Alfalfa: Hay, Haylage, Baleage and Other Novel Products

Idaho Alfalfa and Forage Conference 23 February 2004
Neal P. Martin, David R. Mertens and Paul J. Weimer
Alfalfa: Hay, Haylage, Baleage, and Other Novel Products

- Introduction
- Alfalfa utilization by dairy cattle
  - Alfalfa vs corn silage in diets
  - Protein utilization of alfalfa
- Composition of alfalfa hay and corn silage
- Novel alfalfa products
2003 U.S. Alfalfa Hay Production

- 76.3 million tons
- $6.9 billion
- 4th following corn, soybeans, and wheat
- Idaho ranks 2nd behind CA in value
Leading Alfalfa Hay Production States, 1,000 tons, 2003

- Top 10 States
  - 58 % of U. S.
  - 60 % of Acre
  - 4 states NC
  - 6 states West
  - 5 Lead Dairy
Leading Alfalfa Hay Acreage States, 1,000 acres, 2003

- Top 10 States
  - 58% of U. S.
  - 63% of Acre
  - 3 states NC
  - 7 states West
  - 4 Lead Dairy
Leading Alfalfa Forage Production States, 1,000 tons, 2003

- Top 10 States
  - 59% of U. S.
  - 59% of Acre
  - 4 states NC
  - 1 state NE
  - 5 states West
  - 6 Lead Dairy
Percent of Total 2003 Alfalfa Production - Haylage
California Dairy
Nutritionists Value Alfalfa Hay

- High energy value
- Its rapid ruminally digested structural fiber which stimulates intake
- Coarse structural fiber that stimulates chewing and salivation which results in rumen buffering and buffering capacity
- High protein
- Relatively high proportion of protein that escapes rumen undegraded

Peter Robinson, University of Davis - CA
## Alfalfa: Corn Silage

50% forage: 50% concentrate

<table>
<thead>
<tr>
<th>Item</th>
<th>AS 1</th>
<th>2/3 AS</th>
<th>1/3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Milk production</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mature cows, lb/hd/305</td>
<td>21,148</td>
<td>22,422</td>
<td>22,100</td>
</tr>
<tr>
<td>1st calf cows, lb/hd/305</td>
<td>17,911</td>
<td>18,546</td>
<td>18,088</td>
</tr>
<tr>
<td>3.5% FCM, lb/d</td>
<td>68.2</td>
<td>72.4</td>
<td>70.0</td>
</tr>
<tr>
<td>Milk protein, lb/d</td>
<td>2.09</td>
<td>2.22</td>
<td>2.18</td>
</tr>
</tbody>
</table>

1 (AS) Alfalfa silage: % DM, 40.2; CP, 19.5; ADF, 33.9; and NDF, 40.1.
High Alfalfa Haylage Diet

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Protein</th>
<th>Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM intake, lb</td>
<td>48.4\textsuperscript{b}</td>
<td>55.9\textsuperscript{a}</td>
<td>49.5\textsuperscript{b}</td>
</tr>
<tr>
<td>BW gain, lb</td>
<td>50.6</td>
<td>48.4</td>
<td>33.0</td>
</tr>
<tr>
<td>3.5 % FCM, lb</td>
<td>63.4\textsuperscript{c}</td>
<td>75.0\textsuperscript{a}</td>
<td>67.5\textsuperscript{b}</td>
</tr>
<tr>
<td>Milk protein, lb</td>
<td>1.89\textsuperscript{b}</td>
<td>2.29\textsuperscript{a}</td>
<td>1.94\textsuperscript{b}</td>
</tr>
</tbody>
</table>

\textsuperscript{abc} Means in same row with different superscripts differ (p<0.01)

## Protein Use of Alfalfa

<table>
<thead>
<tr>
<th>Item</th>
<th>silage +FM&lt;sup&gt;1&lt;/sup&gt;</th>
<th>hay +FM&lt;sup&gt;1&lt;/sup&gt;</th>
<th>silage</th>
<th>hay +FM&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP, % of DM</td>
<td>17.1</td>
<td>15.4</td>
<td>18.6</td>
<td>17.0</td>
</tr>
<tr>
<td>DM intake</td>
<td>49.2&lt;sup&gt;c&lt;/sup&gt;</td>
<td>52.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>51.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>53.4&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>BW change</td>
<td>-0.86&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.99&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.08&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Milk</td>
<td>77.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>79.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>82.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>81.4&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fat</td>
<td>2.65&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.60&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.82&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.69&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Protein</td>
<td>2.29&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.43&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.51&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.49&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>SNF</td>
<td>6.64&lt;sup&gt;c&lt;/sup&gt;</td>
<td>6.81&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

abc Means in same row with different superscripts differ (p<0.05)

<sup>1</sup> Diets supplemented with 3 % (DM basis) low-soluble fish meal.

**SOURCE:** Broderick, 1995.
Feed Storage Problems

• However in alfalfa, our primary forage:
Supplementation of a 50% Alfalfa Silage Diet with Raw or Roasted Soybeans (Faldet & Satter, 1991)

![Graph showing milk production (lb/day) over weeks of lactation for roasted soybeans, raw soybeans, and solvent soybean meal.](image-url)
# Effect of Silage Preservation on Alfalfa

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Formic Acid</th>
<th>Grainmax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silage comp</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture, %</td>
<td>61.7</td>
<td>64.8</td>
<td>64.1</td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>21.4</td>
<td>20.8</td>
<td>21.1</td>
</tr>
<tr>
<td>NPN, % of N</td>
<td>43.1</td>
<td>29.1</td>
<td>35.5</td>
</tr>
<tr>
<td>NDF, %</td>
<td>38.0</td>
<td>41.2</td>
<td>41.3</td>
</tr>
</tbody>
</table>

3 Control silage was ensiled untreated
4 Silage ensiled after treatment of 2 gal/T of 90 % formic acid
5 Silage ensiled after treatment with 1.5 gal/T of Grainmax & 16% formaldehyde.

Broderick and Satter. 1998. Proc. 4-State DFFMC
**Effect of Silage Preservation on Alfalfa**

<table>
<thead>
<tr>
<th>Item</th>
<th>Control</th>
<th>Formic Grainax</th>
<th>Grainax acid</th>
<th>Formic Grainax acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM intake, lb/day</td>
<td>40.3</td>
<td>40.1</td>
<td>43.4</td>
<td></td>
</tr>
<tr>
<td>Milk, lb/day</td>
<td>64.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>71.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>71.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Fat, lb/day</td>
<td>2.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Protein, lb/day</td>
<td>1.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.9&lt;sup&gt;ab&lt;/sup&gt;</td>
<td></td>
</tr>
</tbody>
</table>

<sup>3</sup> Control silage was ensiled untreated

<sup>4</sup> Silage ensiled after treatment of 2 gal/T of 90% formic acid

<sup>5</sup> Silage ensiled after treatment with 1.5 gal/T of Grainmax & 16% formaldehyde.

Broderick and Satter. 1998. Proc. 4-State DFFMC
Post Harvest Proteolysis in Alfalfa Impact on dairy production

- Increased NPN decreases the efficiency of protein utilization in ruminants
  - Inefficient utilization of alfalfa protein requires the feeding of supplemental protein with high RUP to maximize milk production.
  - Inefficient utilization of alfalfa protein also results in the excretion of excess rumen NH3, leading to increased N losses to the environment.
Red Clover vs. Alfalfa Silage

Protein breakdown (% of alfalfa)

Alfalfa can be used as a model to study the inhibition of protein breakdown in silages.

PPO = Polyphenol Oxidase gene from red clover
Improving Alfalfa for Dairy Rations

Currently using harvesting management to improve alfalfa quality
- Immature alfalfa has many appealing nutritional properties
  - Low in fiber
    - High digestibility
    - High intake potential
  - Rapid rate of digestion
  - High in crude protein
### Impact of Harvest Management on Forage Quality

<table>
<thead>
<tr>
<th>Description</th>
<th>CP</th>
<th>EE</th>
<th>Ash</th>
<th>Starch</th>
<th>Pectin</th>
<th>aNDF</th>
<th>ADF</th>
<th>ADL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ALFALFA HAY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exceptional</td>
<td>25.4</td>
<td>2.7</td>
<td>10.4</td>
<td>3.1</td>
<td>14.2</td>
<td>30.0</td>
<td>24.0</td>
<td>4.53</td>
</tr>
<tr>
<td>Very high</td>
<td>24.0</td>
<td>2.6</td>
<td>9.9</td>
<td>2.9</td>
<td>13.2</td>
<td>34.1</td>
<td>27.0</td>
<td>5.38</td>
</tr>
<tr>
<td>High quality</td>
<td>22.5</td>
<td>2.5</td>
<td>9.5</td>
<td>2.7</td>
<td>12.3</td>
<td>38.2</td>
<td>30.0</td>
<td>6.23</td>
</tr>
<tr>
<td>Good quality</td>
<td>21.0</td>
<td>2.4</td>
<td>9.1</td>
<td>2.5</td>
<td>11.4</td>
<td>42.2</td>
<td>33.0</td>
<td>7.08</td>
</tr>
<tr>
<td>Fair quality</td>
<td>19.5</td>
<td>2.2</td>
<td>8.7</td>
<td>2.3</td>
<td>10.5</td>
<td>46.3</td>
<td>36.0</td>
<td>7.93</td>
</tr>
<tr>
<td><strong>CORN SILAGE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V. high grain</td>
<td>8.3</td>
<td>3.2</td>
<td>4.1</td>
<td>31.1</td>
<td>1.7</td>
<td>36.0</td>
<td>21.0</td>
<td>1.57</td>
</tr>
<tr>
<td>High grain</td>
<td>8.6</td>
<td>3.1</td>
<td>4.6</td>
<td>27.2</td>
<td>1.6</td>
<td>40.5</td>
<td>24.0</td>
<td>1.91</td>
</tr>
<tr>
<td>Normal</td>
<td>8.8</td>
<td>3.0</td>
<td>5.1</td>
<td>23.2</td>
<td>1.5</td>
<td>45.0</td>
<td>27.0</td>
<td>2.25</td>
</tr>
<tr>
<td>Low grain</td>
<td>9.0</td>
<td>2.8</td>
<td>5.7</td>
<td>19.2</td>
<td>1.4</td>
<td>49.5</td>
<td>30.0</td>
<td>2.59</td>
</tr>
<tr>
<td>Very low grain</td>
<td>9.3</td>
<td>2.7</td>
<td>6.2</td>
<td>15.3</td>
<td>1.3</td>
<td>54.0</td>
<td>33.0</td>
<td>2.93</td>
</tr>
</tbody>
</table>
## Ideal Alfalfa – Sole Diet

<table>
<thead>
<tr>
<th>Insoluble CHO and Lignin</th>
<th>Cow Req.</th>
<th>Corn Silage</th>
<th>Alfalfa Silage</th>
<th>Hi-Qual Alfalfa</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDF</td>
<td>28</td>
<td>43</td>
<td>43</td>
<td>28</td>
</tr>
<tr>
<td>ADF</td>
<td>19</td>
<td>24</td>
<td>33</td>
<td>19</td>
</tr>
<tr>
<td>AD Lignin</td>
<td>3.0</td>
<td>8.6</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>NDF digestion rate</td>
<td>.06</td>
<td>.10</td>
<td>.15</td>
<td></td>
</tr>
<tr>
<td>Physically effective NDF</td>
<td>22</td>
<td>38.7</td>
<td>40.8</td>
<td>25.2</td>
</tr>
</tbody>
</table>
## Ideal Alfalfa – Sole Diet

<table>
<thead>
<tr>
<th></th>
<th>Soluble CHO</th>
<th>Cow Req.</th>
<th>Corn Silage</th>
<th>Alfalfa Silage</th>
<th>Hi-Qual Alfalfa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nonfibrous CHO</strong></td>
<td>45</td>
<td>42.0</td>
<td>25.0</td>
<td>28.0</td>
<td></td>
</tr>
<tr>
<td><strong>Nonstructural CHO</strong></td>
<td>40</td>
<td>10</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Starches</strong></td>
<td>30</td>
<td>36</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Pectins+</strong></td>
<td>2</td>
<td>15</td>
<td>18</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Apparent Dry Matter Digestibility of AH and CS

<table>
<thead>
<tr>
<th>Item</th>
<th>AH proc</th>
<th>AH</th>
<th>CS proc</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>24%ADF</td>
<td>24%ADF</td>
<td>27%ADF</td>
<td>24%ADF</td>
<td>27%ADF</td>
</tr>
<tr>
<td>ADF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% aNDF</td>
<td>30.0</td>
<td>34.1</td>
<td>40.5</td>
<td>45.0</td>
</tr>
<tr>
<td>% NDFD</td>
<td>52.1</td>
<td>46.8</td>
<td>61.4</td>
<td>60.6</td>
</tr>
<tr>
<td>% dNDF</td>
<td>15.6</td>
<td>16.0</td>
<td>24.9</td>
<td>27.3</td>
</tr>
<tr>
<td>% NDS</td>
<td>70.0</td>
<td>65.9</td>
<td>59.5</td>
<td>55.0</td>
</tr>
<tr>
<td>% dNDS</td>
<td>68.6</td>
<td>64.6</td>
<td>58.3</td>
<td>53.9</td>
</tr>
<tr>
<td>% True DM digestibility</td>
<td>84.2</td>
<td>80.6</td>
<td>83.2</td>
<td>81.2</td>
</tr>
<tr>
<td>% Endo fecal DM excr</td>
<td>-12.9</td>
<td>-12.9</td>
<td>-12.9</td>
<td>-12.9</td>
</tr>
<tr>
<td>% Apparent DMD</td>
<td>71.3</td>
<td>67.7</td>
<td>70.3</td>
<td></td>
</tr>
</tbody>
</table>
New Alfalfa Products of high value are needed to expand acreage...

- Research efforts underway to:
  - Develop alfalfa with value-added traits
  - Develop new processing technologies

Reconstituted bales are sold year-round to French dairy farmers.
Three methods of forage fractionation exist:

- Wet fractionation; separation into a juice and a fiber fraction
- Dry fractionation; separation into leaves and stems
- Animal fractionation; passage of whole plant through digestive systems of ruminant animals, leaving a high fiber residue.
Two important conditions must be met for alfalfa fractionation to be feasible and sustainable:

- Total value of resulting products must be greater than the original forage plus the cost of processing;
- All fractions must have economic value to avoid creating a waste stream.
Wet-fractionation process has two advantages for agriculture:

- Forage crops can be harvested almost independent of weather, since moisture is removed mechanically rather than by mother nature.

- A versatile protein concentrate is obtained which can be fed to non-ruminants, including humans, as well as dairy cattle.
FRACTIONATION METHODS

Wet Herbage

Juice

"Fiber"

Enzymes (Transgenic)

Dry Herbage

Leaves

Stems

Enzymes (Transgenic)

Anima lHerbage

"Digestibles" (to animal)

Fibrous Fraction

Hardwood

"Masonite"

Biofilters

Bio plywood
Development of Green Genes

Transgenic Phytase-rich Alfalfa

- Phytase enzyme makes P in grain ration of monogastric diets more available (poultry, swine, and fish)
- Less P excreted in feces
- Phytase enzyme levels of 1 - 2% of soluble protein possible
- Phytase extraction with wet fractionation gives added value of xanthophyll & high protein
- Phytase is stable - alfalfa leaf meal
Alfalfa - Produced Phytase in Poultry Rations:

- Eliminates need for phosphorus supplementation
- Reduces the phosphorus content of feces to less than half
VALUE OF PHYTASE-PROTEIN-PIGMENT CONCENTRATE PER ACRE-YEAR

PHYTASE
$600
4lb @ $150/lb = $600

XANTHOPHYLL
$245
1.2lb @ $175/lb = $245

PROTEIN CONC.
$137
1375lb x $0.10/lb = $137

Total
$982
Potential new uses of alfalfa

- Electric generation
Minnesota Agri-Power: Project to Produce Electricity and Livestock Feed (and Improve the Environment) with Alfalfa

- Separate alfalfa hay into leaf and stem fractions.
- Produce electricity from the low-value stems.
- Utilize the leaves as a feed supplement for livestock.
## Composition of Leaf Meal - Fractionation

<table>
<thead>
<tr>
<th>Component</th>
<th>Separation</th>
<th>Mechanical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lab '96</td>
<td>'98 '98</td>
</tr>
<tr>
<td>Crude protein</td>
<td>25.2</td>
<td>21.9</td>
</tr>
<tr>
<td></td>
<td>25.8</td>
<td>28.2</td>
</tr>
<tr>
<td>NDF</td>
<td>36.0</td>
<td>36.5</td>
</tr>
<tr>
<td></td>
<td>43.6</td>
<td>34.4</td>
</tr>
<tr>
<td>ADF</td>
<td>21.5</td>
<td>21.9</td>
</tr>
<tr>
<td></td>
<td>26.6</td>
<td></td>
</tr>
<tr>
<td>25.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>--</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.8</td>
</tr>
</tbody>
</table>

Dry Alfalfa

- Leaf Meal
  - Protein Supplement
    - Dairy, Beef, and Poultry
      - 40-50 % of ground hay
  - High fiber
    - Combustion, Gasification
      - Or Enzymatic Hydrolysis
    - 50-40 % of ground hay
Bio-degradable plastics made from Lactic Acid
Fiber Board and Filter Mats from Manure

Thick Filter Mat

Fiber Board

Thin Filter Mat
Fresh Alfalfa

- Juice
  - Heat coagulate
  - Protein Concentrate
    - Poultry supplement or calf-replacer
    - 25 % of original crop dry matter

- High fiber
  - Ruminant feed
    - Store silage in bunkers
    - Process fiber
    - New products
  - 75 % of original crop dry matter

USDFRC
Fractionating for Quality

- Alfalfa fractionating at harvest:

![Image of alfalfa plants]

JUL 14 2003
Fractionating for Quality

- Alfalfa fractionating at harvest:
Fractionating for Quality

- Why fractionate alfalfa at harvest:
  - Leaf yield and quality relatively unaffected by maturity.
  - Stem quality diluted with age.
  - Conventional practices co-mingle high- and low-quality.
Fractionating for Quality

Why fractionate alfalfa at harvest:

- Fractionated leaves and stems can be target fed more optimally.

- Single day harvesting possible.

  - **Leaves**: direct-ensiled with amendment
  
  - **Stems**: wilted and chopped on same day

- Fewer cutting possible
Fractionating for Quality

- Whole plant
- Stripped Stems

Moisture % w.b.

11:00 AM  1:00 PM  3:00 PM  5:00 PM
Fractionating for Quality

- Why fractionate alfalfa at harvest:
  - Value-added products possible:
    - Leaves: protein concentrates, pigmenting agents
Fractionating for Quality

- What is the big hurdle with alfalfa harvest fractionation:
  - Direct ensiling with amendment:
    - About 1 ton ground corn grain or DDG needed for every acre
Potential new uses of alfalfa

- Electric generation
- Protein production
Biotechnology Applications in Alfalfa

- Insertion of BT gene to deter insect feeding
- Coat protein for control of viruses
- Improved winterhardiness
- Balanced animal diets
- Alfalfa bioremediation
- Alfalfa root & nodules
- Human proteins

French May Produce Hemoglobin In Alfalfa Plants

Farmers in France may soon be growing alfalfa to produce human hemoglobin. Viridis, a subsidiary of AlfaLis, which specializes in alfalfa production, hopes to begin manufacturing various proteins, especially hemoglobin.

"Alfalfa is a true protein factory," says Damien Levesque, Viridis' managing director. "It is the plant that can produce the largest quantity of proteins per acre – far ahead of soybeans. Alfalfa produces 2,200 lbs of protein per acre, compared with 850 to 890 lbs for soybeans.

His company specializes in the extraction of alfalfa juice for pigments and other products.

"The special characteristic of alfalfa is storing the proteins in the leaves and not in the seeds like soybeans or peas," says Levesque. "Extraction is therefore carried out by pressing the green foliage in order to recover proteins in the alfalfa juice without altering its quality. We have developed a specific technology for pressing."

Viridis has acquired Medicago, a Quebec biotechnology company that successfully introduced the gene for hemoglobin production in alfalfa plants.
Potential new uses of alfalfa

- Electric generation
- Protein production
- Ethanol production
Biomass Conversion to Ethanol

1. **Grind**
2. **Pretreatment to Remove Inhibitors**
3. **Enzymatic Breakdown of Polysaccharides**
4. **Residual Solids**
5. **Electricity & Processing Heat**
6. **Fermentation**
7. **Ethanol Recovery**
8. **Sugars**
Alfalfa in Crop Rotations:

- Adds nitrogen via biological fixation
- Improves water infiltration and soil quality
- Reduces soil erosion from wind and water
- Improves yield of subsequent crop
- Reduces N fertilizer demands of subsequent crops
Alfalfa in Crop Rotations:

- Helps protect surface and ground water
- Acts as waste-water recycler
Alfalfa and grass CRP effectively filter tile drain water.

40 million acres are tile drained in the Upper Midwest.

Randall, Huggins, Russelle et al., 1999
Risk of ground water nitrate contamination

Alfalfa is well adapted to grow in these areas

Alfalfa Hay Harvested: 1997

Source: 1997 Census of Agriculture
A multidisciplinary collaboration of public and private scientists

- Dairy Nutrition (USDFRC)
- Biochemistry (Noble Foundation and USDFRC)
- Molecular/cell biology (Noble, FGI and DowAgro)
- Agronomy
- Plant breeding (FGI)
Summary and Conclusions

- Alfalfa can be processed to provide products of higher value.
- Processing green alfalfa via wet fractionation removes effects of weather on harvest.
- Corn and soybean cash farmers will benefit from all types of fractionation discussed.
- The Alfalfa Industry must cooperate to support research and development to obtain new products from alfalfa.