New Alfalfa Technology

“Reduced-Lignin Alfalfa”

Alfalfa U, Feb. 23, 2016

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Importance of Lignin in Alfalfa

✓ Provides strength to plants
✓ Allows the plant vascular system to transport water in the plant without leakage.
✓ Increases with advanced maturity in alfalfa
✓ Is indigestible and reduces fiber digestibility

Lignin Subunits

Fig 1. Three Lignin Precursors

Dan Undersander, 2009
Lignin – Enemy of Digestibility

- Increase retention time in rumen
- Increase gut fill
- Lower intake
- Lower milk/meat production
- Reduce body condition score?
- Reduce reproductive performance?
Secondary Wall
Van Soest Fiber Analysis

Ground forage material

- Digest with neutral detergent solution
  - Neutral Detergent Solubles (Cell Contents)
  - Neutral Detergent Insoluble Fiber (NDF)

- Digest with acid detergent solution
  - Acid Detergent Solubles
    - Hemicellulose, cell wall N
  - Acid Detergent Insoluble Fiber (ADF)

- Digest with sulfuric acid
  - Solubles (Cellulose)
  - Acid Insoluble Lignin
**Effect of low lignin genes on in vivo digestibility**

Digestibility of low lignin alfalfa types and controls fed to lambs, diet was 100% alfalfa hay fed ad libitum.

<table>
<thead>
<tr>
<th>Diet Type</th>
<th>aNDF % DM</th>
<th>ADL % DM</th>
<th>NDFD % NDF</th>
<th>DMD % DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% alfalfa hay diet</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMT Inactive</td>
<td>38.2</td>
<td>5.3</td>
<td>57.5*</td>
<td>67.5*</td>
</tr>
<tr>
<td>COMT Active (Control)</td>
<td>39.0</td>
<td>5.8</td>
<td>49.1</td>
<td>64.5</td>
</tr>
<tr>
<td>CCOMT Inactive</td>
<td>39.4</td>
<td>5.2</td>
<td>50.1</td>
<td>65.3</td>
</tr>
<tr>
<td>CCOMT Active (Control)</td>
<td>39.4</td>
<td>5.9</td>
<td>46.4</td>
<td>63.7</td>
</tr>
</tbody>
</table>

*Significant, P < 0.05

**SOURCE:** Mertens et al. 2008. J. Dairy Sci. Supple. 1
Influence of NDFD on TDN

![Bar graph showing the effect of NDFD on TDN for alfalfa and corn silage.](image)
Forage NDFD and DMI

Forage NDFD, %NDF

DMI, lb/d

Forage NDFD, %NDF

40 50 60 70
## Responses of Cattle

<table>
<thead>
<tr>
<th></th>
<th>45% NDFD</th>
<th>50% NDFD</th>
<th>55% NDFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, lb/d</td>
<td>45.1</td>
<td>48.6</td>
<td>51.3</td>
</tr>
<tr>
<td>NDF Intake, lb/d</td>
<td>18.7</td>
<td>19.0</td>
<td>21.6</td>
</tr>
<tr>
<td>Milk, lb/d</td>
<td>70.3</td>
<td>73.2</td>
<td>73.6</td>
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</table>
Grass Maturity and NDFD

The diagram shows the in vitro NDFD (% of NDF) for various maturity stages of grass:

- **Early Veg**: High NDFD
- **Mid Veg**: Moderate NDFD
- **Boot**: Increasing NDFD
- **Anthesis**: Steady NDFD
- **Mature**: Lower NDFD

The graph illustrates the trend of decreasing NDFD as the grass matures.
Legume Maturity and NDFD

![Graph showing the relationship between legume maturity stages and NDFD. The graph compares NDFD and NDF at different maturity stages: Early Veg, Pre-Bud, 1/2 Bloom, Full Bloom, and Seed Pod. The graph indicates an increase in NDFD as the maturity stages progress.]
# Alfalfa Maturity

<table>
<thead>
<tr>
<th>Stage of Maturity</th>
<th>Bud</th>
<th>EB</th>
<th>MB</th>
<th>FB</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP</td>
<td>22-23</td>
<td>20-21</td>
<td>18-19</td>
<td>16-17</td>
</tr>
<tr>
<td>NDF</td>
<td>&lt;40</td>
<td>40-45</td>
<td>45-59</td>
<td>&gt;50</td>
</tr>
<tr>
<td>ADF</td>
<td>&lt;30</td>
<td>30-35</td>
<td>35-40</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Lignin</td>
<td>3.0</td>
<td>3-4</td>
<td>4-5</td>
<td>&gt;5</td>
</tr>
</tbody>
</table>
Impact on Fermentation

- Reduced digestibility
- Increased retention time
- Decreased intake
Alfalfa Yield and Quality

Maturity

Forage Yield

Forage Quality
Reduced-Lignin Alfalfa
Reduced Lignin Alfalfa

- Reducing lignin content should increase fiber digestibility and alter change in quality w/ maturity.

- Genetic engineering can be used to reduce lignin content in alfalfa
  - “knockout” genes for key enzymes in the lignin biosynthetic pathway.
Reduced Lignin Alfalfa Potential Benefits

• Delayed harvest advantages
  – Fewer harvests (less traffic and fuel costs)
  – Higher forage yield
  – Improved persistence
  – Increased harvest timing flexibility (rainy weather)
RL1 Alfalfa
Changes in NDF Digestibility over Time

• RL Alfalfa = Increased flexibility in harvest timing

- Reduced lignin
- Null control

(Forage Genetics International)
Reduced Lignin Alfalfa Potential Benefits

• Forage quality advantage
  – Higher likelihood of harvesting premium quality hay
    - increase a whole plant NDFD
    - enables a delayed harvest

• Market flexibility
  - Short supply and high price alfalfa:
    Producers can delay harvest to increase yield
Reduced Lignin Alfalfa

• The USDFRC estimates that a 10% increase in fiber digestibility would:

  • Increase milk/beef production by $350M/yr
  • Decrease manure production by 2.8M T/yr
Advantage in the ration

- By increasing 1% in neutral detergent fiber digestibility (NDFD), the relative forage quality (RFQ) increases between 2 and 3%, milk per ton fed increase by 21 lbs and milk per acre increase by 167 pounds (Alforex, 2015)
Three Companies Working on RLA

- Forage Genetics International (HarvXtra) (12 – 18% less lignin)
- Alforex Seeds (Hi-Gest) (7 – 10% less lignin)
- Pioneer Hi-Bred International (54Q14) (5% less lignin)
K-State Forage Bowl Team Win (2015 and 2016)

Baton Rouge, LA, Jan.10-13, 2016

St. Louis, MO, Jan.11-14, 2015
Summary

• Low lignin alfalfa:
  – Higher fiber digestibility
  – Delay harvest while maintaining forage quality
  – Eliminate one or more annual harvest
  – Increase yield by 20 to 30%
Thanks & Questions?
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Farming is a profession of hope.

Brian Brett

TO BE SUCCESSFUL,
THE FIRST THING TO DO IS
FALL IN LOVE WITH YOUR WORK.