2014 Research Report:

Hydroponic Barley Fodder as a Grain Alternative in the Organic Dairy Ration

Funded in part by:
California Agriculture Research Institute, CSU Chico Research Foundation & Simply Country, Inc., www.simplycountry.net

C.A. Daley, Ph.D.; Celina Phillips, Ph.D.; Darby Heffner and Breanna Roque - College of Agriculture California State University Chico, Organic Dairy Program
What is fodder?

- Grain is soaked in water and placed in trays to allow seeds to germinate and "sprout" for 5 to 6 days.

- Has been used for centuries in Asian countries to improve feed quality for livestock.

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Why study fodder?

- Assess value as an alternative source feed
- Can fodder serve as a grain substitute
- Determine feasibility and cost effectiveness
- Very little has been done
### SPROUTING GRAINS

Sprouting Grain Makes Cereals More Nutritious

- Converts starch to sugar (better rumen energy, less acidosis)
- Converts soluble protein to "by pass" protein (less rumen ammonia, BUN, MUN)
- Neutralizes Phytates (aka phytic acid) which inhibit mineral absorption
- Destroys Enzyme Inhibitors (which compromise digestion)
- Increases Enzyme Levels (for better digestion and absorption)
- Increases Vitamin Levels
- Increases Amino Acids (quality protein)
- Increases Fatty Acids (quality energy)

### FIVE DAY SPROUT ANALYSIS

<table>
<thead>
<tr>
<th>ID#</th>
<th>Sample</th>
<th>*%NSC</th>
<th>**% Sugar</th>
<th>***% Starch</th>
<th>% Protein Solubility</th>
</tr>
</thead>
<tbody>
<tr>
<td>R218</td>
<td>Sprouted Conventional Corn</td>
<td>82.34</td>
<td>2.13</td>
<td>80.21</td>
<td>10.00</td>
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<tr>
<td>R228</td>
<td>Unsprouted Conventional Corn</td>
<td>71.13</td>
<td>2.11</td>
<td>69.02</td>
<td>13.30</td>
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<tr>
<td>R219</td>
<td>Sprouted Organic Corn</td>
<td>80.85</td>
<td>2.75</td>
<td>78.10</td>
<td>9.00</td>
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<tr>
<td>R227</td>
<td>Unsprouted Organic Corn</td>
<td>77.82</td>
<td>3.30</td>
<td>74.52</td>
<td>17.20</td>
</tr>
<tr>
<td>R220</td>
<td>Sprouted Organic Wheat</td>
<td>72.55</td>
<td>24.23</td>
<td>48.32</td>
<td>36.90</td>
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<tr>
<td>R234</td>
<td>Unsprouted Organic Wheat</td>
<td>74.75</td>
<td>3.42</td>
<td>71.33</td>
<td>35.10</td>
</tr>
<tr>
<td>R221</td>
<td>Sprouted Organic Barley</td>
<td>65.17</td>
<td>5.47</td>
<td>59.70</td>
<td>8.00</td>
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<tr>
<td>R229</td>
<td>Unsprouted Organic Barley</td>
<td>52.90</td>
<td>1.78</td>
<td>51.12</td>
<td>13.80</td>
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<tr>
<td>R222</td>
<td>Sprouted Conventional Oats</td>
<td>52.05</td>
<td>4.62</td>
<td>47.43</td>
<td>20.10</td>
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<tr>
<td>R232</td>
<td>Unsprouted Conventional Oats</td>
<td>56.63</td>
<td>1.83</td>
<td>54.80</td>
<td>42.30</td>
</tr>
<tr>
<td>R223</td>
<td>Sprouted Organic Oats</td>
<td>52.20</td>
<td>3.48</td>
<td>48.72</td>
<td>23.60</td>
</tr>
<tr>
<td>R233</td>
<td>Unsprouted Organic Oats</td>
<td>53.17</td>
<td>2.37</td>
<td>50.80</td>
<td>39.50</td>
</tr>
<tr>
<td>R224</td>
<td>Sprouted Conventional Rye</td>
<td>70.53</td>
<td>40.38</td>
<td>30.15</td>
<td>38.90</td>
</tr>
<tr>
<td>R231</td>
<td>Unsprouted Conventional Rye</td>
<td>71.93</td>
<td>5.90</td>
<td>66.03</td>
<td>43.30</td>
</tr>
<tr>
<td>R226</td>
<td>Sprouted Conventional Buckwheat</td>
<td>52.03</td>
<td>9.64</td>
<td>42.39</td>
<td>21.30</td>
</tr>
<tr>
<td>R230</td>
<td>Unsprouted Conventional Buckwheat</td>
<td>56.45</td>
<td>1.75</td>
<td>54.70</td>
<td>45.50</td>
</tr>
<tr>
<td>R225</td>
<td>Sprouted Conventional Sunflower</td>
<td>12.71</td>
<td>1.80</td>
<td>10.91</td>
<td>33.50</td>
</tr>
</tbody>
</table>

* NSC Non Structural Carbohydrates = Total of starch and sugar
** Sugars consist of: sucrose, fructans, fructose, glucose, and lactose extracted from feed by stirring in water 39°C for (1) hour.
*** Starch consists of: Starch plus other sugars not extracted at 39°C in water for (1) hour.

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Installation T-126 – 1100lbs per day

- 63 18 lb biscuits
- 2.5 lbs seed/ biscuit
- 335 gallons water/day
- 220V 30A
Fodder unit is seeded and harvested every day.
Fodder is fed using a feed wagon to mix with other supplements 1 time/day
What we know about fodder/sprouts based on the literature

High (higher) in vitamins & minerals

(USDA National Nutrient Database Standard Reference V.1.3.1.)

- 100 g wheat sprouts = 2.6 mg Vitamin C; 0.225 mg Thiamin; 0.155 mg Riboflavin; 3.087 mg Niacin; 0.265 mg Vitamin B6; and 38 mcg Folate

- 100 g wheat sprouts = 28 mg Ca; 82 mg Mg; 200 mg P; 169 mg K; 1.65 mg Zn
What we know about fodder/sprouts

Converts starches to highly digestible sugars

(Food Science & Nutrition 28(5):401-437 1989)

- May change feed conversion
- We don’t know impact on rumen function
- May result in lowered incidence of acidosis (high starch diets)

Free amino acid content increases – suggesting better protein utilization

(Food Chemistry 119:1195-1200 - 2010)

May reduce MUN’s

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What we know about sprouts/fodder

Sprouting legumes reduces alkaloids and improves the overall palatability and bioavailability of the nutrients

(Food Chemistry 117:599-602 2009)

Also rich in plant secondary metabolites called phenolic compounds – anti-cancer – very potent antioxidants.
What we know about sprouts/fodder

Reduces phytic acid – will not tie up minerals to same degree as grains

*(Food Chemistry 119:1195-1200 - 2010)*
### Fermentation Report

<table>
<thead>
<tr>
<th>Component</th>
<th>DM Basis</th>
<th>Goal</th>
<th>Typical Value for DM Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Matter, %</td>
<td>8.71</td>
<td>&gt; 3</td>
<td>3.34</td>
</tr>
<tr>
<td>Lactic Acid, %</td>
<td>7.10</td>
<td>&lt; 3</td>
<td>4.02</td>
</tr>
<tr>
<td>Acetic Acid, %</td>
<td>1.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactic/Acetic Ratio</td>
<td>4.68</td>
<td>2.0 - 3.0</td>
<td>0.80</td>
</tr>
<tr>
<td>Propionic Acid, %</td>
<td>0.12</td>
<td>&lt; 1.0</td>
<td>0.72</td>
</tr>
<tr>
<td>Butyric Acid, %</td>
<td>0.13</td>
<td>&lt; 0.1</td>
<td>1.60</td>
</tr>
<tr>
<td>IsoButyric, %</td>
<td>0.09</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Acids, %</td>
<td>8.96</td>
<td>5.0 - 10.0</td>
<td>9.70</td>
</tr>
<tr>
<td>pH, As sampled</td>
<td>3.60</td>
<td>&lt; 5</td>
<td>5.03</td>
</tr>
<tr>
<td>Crude Protein, %</td>
<td>15.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia, CPE %</td>
<td>0.75</td>
<td></td>
<td>4.05</td>
</tr>
<tr>
<td>Amm-N, % of Total N</td>
<td>4.87</td>
<td>8.0 - 15.0</td>
<td>26.47</td>
</tr>
</tbody>
</table>

**UNIVERSITY FARM/DAIRY UNIT**

**FODDER DAYS S N**

**Feed Type:** MISC HAYLAGE

**Statement ID:** FODDER DAYS S N

**Description:**

**Sample #:** 19438690

**Date:** 07/30/2013

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## Fodder Nutrient Analysis

**FORAGE TESTING LABORATORY**

**DAIRY ONE, INC.**

730 Warren Road

Ithaca, New York 14850

607-257-1272 (fax 607-257-1350)

**CHICO STATE DAIRY**

University Farm/Dairy Unit

311 Nichols C Schouten Lane

Chico, CA 95928

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### ENERGY TABLE - NRC 2001

<table>
<thead>
<tr>
<th>Component</th>
<th>As Fed</th>
<th>DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE, 1X</td>
<td>1.33</td>
<td>2.93</td>
</tr>
<tr>
<td>ME, 1X</td>
<td>1.14</td>
<td>2.51</td>
</tr>
<tr>
<td>NEL, 3X</td>
<td>0.66</td>
<td>1.45</td>
</tr>
<tr>
<td>NEM, 3X</td>
<td>0.69</td>
<td>1.52</td>
</tr>
<tr>
<td>NE, 3X</td>
<td>0.42</td>
<td>0.93</td>
</tr>
<tr>
<td>TDN, %</td>
<td>11</td>
<td>70</td>
</tr>
<tr>
<td>NEL, Mcal/Lb</td>
<td>0.12</td>
<td>0.77</td>
</tr>
<tr>
<td>NEM, Mcal/Lb</td>
<td>0.11</td>
<td>0.75</td>
</tr>
<tr>
<td>NE, Mcal/Lb</td>
<td>0.07</td>
<td>0.47</td>
</tr>
<tr>
<td>Relative Feed Value</td>
<td>272</td>
<td></td>
</tr>
<tr>
<td>Calcium</td>
<td>0.03</td>
<td>0.19</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.07</td>
<td>0.45</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.03</td>
<td>0.18</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.08</td>
<td>0.50</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.008</td>
<td>0.055</td>
</tr>
<tr>
<td>PPM Iron</td>
<td>21</td>
<td>140</td>
</tr>
<tr>
<td>PPM Zinc</td>
<td>6</td>
<td>38</td>
</tr>
<tr>
<td>PPM Copper</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>PPM Manganese</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>PPM Molybdenum</td>
<td>0.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.03</td>
<td>0.19</td>
</tr>
<tr>
<td>IVTD 30hr, % of DM</td>
<td>89</td>
<td></td>
</tr>
<tr>
<td>NDFD 30hr, % of NDF</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>% Total Nitrogen</td>
<td>0.4</td>
<td>2.4</td>
</tr>
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</table>

**Sample Description**

<table>
<thead>
<tr>
<th>Farm Code</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR BARLEY FORAGE</td>
<td>213</td>
</tr>
</tbody>
</table>

**Comments:**

1. This sample was tested twice for crude protein to confirm the value listed.

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Changes in rumen micro-flora with pH

Figure 2. Ruminal fermentation as a consequence of adaptation due to pH regulation.

Microbes impact on milk components

Figure 3. Feed, nutrient flow from the rumen, and milk components.

Feed → Crude protein → DIP → UIP → Microbial growth and fermentation → Microbial protein

Feed → Sugar, starch → Fermentable fiber

Nutrients → Amino acids → Milk protein

Nutrients → Propionic (glucose) → Milk lactose

Nutrients → Acetic, butyric → Milk fat

Nutrients → Fatty acids

Milk components:

- Milk protein
- Milk lactose
- Milk fat


Note: UIP = undegradable intake protein; DIP = degradable intake protein.
# Differences among seed sources

Two different barley seed lots tested side by side

<table>
<thead>
<tr>
<th>Seed</th>
<th>%Adj CP</th>
<th>SP % of CP</th>
<th>%ADF</th>
<th>%NDF</th>
<th>%NFC</th>
<th>%TDN</th>
<th>DM%</th>
<th>NeI</th>
<th>RFV</th>
<th>%N</th>
<th>ME</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6 Utah</td>
<td>20.3</td>
<td>70</td>
<td>24.9</td>
<td>47.3</td>
<td>26.6</td>
<td>60</td>
<td>7.6</td>
<td>0.60</td>
<td>137</td>
<td>3.2</td>
<td>1.09</td>
</tr>
<tr>
<td>D6 LW</td>
<td>15.3</td>
<td>54</td>
<td>14.4</td>
<td>26.6</td>
<td>44.8</td>
<td>70</td>
<td>15</td>
<td>0.77</td>
<td>272</td>
<td>2.4</td>
<td>1.32</td>
</tr>
</tbody>
</table>
Fodder Quality over Time on DM basis

<table>
<thead>
<tr>
<th>Day 1</th>
<th>DM%</th>
<th>%CP</th>
<th>%Adj. CP</th>
<th>Soluble Protein as % of CP</th>
<th>Degradable P as % of CP</th>
<th>%NDIC P</th>
<th>%ADF</th>
<th>%NDF</th>
<th>%NFC</th>
<th>% Starch</th>
<th>%TDN</th>
<th>Nel Mcal/lb</th>
<th>RFV</th>
<th>% total N</th>
<th>Metabolizable Energy Mcal/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63.1</td>
<td>10.8</td>
<td>10.8</td>
<td>34</td>
<td>43</td>
<td>2.2</td>
<td>6.7</td>
<td>19.5</td>
<td>65.1</td>
<td>54.8</td>
<td>81</td>
<td>.86</td>
<td></td>
<td>1.7</td>
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<tr>
<td>Day 2</td>
<td>44.4</td>
<td>11.1</td>
<td>11.1</td>
<td>50</td>
<td>59</td>
<td>1.8</td>
<td>8.4</td>
<td>17.3</td>
<td>67.5</td>
<td>50.3</td>
<td>82</td>
<td>.87</td>
<td></td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Day 3</td>
<td>35.5</td>
<td>11.2</td>
<td>11.2</td>
<td>59</td>
<td>68</td>
<td>1.3</td>
<td>9.4</td>
<td>18.4</td>
<td>65.9</td>
<td>46.3</td>
<td>81</td>
<td>.86</td>
<td></td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Day 4</td>
<td>20.8</td>
<td>11.4</td>
<td>11.4</td>
<td>65</td>
<td>9.8</td>
<td>21.1</td>
<td>56.9</td>
<td>68</td>
<td>.76</td>
<td>358</td>
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<td>1.8</td>
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<tr>
<td>Day 5</td>
<td>12.6</td>
<td>13.7</td>
<td>13.7</td>
<td>69</td>
<td>12.4</td>
<td>25.6</td>
<td>50.2</td>
<td>67</td>
<td>.73</td>
<td>288</td>
<td></td>
<td>2.2</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

%CP increases
Soluble protein increases
Energy decreases

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Day 1 – fresh seed
Day 2
Day 3
Day 5
Day 6

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## Experiment #1: Replacement Rates

**Key Question:** How many pounds of fodder does it take to replace a pound of grain?

<table>
<thead>
<tr>
<th>Barley</th>
<th>Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed Cost</td>
<td>$880/T</td>
</tr>
<tr>
<td>lbs seed/brick</td>
<td>2.5</td>
</tr>
<tr>
<td>lbs/brick</td>
<td>18</td>
</tr>
<tr>
<td># bricks /d</td>
<td>63</td>
</tr>
<tr>
<td>lbs fodder/d</td>
<td>1134</td>
</tr>
<tr>
<td>DM</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Experiment # 1: Replacement Rates

Treatments based on DM analysis

- 12 lbs of grain (as fed)  n=15
- 6 lbs of grain (as fed)  n=15
- 3 lbs of grain + 18 lbs of fodder (as fed)  n=15
- 36 lbs of fodder (as fed)  n=15
## Establishing equivalence on a DM basis

<table>
<thead>
<tr>
<th>Feed Analysis</th>
<th>Nel DM basis</th>
<th>% DM</th>
<th>Treatments</th>
<th>DM Fed</th>
<th>Meg Calories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parlor Grain mix</td>
<td>0.80</td>
<td>0.89</td>
<td>6 lbs grain</td>
<td>5.34</td>
<td>4.75</td>
</tr>
<tr>
<td>Fodder</td>
<td>0.77</td>
<td>0.15</td>
<td>36 lbs fodder</td>
<td>5.4</td>
<td>4.66</td>
</tr>
</tbody>
</table>

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Table 1. Means and standard deviations of milk production traits among the four treatments fed to CSUC organic dairy cows

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk Fluid*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Protein</td>
<td>3.10(0.30)</td>
<td>3.10(0.30)</td>
<td>2.70(1.10)</td>
<td>3.20(0.20)</td>
<td>0.15</td>
</tr>
<tr>
<td>% Fat</td>
<td>3.90(0.30)</td>
<td>3.90(0.40)</td>
<td>3.70(1.00)</td>
<td>3.70(0.70)</td>
<td>0.53</td>
</tr>
<tr>
<td>% SNF</td>
<td>8.80(0.40)</td>
<td>8.80(0.30)</td>
<td>7.70(2.80)</td>
<td>9.00(0.30)</td>
<td>0.07</td>
</tr>
<tr>
<td>DIM</td>
<td>46.6(10.2)</td>
<td>48.5(7.00)</td>
<td>53.4(7.30)</td>
<td>52.5(13.0)</td>
<td>0.24</td>
</tr>
<tr>
<td>MUN</td>
<td>13.4(1.80)</td>
<td>14.2(2.10)</td>
<td>13.7(3.90)</td>
<td>14.7(3.10)</td>
<td>0.76</td>
</tr>
</tbody>
</table>

All numbers rounded up to 3 significant figures. Standard Deviation in parentheses

*Milk Fluid measured in pounds.
Experiment #1: Replacement Rates

Grain rations produced more milk/day on average (3 lbs) - although NS
Fodder rations produced more butter fat (0.4 % BF) – although NS
Experiment #1: Replacement Rates

Milk pricing by component pricing ($2.09 BF; P; SNF)

12 lbs grain ration generated $17.30
6 lbs of grain generated $15.78
3 lbs grain & 18 lbs of fodder generated $16.33
36 lbs of fodder generated $16.45

<table>
<thead>
<tr>
<th>Treatment</th>
<th>#’s/cow/d</th>
<th>% BF</th>
<th>Total lbs</th>
<th>$/day</th>
<th>% Protein</th>
<th>Total lbs</th>
<th>$/day</th>
<th>% SNF</th>
<th>Total lbs</th>
<th>$/day</th>
<th>Total $/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 lbs grain</td>
<td>52.5</td>
<td>3.66</td>
<td>1.92</td>
<td>$4.01</td>
<td>3.15</td>
<td>1.65</td>
<td>$3.45</td>
<td>8.96</td>
<td>4.70</td>
<td>$9.83</td>
<td>$17.30</td>
</tr>
<tr>
<td>6 lbs grain</td>
<td>53.4</td>
<td>3.70</td>
<td>1.98</td>
<td>$4.13</td>
<td>2.71</td>
<td>1.45</td>
<td>$3.02</td>
<td>7.74</td>
<td>4.13</td>
<td>$8.63</td>
<td>$15.78</td>
</tr>
<tr>
<td>3 lbs grain/18 lbs</td>
<td>49.4</td>
<td>3.91</td>
<td>1.93</td>
<td>$4.04</td>
<td>3.09</td>
<td>1.53</td>
<td>$3.19</td>
<td>8.82</td>
<td>4.35</td>
<td>$9.10</td>
<td>$16.33</td>
</tr>
<tr>
<td>36 lbs fodder - as</td>
<td>49.6</td>
<td>3.93</td>
<td>1.95</td>
<td>$4.08</td>
<td>3.11</td>
<td>1.54</td>
<td>$3.22</td>
<td>8.82</td>
<td>4.38</td>
<td>$9.15</td>
<td>$16.45</td>
</tr>
</tbody>
</table>

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### Experiment # 1: Replacement Rates

<table>
<thead>
<tr>
<th>Feed Costs (As Fed)</th>
<th>Parlor Grain #’s</th>
<th>$/lb</th>
<th>$ Parlor Grain $617/Ton</th>
<th>Fodder Grain #’s</th>
<th>$ Fodder grain $880/T</th>
<th>$ Supp. costs</th>
<th>Income over Supp Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 lbs grain</td>
<td>12</td>
<td>0.31</td>
<td>3.72</td>
<td></td>
<td></td>
<td></td>
<td>13.58</td>
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<tr>
<td>6 lbs grain</td>
<td>6</td>
<td>0.06</td>
<td>1.86</td>
<td></td>
<td></td>
<td></td>
<td>13.92</td>
</tr>
<tr>
<td>3 lbs grain/18 lbs</td>
<td>3</td>
<td>0.93</td>
<td>0.93</td>
<td>18</td>
<td>1.08</td>
<td>2.01</td>
<td>14.32</td>
</tr>
<tr>
<td>36 lbs fodder - as fed</td>
<td>36</td>
<td>2.16</td>
<td>2.16</td>
<td></td>
<td></td>
<td></td>
<td>14.29</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NeL/ # DM % DM</th>
<th>DM Fed</th>
<th>MegaCal Fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parlor Grain</td>
<td>0.80</td>
<td>5.34</td>
</tr>
<tr>
<td>Fodder</td>
<td>0.77</td>
<td>5.4</td>
</tr>
</tbody>
</table>

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Experiment #1: Replacement Rates

Income over feed costs IOFC

- 12 lbs of grain = $13.58
- 6 lbs of grain = $13.92
- 3 lbs grain/18 lbs fodder = $14.32
- 36 lbs fodder = $14.29

Highest to lowest IOFC

- 3 lbs grain/18 lbs fodder
- 36 lbs fodder (zero grain)
- 6 lbs of grain
- 12 lbs of grain (I’m not making this up – I swear)

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Experiment # 2  Fodder Milk Lipids

Question #2: What is the impact of fodder on milk lipids important to human health?

Treatments/Rations

- 12 lbs of grain
- 6 lbs of grain
- 3 lbs grain/18 lbs fodder
- 36 lbs fodder

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Milk Sampling Crew
Saturated Fats: reportedly hard on your heart and vascular system – particularly the shorter chain SFA such as C14:0 (myristic); C16:0 (palmitic) because they elevate blood LDL.

Overall - No difference in Total SFA content between treatments

However…. Fodder consistently reduced the shorter chain SFA concentrations (C5:0; C7:0; C8:0; C9:0; C10:0; C11:0; C12:0; C13:0 and C14:0) responsible for elevating serum LDL
Experiment # 2  Fodder Milk Lipids

Omega 6 & Omega 3 and the n6:n3 ratio

Elevated intake of Omega 3 reduces CVD; Type 2 Diabetes; Hypertension; Cancer; Dementia

Omega 6 causes inflammation

Fodder elevates DHA (C22:6 n-3)
Grain elevates n-6 (not good)

Fodder has a healthier n-6:n-3 ratio

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Experiment #3: In-Situ Digestibility

Question: What is the impact of fodder on the rumen – and how does it impact feed digestibility?

In-Situ digestibility experimentation provides feed degradation rates under different rumen conditions.

We created two rumen environments:
1) Grain diet (6 lbs grain plus alfalfa)
2) Fodder diet (18 lbs fodder plus alfalfa)

2 lbs of fodder for every 1 lb of grain

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5 gram samples of dried/ground feed were deposited in the rumen.

Feed tested included:
- Alfalfa
- Corn
- Fodder

Samples were removed at various time points to determine how much feed had been degraded:

Time points included: 96 hrs; 72 hrs; 48 hrs; 36 hrs; 24 hrs; 16 hrs; 12 hrs; 8 hrs; 6 hrs; 4 hrs and 2 hrs.
Rumen bacteria attached to alfalfa stem tissues during digestion as observed by scanning electron microscopy.

Jung et al., USDA-ARS/University of Minnesota
http://oca.cce.umn.edu/ltu_portfolio/example/ag/pdfs/jung.pdf
Rumen Fluid Collection Crew

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Preliminary Alfalfa Degradation Rates

Average Alfalfa Degradation (%DM)

- GRAIN DIET
- FODDER DIET

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Preliminary Corn Degradation Rates

Average Corn Degradation (%DM)

GRAIN DIET

FODDER DIET

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Preliminary Average Fodder Degradation (%DM)

- GRAIN DIET
- FODDER DIET

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In-Situ Degradation: Average Corn DM Residual (%)

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In-Situ Degradation: Average Alfalfa DM Residual (%)
In-Situ Degradation:
Average Fodder DM Residual (%)
Rumen Fluid Extraction Results: pH Measurements

**pH Measurements**

Average pH Levels Per Diet:
- Grain: 7.356, Standard Error: 0.059
- Fodder: 7.485, Standard Error: 0.057

Analysis of Variance P-Value: 0.124
- No Statistical Difference

**Average pH Levels**

Sprouted grain (fodder) has a pH of 5.0

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Hypothesis:

Sprouted grains may break down quickly in the rumen making additional energy available for rumen microbial replication and digestion; thus improving the rate of degradation of all feeds (both fiber and starch).
Feeding sprouted grains improves the efficiency of feed degradation at the 12, 14 and 16 hr time point.

Faster feed degradation rates would suggest a higher throughput - and may therefore represent more total milk production due to higher feed intakes over time.
Funding

California Agriculture Research Institute

Curt Chittock with Simply Country, Grass Valley, CA

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Installation Afi Milking System

- Daily milk weights
- Pedometers – monitor heat activity/health in real time
- Daily somatic cell readings

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Students and Staff that make this possible

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Conclusions

- Rumen dynamics change under the influence of fodder and do not appear to hold to the 6:1 conversion as implied by the DM analysis.
- Comparable milk production was established with a 2 lbs of fodder to 1 lb of grain exchange.
- Fodder improves the milk lipid profile by reducing LDL enhancing short chain SFA; enhancing DHA n-3 concentration and reducing the amount of n-6 (more favorable n-6:n-3 ratio).
- Adding fodder to the ration at a rate of 18 lbs/day enhances feed degradation rates of both fiber and starch-based feeds.
- Fodder based rations had a higher IOFC than the grain-based rations.
Caveats

Fodder production can be difficult

- Systems vary widely and can be very costly
  - Need to fully assess the ROI
- There is considerable labor associated with most systems
- Requires a high degree of persistence
- Mold is a continual problem - we had a lot of down time
- Training is necessary
- Can be a long learning curve
- There can be a lot of maintenance associated with the system