Silage inoculants affect animal performance as well as crop fermentation

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Inoculants

- Silage additives whose main ingredients are lactic acid bacteria
Purpose of Inoculants

- Lactic acid bacteria are the group of bacteria that ferment sugars in the crop and help preserve it.
- Help insure that the fermentation goes in the direction that you want it.
Different Types of Inoculants

- Traditional homofermentative types:
  - *Lactobacillus plantarum*, *L. casei*, *Pediococcus* species, *Enterococcus faecium*
  - *Lactobacillus buchneri*, a heterofermenter
  - Combination of homofermenters with *L. buchneri*
Scope of Talk

- What does a homofermentative silage inoculant do?
- Why are effects of inoculants on milk production important?
- Is there a good explanation as to why an inoculant would increase milk production?
Homofermenter vs. Heterofermenter

- **Homofermenter**
  1 6-C Sugar $\rightarrow$ 2 Lactic Acid

- **Heterofermenter**
  1 6-C Sugar $\rightarrow$ 1 Lactic Acid + 1 Acetic Acid + CO$_2$
  1 6-C Sugar $\rightarrow$ 1 Lactic Acid + 1 Ethanol + CO$_2$
  1 Lactic Acid $\rightarrow$ 1 Acetic Acid + CO$_2$ (*L. buchneri*, not all heteros)
End Product Comparison

- Lactic acid - strong acid; weak spoilage inhibitor; fermented in rumen
- Acetic acid - weak acid; good spoilage inhibitor; not fermented in rumen
- Ethanol - neutral; poor spoilage inhibitor; partially fermented in rumen
- Carbon dioxide - lost dry matter
So…

- If you want to preserve crop quality:
  - Lactic acid

- If you want a silage that doesn’t heat:
  - Acetic acid

- In any case, you want to minimize ethanol, $\text{CO}_2$
Homofermentative Inoculants - Expectations

- High lactic acid content, low other products
- Low pH
- Improved DM recovery
- Slightly better animal performance
Homofermentative Silage Inoculants - Results

**pH**

- Lower but not all the time
- Works more often in hay crop than whole-grain silages

(Muck and Kung, 1997)
Why Don’t These Inoculants Always Work?

- Some products may be ineffective or misapplied
- It may be difficult to improve on the natural fermentation; e.g., corn silage
- Competition from the natural population
  - If inoculant population < 10% natural LAB, less likely the inoculant will work.
Natural LAB Populations

- Corn silage
  - Tends to have high natural population
- Alfalfa
  - Tends to have low natural population
Homofermentative Silage Inoculants - Results

Dry Matter Recovery

- Improved 38% of trials (Muck and Kung, 1997)
- Improvement when successful: 6%
- On average, 2-3% improvement
Homofermentative Silage Inoculants - Results

Bunk Life/Aerobic Stability

- Positive in hay crop silages
- Reductions largely in corn and small grain silages

Aerobic Stability in All Silages as Affected by Inoculants

(Muck and Kung, 1997)
Reasons for Aerobic Stability Differences

- **Aerobic stability**
  - Improved by lower pH
  - Reduced by decreasing acetic acid

- **Hay crop silages**
  - Lower pH from inoculants offsets reductions in acetic acid

- **Corn silage**
  - Little reduction in pH possible so loss of acetic acid by inoculants could reduce stability
Homofermentative Silage Inoculants - Results

Animal Performance

- Typical improvements when worked: 3 to 5%

(Muck and Kung, 1997)
Homofermentative Silage Inoculants – ROI

- Improved DM recovery, 2-3% on average
  - Treat 1000 tons as fed: $1000
  - Save 25 tons as fed
  - If each ton saved is worth $40 or more, you break even.

- Improved animal performance 3-5% when effective
  - Assume 3 lbs. milk/cow/day when effective
  - If effective 50% of the time, 1.5 lbs. milk/cow/day
  - With milk at $16 per 100 lbs., $0.24 extra income/cow/day
  - If cow is eating 60 lbs. silage as fed/day, then inoculant cost is $0.03/cow/day.
Bottom Line on ROI from a Homofermentative Inoculant

- If inoculant only improves DM recovery, you will at least breakeven and most likely make a small profit.

- If the inoculant improves milk production, you will get a big return on your investment.
So…

- How can a homofermentative inoculant improve milk production by 2 to 3 lbs. per cow per day?

- Can we expect all homofermentative inoculants to improve milk production that much?
Do Inoculants Improve *In Vitro* Dry Matter Digestibility?

They didn’t in two alfalfa silage trials that we ran, but…
Gas Production: Lower on Some Inoculants Than Predicted

```
<table>
<thead>
<tr>
<th>Control</th>
<th>Homo. Inoculants</th>
<th>Homo. Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y = 205 X/258</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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Attachment: Graph showing Actual Gas vs. Predicted Gas for different inoculants. The graph includes a linear equation line Y = 205 X/258.
Main Products of Rumen Fermentation

- Rumen Microbes
- Volatile Fatty Acids
- Gases ($\text{CO}_2$, $\text{CH}_4$)
Main Products of Rumen Fermentation

Rumen Microbes

Volatile Fatty Acids

Gases (CO$_2$, CH$_4$)

Untreated?

Inoculated?
### In Vitro Microbial Biomass Production from Lab Silages

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Rumen Microbes (mg/100 mg digested)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>35.4</td>
</tr>
<tr>
<td>LP-EF</td>
<td>35.5</td>
</tr>
<tr>
<td>LP</td>
<td>37.9</td>
</tr>
<tr>
<td>Lpe</td>
<td>39.0</td>
</tr>
<tr>
<td>LL</td>
<td>38.0</td>
</tr>
</tbody>
</table>

Inoculated silages from 3 of the 4 inoculants produced 8% more rumen microbes than untreated.

That could support up to 4 lbs. more milk/cow/day.
Lactating Cow Trial: Alfalfa Silage Quality

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Untreated</th>
<th>L. plantarum MTD/1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM, %</td>
<td>51.5</td>
<td>49.1</td>
</tr>
<tr>
<td>pH</td>
<td>4.93</td>
<td>4.56</td>
</tr>
<tr>
<td>Crude protein, % DM</td>
<td>25.0</td>
<td>25.2</td>
</tr>
<tr>
<td>NDF, % DM</td>
<td>31.9</td>
<td>31.9</td>
</tr>
<tr>
<td>ADF, % DM</td>
<td>24.1</td>
<td>24.1</td>
</tr>
<tr>
<td>Ash, % DM</td>
<td>10.2</td>
<td>9.8</td>
</tr>
</tbody>
</table>

Alfalfa silage was fed at 50% of ration along with corn silage, HMC, and soy hulls.

Ration: 16.2% CP, 27.3% NDF
## Lactating Cow Trial: Performance/Cow/Day

<table>
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<tr>
<th>Characteristics</th>
<th>Untreated</th>
<th>L. plantarum MTD/1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM Intake, lbs.</td>
<td>56.0</td>
<td>56.9</td>
</tr>
<tr>
<td>Milk, lbs.</td>
<td>87.3</td>
<td>89.1</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.80</td>
<td>3.79</td>
</tr>
<tr>
<td>Protein, %</td>
<td>2.81</td>
<td>2.78</td>
</tr>
<tr>
<td>Lactose, %</td>
<td>4.82</td>
<td>4.89</td>
</tr>
<tr>
<td>MUN, mg/dL</td>
<td>12.7</td>
<td>11.6</td>
</tr>
</tbody>
</table>

The 10% reduction in milk urea N indicates better N utilization by the cows on the inoculated silage, suggesting more rumen microbe production.
What More Do We Need to Know?

- Confirm that more rumen microbes were produced in our trial.
- Figure out why certain inoculants are causing silages to produce more rumen microbes.
- Confirm that the \textit{in vitro} test really does screen for inoculants that can produce a significant animal response.
The Bottom Line

- Sound evidence that some inoculants can increase rumen microbe production *in vitro*
- These increases can explain the milk production increases observed with some inoculants.
- The inoculant we tested in a production trial increased milk and reduced MUN like we expected.
The Bottom Line

- We now have increased confidence that some inoculants can truly increase milk production 2 to 4 lbs./cow/day.
- More research is needed to understand why this is happening.
- We may have a tool for looking for better inoculants in the future.
Questions?