heterolactics or combo)
- Stressed forage (disease, frost etc)
- Destroying pathogens
- Preventing aflatoxin production in corn

- *Inoculants don’t correct for bad management*
Conclusions

- Different types of inoculants exist.
- Many are only effective on only one phase of silage production.
- Using the wrong inoculant wastes time & money.
- Choose carefully.
Take home messages

- **Know your inoculants:**
  - Use homolactics (e.g. L. plantarum) for fermentation improvement – best for grasses & legumes
  - Use heterolactics (e.g. L. buchneri) for bunk life improvement – suitable for all forages
  - Use combo inoculants for both phases – suitable for all forages

- Use inoculants only for the forages on the label
Take home messages

- Choose inoculants with at least 90 billion live bacteria / ton or 100,000 cfu/g
- Apply inoculants at the chopper, not into wagon or at bunker
- Apply them at ensiling not at feedout
- Store in a cool, dry place before use
- Do not leave inoculants in the sun or on the truck bed
- Use within 24 h after dilution.
Choose inoculants carefully

- Don’t choose by cost (price varies from 40 cents to $2 per ton);

- A 4% loss reduction achieved at least 75% of the time is necessary to breakeven with inoculant costs (Buckmaster and Lundmark, PSU)

- Choose based on efficacy in independent tests