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?**

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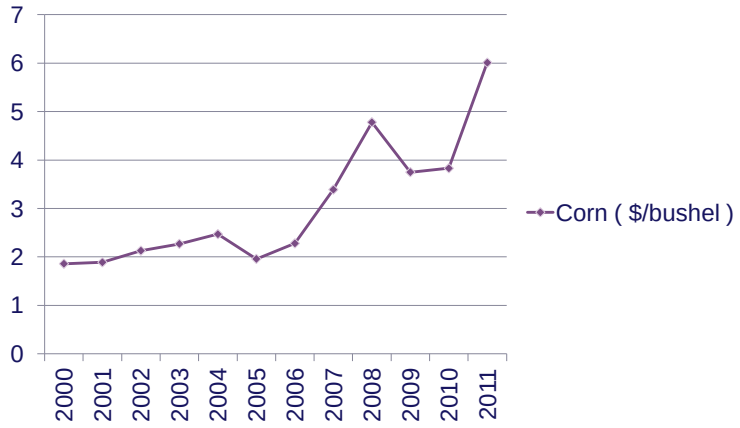
Historical Price of Corn



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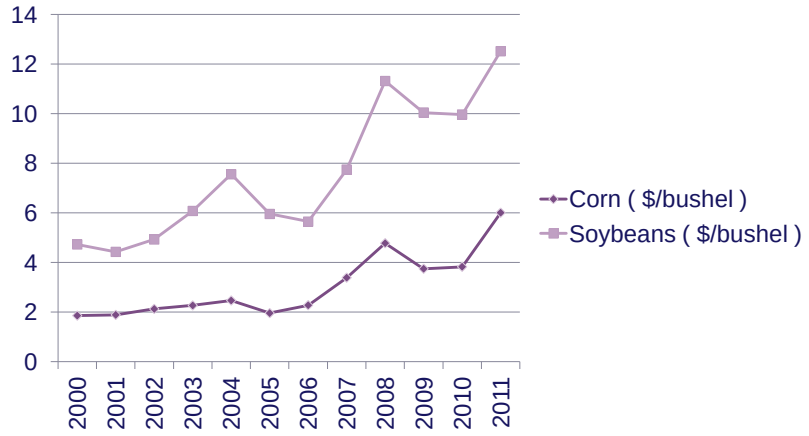
Historical Price of Corn and Soybeans



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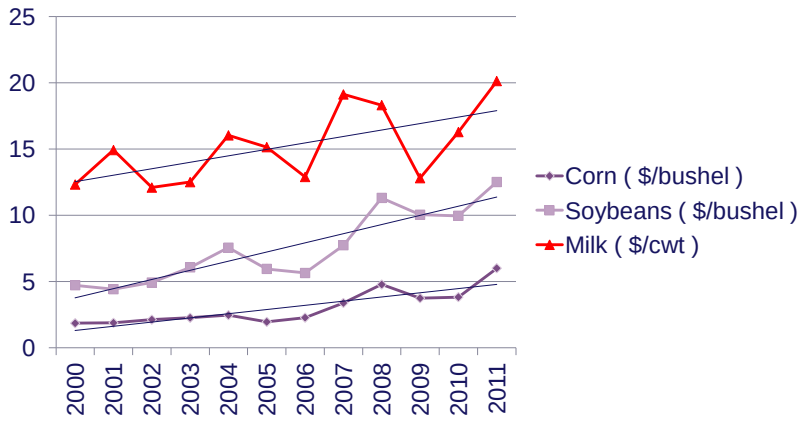
Historical Price of Corn, Soybeans, and Milk



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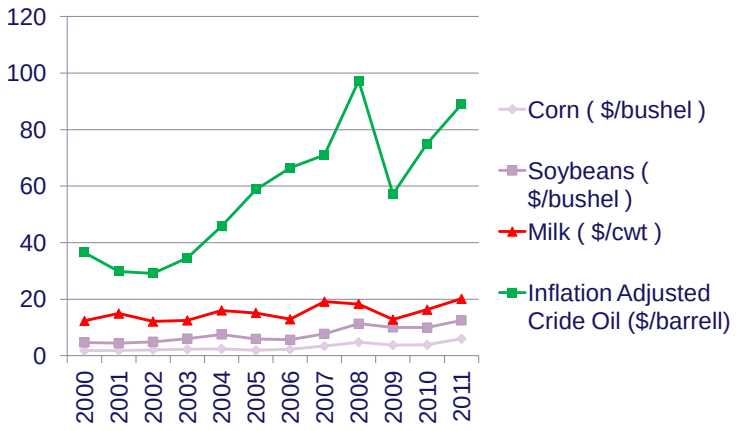
Add Crude Oil



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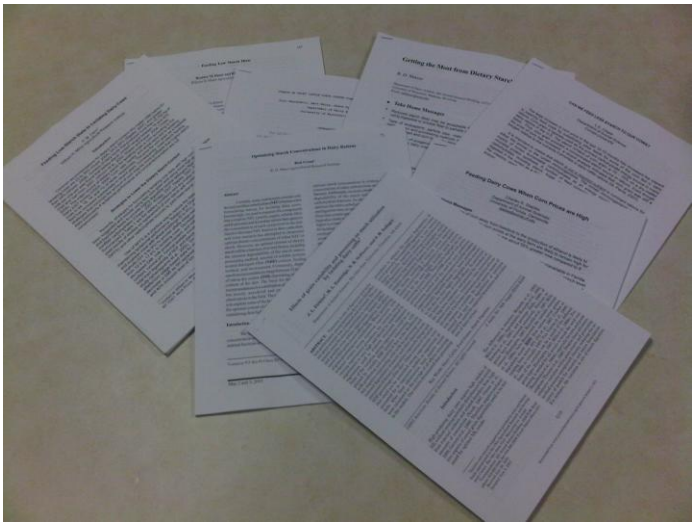
InflationData.com

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

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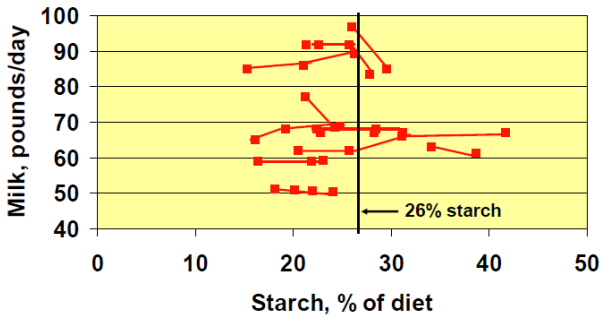
Impact of replacing starch with corn gluten feed on milk yield



Staples, 2007 Florida Dairy Production Conference

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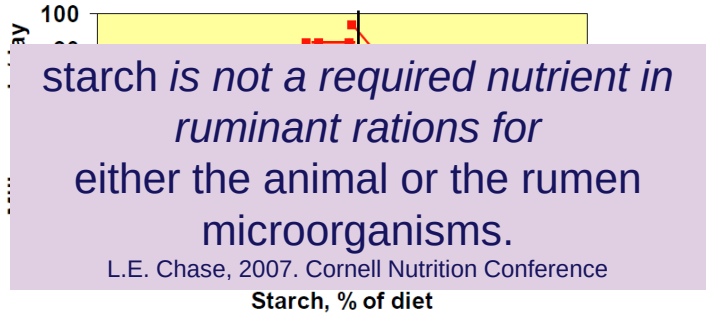
Why do the lines all appear horizontal?

- **'The comparison of NEl 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 NEl concentration of a grain source can be at the expense of the actual NEl 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.

L.E. Chase, 2007. Cornell Nutrition Conference

Staples, 2007 Florida Dairy Production Conference

What are the alternatives

- **Increase starch digestibility**
- **Forage**
- **By-product fiber**
- **Fat**
- **Sugar**
- **Enzymes**
- **Additives**

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What is wrong with this picture?

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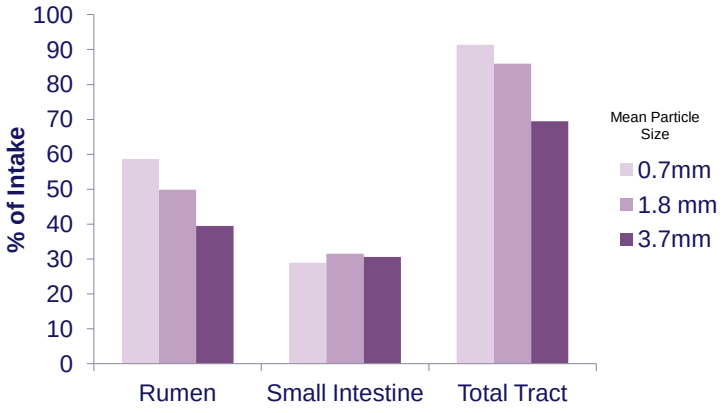
Improving Starch Digestion

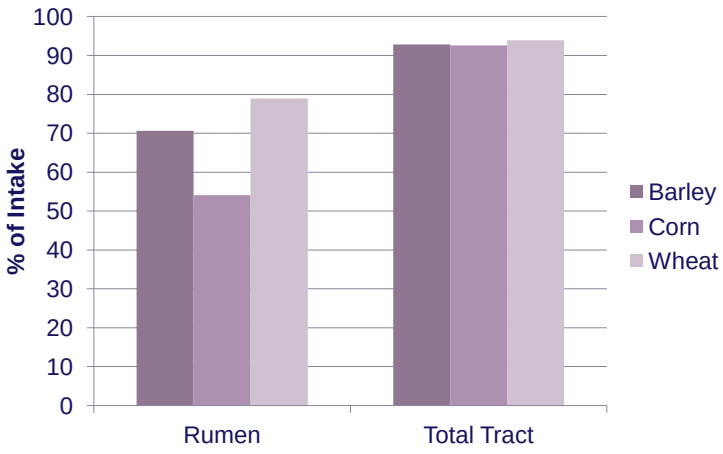
- **Fineness of grind**
- **Storage method**
- **Variety**
- **"Other" parts of the base diet**

Influence of particle size on digestion of starch in corn grain



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

Influence of starch source on digestibility



Ferreratto et al., J. Dairy Sci. 2013.9:533

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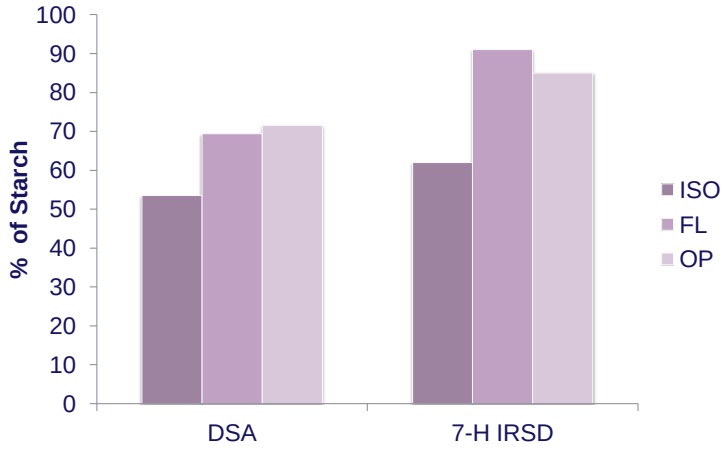
Influence of Corn Variety on Starch Digestibility



Lopes et al. J. Dairy Sci. 2009. 92:4541

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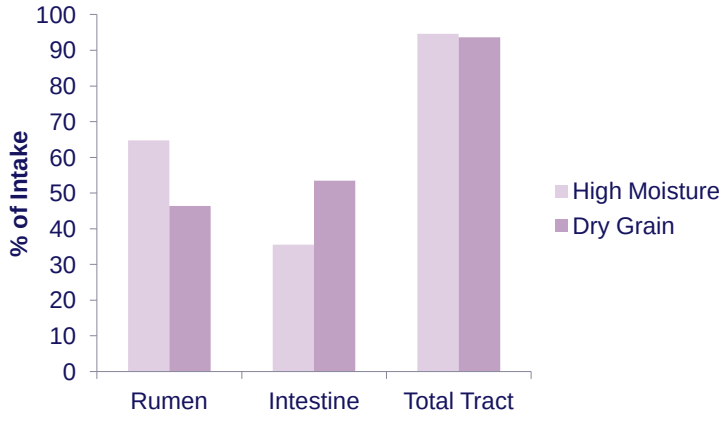
Influence of grain storage method on starch digestion



Oba and Allen, J. Dairy Sci. 2003. 86:183

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**

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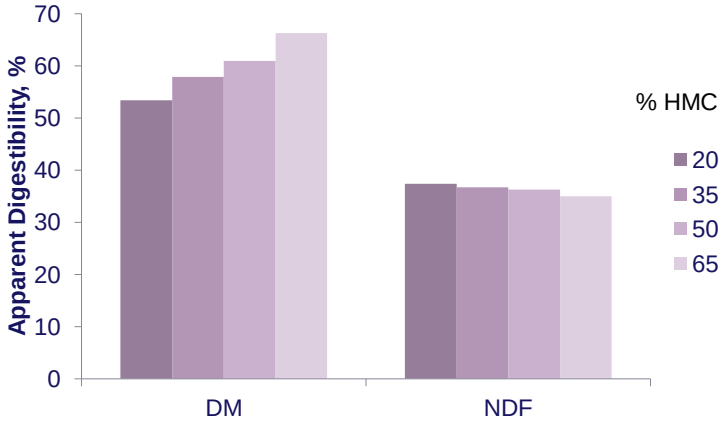
Effect of Substituting Alfalfa Silage for High Moisture Corn on Nutrient Digestion



Valadares Filho et al. J. Dairy Sci. 2000. 83:106

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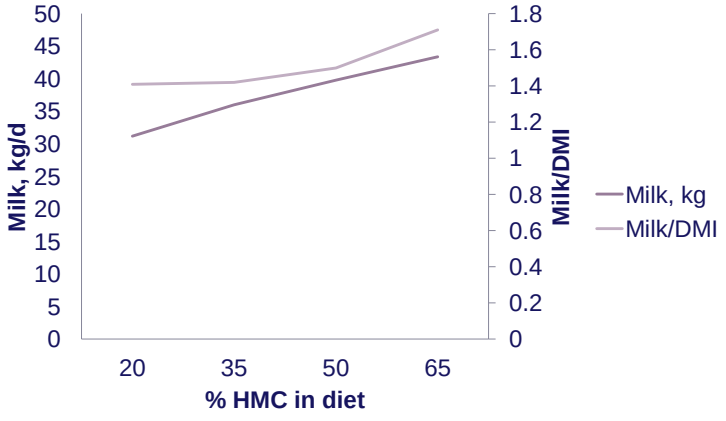
Effect of Substituting Alfalfa Silage for High Moisture Corn on Production



Valadares Filho et al. J. Dairy Sci. 2000. 83:106

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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

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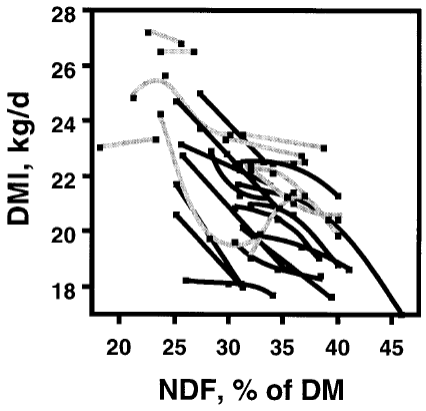
Impact of Increasing NDF through altering forage: concentrate ratio on DMI



Solid lines → Early lactation
Grey lines → Later lactation

Allen, 2000. J. Dairy Sci. 83:1598

Increase Forage Summary

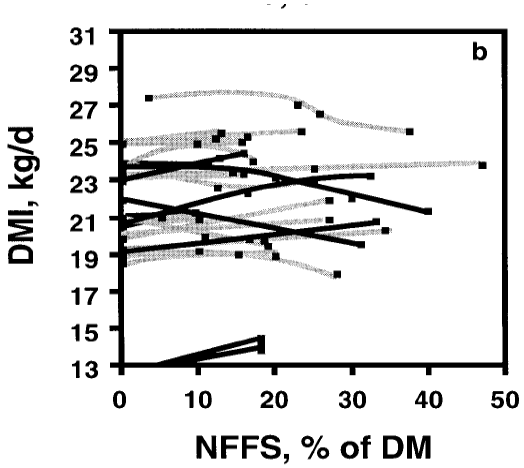
- **Usually will result in dilution of diet energy**
  - Reduced milk yield
- **May negatively impact DMI, especially in early lactation when 'Fill' limits intake**

"Energy Content' of Fiber By-product Feeds

Feed	NE
Ground Corn	0.89
Beet Pulp	0.788
Dried Brewers Grain	0.69
Citrus Pulp	0.857
Corn Gluten Feed	0.866
Distillers Grains w/Solubles	0.925
Rice Bran	0.777
Soybean Hulls	0.812
Wheat Midds	0.838

MacGregor,2000. Directory of Feeds and Feed Ingredients

Impact of Replacing Grain with Non-forage Fiber on DMI



Solid lines → Early lactation
Grey lines → Later lactation

Allen, 2000. J. Dairy Sci. 83:1598

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

Variable	Control	C30	C50
Total VFA, mM	100.4	97.3	98.5
pH	6.13	6.11	6.25
DMI, kg/d	24.1	23.1	23.3
Milk, Kg/d	28.6	26.6	28.4
Milk fat, %	3.83	3.98	3.71
Milk Protein, %	3.33	3.31	3.23

Mowery et al., 1999. J Dairy Sci. 82:2709

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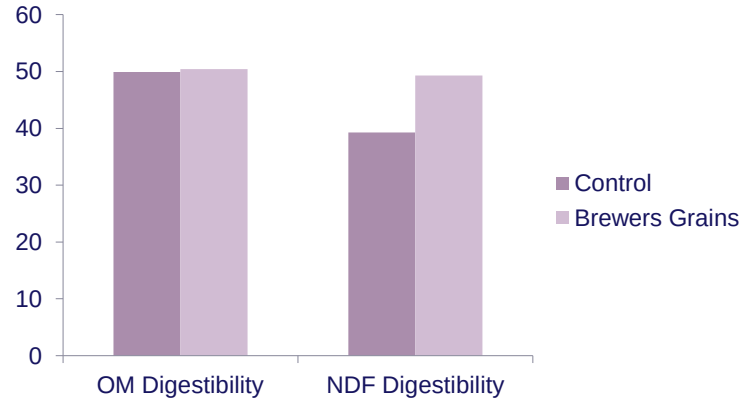
Effect of Replacing Grain with Brewers Grains on Ruminal Digestibility



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

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

Item	% Soyhulls in Diet				
	0	10	20	30	40
DM	72.6	73.0	73.0	71.2	69.4
OM	73.4	74.1	74.5	73.5	70.9
NSC	92.1	93.6	93.2	92.2	87.6
NDF	52.0	56.0	58.3	57.6	58.9
ADF	51.5	58.2	56.0	56.1	56.3

Ipharraguerre et al., J. Dairy Sci. 2002. 85:2890

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

Item	% Soyhulls in Diet				
	0	10	20	30	40
DMI, Kg	23.8	24.8	24.4	22.9	22.7
Milk, Kg	29.5	29.3	29.9	29.3	28.3
Fat, %	3.60	3.61	3.67	3.53	3.91
Protein, %	3.17	3.15	3.17	3.12	3.13

Ipharraguerre et al., J. Dairy Sci. 2002. 85:2905

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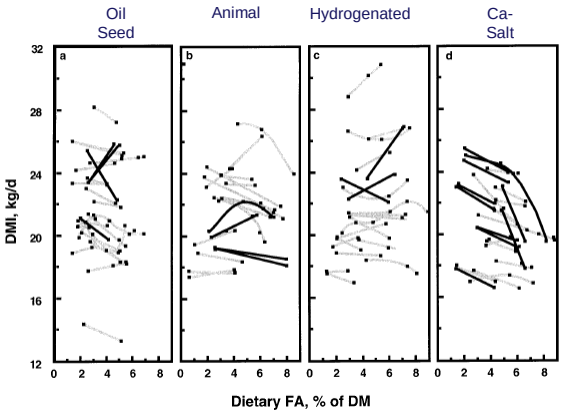
Replacing grain with digestible fiber summary

- **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 availablity (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



Allen, 2000. J. Dairy Sci. 83:1598

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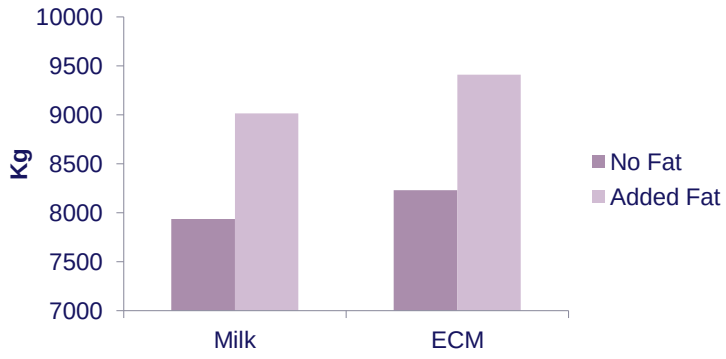
Effect of Fat Added to Rations in Early Lactation on Total Lactation Milk Yield



Schingoethe and Casper. 1991. J. Dairy Sci. 74:2617

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

	21% ADF		28% ADF	
	No Fat	Tallow	No Fat	Tallow
DMI, kg	24.4	21.7	23.7	21.5
Milk, kg	37.5	38.9	34.7	38.0
Fat, %	3.4	2.9	3.5	3.2
Protein, %	3.5	3.3	3.4	3.1

Tackett et al., J. Dairy Science. 1996 79:270

Increasing Fat in the Diet Summary

- **Replacing any component of the diet with fat increases the diets 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**

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Effect of Substituting Sucrose for Starch on Production

	% Added Sucrose			
	0	2.5	5.0	7.5
DMI, kg	24.5	25.4	26.0	26.0
Milk, Kg	38.8	40.6	39.4	39.3
Fat, %	3.81	3.80	4.08	4.16
Protein, %	3.23	3.23	3.27	3.29
Lactose, %	4.75	4.74	4.77	4.74

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

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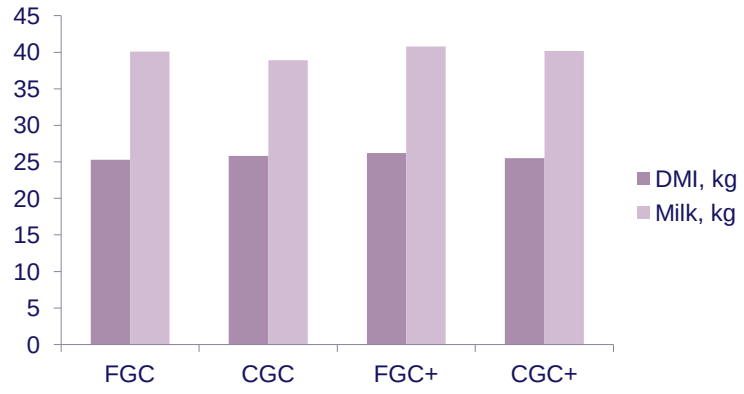
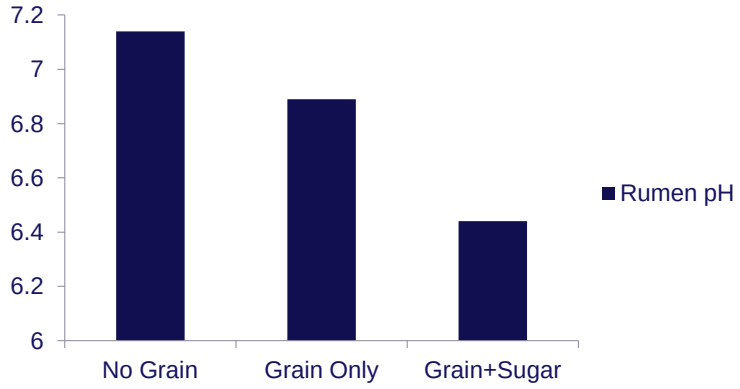
Fermentability of Starch Does Not Interact With Added Sugar



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**

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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**

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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**

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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**

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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**