Low Starch Diets for Dairy Cattle
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Provimi - North America

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“Cow College”
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Questions

- Why consider low starch?
- Why starch in the first place?
- Does digestibility of starch matter?
- What are the alternatives to starch?
- Are their other parts of the diet we need to consider?
- Are economics important?
Historical Price of Corn

Univ. of Ill. FarmDoc

Historical Price of Corn and Soybeans

Univ. of Ill. FarmDoc
Historical Price of Corn, Soybeans, and Milk

- Corn ($/bushel)
- Soybeans ($/bushel)
- Milk ($/cwt)

Add Crude Oil

- Corn ($/bushel)
- Soybeans ($/bushel)
- Milk ($/cwt)
- Inflation Adjusted Crude Oil ($/barrel)

Univ. of Ill. FarmDoc
InflationData.com
What does this all mean?

- Feed prices have increased over time
- Milk prices have increased at a similar or slightly faster rate over the same time period
  - Milk is still profitable to produce
- Energy cost are the real economic driver

Déjà Vu?
Déjà Vu?

What has been will be again, what has been done will be done again; there is nothing new under the sun. Is there anything of which one can say, "Look! This is something new"? It was here already, long ago; it was here before our time.

♦ Ecclesiastes 1:9-10

“That is why we call it ‘re-search’. If we always got it finished on the first try we would just call it ‘search’.”

♦ H.G. Bateman to his grad students

Do we really need starch?

♦ Starch content of diets for dairy cattle can range from 20 to greater than 35% of DM
♦ Substituting starch for fibrous feeds tends to increase energy density of diets
♦ Feeding diets higher in starch (and lower in NDF) tend to increase DMI

♦ Grant, 2005, Tri-state dairy nutrition conference
Impact of replacing starch with corn gluten feed on milk yield

Staples, 2007 Florida Dairy Production Conference

Why do the lines all appear horizontal?

- ‘The comparison of NE\text{\textsuperscript{i}} of a processed grain to a control depends on the fineness of grind for the actual response but also to the control grain treatment in the by-difference calculation’.
- Therefore, improving the NE\text{\textsuperscript{i}} concentration of a grain source can be at the expense of the actual NE\text{\textsuperscript{i}} concentration of other ingredients that contribute potentially digestible fiber.
  - Firkins et al., JAS 2001
Impact of replacing starch with corn gluten feed on milk yield

starch is not a required nutrient in ruminant rations for either the animal or the rumen microorganisms.


Staples, 2007 Florida Dairy Production Conference

What are the alternatives

- Increase starch digestibility
- Forage
- By-product fiber
- Fat
- Sugar
- Enzymes
- Additives
What is wrong with this picture?

Improving Starch Digestion

- Fineness of grind
- Storage method
- Variety
- “Other” parts of the base diet
Influence of particle size on digestion of starch in corn grain

Influence of starch source on digestibility

Remond et al., J. Dairy Sci. 2004. 87:1389

Ferreratto et al., J. Dairy Sci. 2013.9:533
Influence of Corn Variety on Starch Digestibility


Influence of grain storage method on starch digestion

Starch Digestibility Summary

- Finer ground corn tends to improve utilization in the rumen
  - Some substitution for lower gut digestion but can not overcome loss of ruminal digestibility
- Some sources (both within grain and among grains) of starch have a greater ruminal availability than others.
- Grain storage method (dry vs ensiled) influences site of starch availability (assuming adequate processing)

Increase Forage Proportions in the Diet

- Assumes that adequate forage inventory is available for the increase
- Forage substituted for cereal grains
- Diets rebalanced to accommodate the shift in nutrient supplies
Effect of Substituting Alfalfa Silage for High Moisture Corn on Nutrient Digestion

![Graph showing apparent digestibility of DM and NDF with varying % HMC. Valadares Filho et al. J. Dairy Sci. 2000. 83:106](image1)

Effect of Substituting Alfalfa Silage for High Moisture Corn on Production

![Graph showing milk production and Milk/DMI with varying % HMC in diet. Valadares Filho et al. J. Dairy Sci. 2000. 83:106](image2)
Increase Corn Silage?

- **Was not able to locate data in published literature so making educated guesses**
  - Starch will decrease (energy may or may not depending on associative effects)
  - Milk components will stay neutral or possibly fat will improve
  - Milk yield will stay neutral at the worst
  - Diet cost ($/cow/day) may or may not change depending on what else needs to be changed

Impact of Increasing NDF through altering forage: concentrate ratio on DMI

![Graph showing DMI (kg/d) vs NDF (% of DM)]

Solid lines → Early lactation
Grey lines → Later lactation

Increase Forage Summary

- Usually will result in dilution of diet energy
  - Reduced milk yield
- May negatively impact DMI, especially in early lactation when ‘Fill’ limits intake

“Energy Content’ of Fiber By-product Feeds

<table>
<thead>
<tr>
<th>Feed</th>
<th>NE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Corn</td>
<td>0.89</td>
</tr>
<tr>
<td>Beet Pulp</td>
<td>0.788</td>
</tr>
<tr>
<td>Dried Brewers Grain</td>
<td>0.69</td>
</tr>
<tr>
<td>Citrus Pulp</td>
<td>0.857</td>
</tr>
<tr>
<td>Corn Gluten Feed</td>
<td>0.866</td>
</tr>
<tr>
<td>Distillers Grains w/Solubles</td>
<td>0.925</td>
</tr>
<tr>
<td>Rice Bran</td>
<td>0.777</td>
</tr>
<tr>
<td>Soybean Hulls</td>
<td>0.812</td>
</tr>
<tr>
<td>Wheat Midds</td>
<td>0.838</td>
</tr>
</tbody>
</table>

Impact of Replacing Grain with Non-forage Fiber on DMI

Solid lines → Early lactation
Grey lines → Later lactation

Effect of Replacing Corn with a Mixture of Fibrous-Byproduct Feeds

<table>
<thead>
<tr>
<th>Variable</th>
<th>Control</th>
<th>C30</th>
<th>C50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total VFA, mM</td>
<td>100.4</td>
<td>97.3</td>
<td>98.5</td>
</tr>
<tr>
<td>pH</td>
<td>6.13</td>
<td>6.11</td>
<td>6.25</td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>24.1</td>
<td>23.1</td>
<td>23.3</td>
</tr>
<tr>
<td>Milk, Kg/d</td>
<td>28.6</td>
<td>26.6</td>
<td>28.4</td>
</tr>
<tr>
<td>Milk fat, %</td>
<td>3.83</td>
<td>3.98</td>
<td>3.71</td>
</tr>
<tr>
<td>Milk Protein, %</td>
<td>3.33</td>
<td>3.31</td>
<td>3.23</td>
</tr>
</tbody>
</table>
Effect of Replacing Grain with Brewers Grains on Ruminal Digestibility

![Graph showing effect of replacing grain with brewers grains on ruminal digestibility.](image)

Younker et al., 1998. J. Dairy Sci. 81:2645

Impact of Varying Amounts of Soyhulls as Replacement for Corn Grain – Total Tract Digestion

<table>
<thead>
<tr>
<th>Item</th>
<th>% Soyhulls in Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>DM</td>
<td>72.6</td>
</tr>
<tr>
<td>OM</td>
<td>73.4</td>
</tr>
<tr>
<td>NSC</td>
<td>92.1</td>
</tr>
<tr>
<td>NDF</td>
<td>52.0</td>
</tr>
<tr>
<td>ADF</td>
<td>51.5</td>
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</tbody>
</table>

Impact of Varying Amounts of Soyhulls as Replacement for Corn Grain – Production

<table>
<thead>
<tr>
<th>Item</th>
<th>% Soyhulls in Diet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td>DMI, Kg</td>
<td>23.8</td>
</tr>
<tr>
<td>Milk, Kg</td>
<td>29.5</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.60</td>
</tr>
<tr>
<td>Protein, %</td>
<td>3.17</td>
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</table>


Replacing grain with digestible fiber summary

- Can be energy ‘neutral’
- May need adjustments to other dietary fractions (proteins)
- Usually will not impact dry matter intake
- With care during formulation, can be milk neutral
  - Extreme levels tend to reduce total dietary fermentability
- By – product availability (supply)
- By – product consistency (quality)
Replace Starch with Fat

- Fat has approximately 2.5x the calories per unit weight as starch
  - Fat may interfere with rumen fermentation lowering the ‘net’ caloric gain per unit weight
- Fat can stimulate milk fat content if it was marginal in supply

Impact of Added Fat on Dry Mater Intake

Effect of Fat Added to Rations in Early Lactation on Total Lactation Milk Yield


Effect of Tallow on Milk Production at 2 Dietary Levels of ADF

<table>
<thead>
<tr>
<th></th>
<th>21% ADF</th>
<th></th>
<th>28% ADF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Fat</td>
<td>Tallow</td>
<td>No Fat</td>
</tr>
<tr>
<td>DMI, kg</td>
<td>24.4</td>
<td>21.7</td>
<td>23.7</td>
</tr>
<tr>
<td>Milk, kg</td>
<td>37.5</td>
<td>38.9</td>
<td>34.7</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.4</td>
<td>2.9</td>
<td>3.5</td>
</tr>
<tr>
<td>Protein, %</td>
<td>3.5</td>
<td>3.3</td>
<td>3.4</td>
</tr>
</tbody>
</table>

Tackett et al., J. Dairy Science. 1996 79:278
Increasing Fat in the Diet Summary

- Replacing any component of the diet with fat increases the diet's energy gross density
- Fats do have physiological impact on feed intake
- Fats can interfere with rumen fermentation
  - Reduce feed intake
  - Decrease fiber digestion
  - Produce bioactive molecules that reduce milk fat synthesis
- Final impact on lactation dependant upon other parts of the diet and the form of fat supplement used

Substitute Sugars for Starch

- Sugars tend to be more rapidly and completely fermented in the rumen when compared to starch
- Substituting sugar for starch has been reported to enhance microbial fermentation and increase microbial protein yield
- Sugar should be energy neutral with starch
Effect of Substituting Sucrose for Starch on Production

<table>
<thead>
<tr>
<th>% Added Sucrose</th>
<th>0</th>
<th>2.5</th>
<th>5.0</th>
<th>7.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, kg</td>
<td>24.5</td>
<td>25.4</td>
<td>26.0</td>
<td>26.0</td>
</tr>
<tr>
<td>Milk, Kg</td>
<td>38.8</td>
<td>40.6</td>
<td>39.4</td>
<td>39.3</td>
</tr>
<tr>
<td>Fat, %</td>
<td>3.81</td>
<td>3.80</td>
<td>4.08</td>
<td>4.16</td>
</tr>
<tr>
<td>Protein, %</td>
<td>3.23</td>
<td>3.23</td>
<td>3.27</td>
<td>3.29</td>
</tr>
<tr>
<td>Lactose, %</td>
<td>4.75</td>
<td>4.74</td>
<td>4.77</td>
<td>4.74</td>
</tr>
</tbody>
</table>

Broderick et al., 2008. J. Dairy Sci. 91:4801

Fermentability of Starch Does Not Interact With Added Sugar

Eastridge et al., 2011. J. Dairy Sci. 94:3045
Elevated Sugar May Negatively Impact Rumen Fermentation

Golder et al., 2012. J. Dairy Science. 95:1971

Increasing Sugar Summary

- **Decision should be based on economics**
  - No large differences in milk yield
  - No large differences in feed intake
  - Watch total levels in relation to rumen health
Use Enzymes or other Additives?

- What to use?
- When to use it?
- How to use?
- What else do you need to consider?
- Is there a defined ‘mode of action’

Types of Products Available

- Fibrolytic enzymes
- Amylolytic enzymes
- Plant extracts
- Ionophores
Economics?

- Diets formulated in CPM 3.0.8
- Base ingredient library used (no alterations in composition)
- Prices were ‘accurate’ in western Ohio during January 2013

- 1380 Lb BWT, Holstein cow in 3rd lactation
- 80 lb of milk
- 4.00 % fat
- 3.25 % true protein
- ≈ 50 lb DMI

Base Diet

- Processed corn silage and alfalfa silage as forages
  - Fine ground corn, soybean meal, distillers grains
  - Whole cotton seed, heat treated soybean meal, blood meal
  - Vitamins and minerals
- Diet NDF – 33.0%
- Diet Sugar – 3.7%
- Diet Starch – 26.9%
- Forage – 61.15%

- Diet supports 82.5 lb (ME) or 80.0 (MP)
- Diet cost $6.88/cow/d
Raise Sugar and Reduce Starch

- Processed corn silage and alfalfa silage as forages
  - Fine ground corn, soybean meal, distillers grains
  - Whole cotton seed, heat treated soybean meal, blood meal
  - Vitamins and minerals
  - Citrus Pulp, Sugar, and Cereal Blend used in place of fine ground corn
- Diet NDF – 34.8%
- Diet Sugar – 4.3%
- Diet Starch – 16.0%
- Forage – 62.42%

- Diet supports 80.6 lb (ME) or 80.5 (MP)
- Diet cost $7.73/cow/d

Use By-product Fiber Feeds in Place of Corn

- Processed corn silage and alfalfa silage as forages
  - Fine ground corn, soybean meal, distillers grains
  - Whole cotton seed, heat treated soybean meal, blood meal
  - Vitamins and minerals
  - Citrus Pulp, Sugar, Soy hulls, and Beet pulp used in place of fine ground corn
- Diet NDF – 38.0%
- Diet Sugar – 5.7%
- Diet Starch – 15.1%
- Forage – 62.38%

- Diet supports 80.5 lb (ME) or 82.2 (MP)
- Diet cost $8.07/cow/d
Summary

- Commodity prices are increasing
- There is not a nutritional requirement for starch but for the energy that it can provide
  - Allows for potential substitution of other energy sources
- Improving starch digestibility (processing?) can be economically advantageous
- Increasing forage usually dilutes total energy (and has an impact on MP) so may reduce milk yield
- By-product fiber tends to have little to no impact on milk yield when diets are properly balanced after substitution

Summary

- When using fats to replace starch be cautious of influence of fat type on DMI and also on Milk Fat%
- Sugar can be an effective replacement for starch providing similar levels of energy to the cow and the rumen microbes
- Many enzyme and additive products alter diet energy
  - Know the mode of action so you have an idea if they have a chance to work in your specific situation
- Economics of the diet (relative prices of ingredients verses corn along with current milk price) need to be ultimate determinant of should changes be made