SUGAR SOURCE CAN INCREASE FIBER DIGESTIBILITY: WHAT IS THE ECONOMIC IMPACT?

There are three factors that influence the impact of sugar on fiber digestion. They are the rumen degradable protein (RDP) content of the diet; forage content of the diet; and amount of sugar and starch in the diet. Due to the interaction between RDP and sugar source, it is important to compare the impact of sugar on fiber digestibility in diets where RDP is not limiting. When RDP content was adequate for optimum digestion by beef steers, starch and sugars had different impacts on fiber digestibility (Trial 2, table 1.). This difference between starch and sugars did not show up when the diet was deficient in RDP. The effect of starch and sugar on fiber digestion follows a half-moon pattern and nutritionists call this a quadratic response. There is a definite sweet spot where the response is best. On either side of this sweet spot the response is lower or non-existent. Given the interaction between forage, RDP and sugar source, the impact of sugar source on fiber digestibility will be examined using trials where RDP was not deficient and the diet contained a minimum of 42% forage. In dose response trials, the most effective dose was selected for comparison with the base diet (table 1.).

Where is the sweet spot for improving fiber digestibility by replacing starch with molasses or sugar? Exceeding 8.1% total sugar in the dairy cow diet eliminated the impact of molasses on fiber digestibility (Trials 4, 7 and 8 in table 1.) Dose response trials indicated that the impact of sugar on NDF digestibility was reduced when the dairy cow diet contained less than 5.1% total sugar (Trials 3, 4, 5, 6 in table 1.) Feeding 2.97 pounds of sugar to beef steers on very high forage diets improved NDF and OM digestibility when the sugar replaced starch (Trial 2, table 1.). Feeding dairy heifers a diet containing 5.6% dextrose (1 pound of dextrose) increased the rate of NDF digestion (Trial 1, table 1.)

Table 1. Effect of sugar source on fiber digestibility compared to starch source

Trial No. and Year	Animal Type	Forage % of Diet DM	NFC Source of Base Diet	NFC Source of Treatment Diet	Improvement in NDF Digestibility over base diet	Improvement of OM or ADF Digestibility over base diet	*P* Value
1 1994	Dairy Heifers	74.5	Corn Silage + Ground Barley	Dextrose (D-glucose)	14.5% Increased rate of digestion	5.8% (+2.2 units)	<0.05 OM, NDF
2 1999[2]	Steers	79-80	Corn Starch	Glucose	10.1% (+6.9 units)	8.8% (+6.4 units)	0.04 OM 0.05 NDF
2 1999[2]	Steers	79-80	Corn Starch	Fructose	14.2% (+10.1 units)	11.3% (+8.5 units)	0.04 OM 0.05 NDF
2 1999[2]	Steers	79-80	Corn Starch	Sucrose	1.8% (+1.1 units)	1.5% (+1.0 units)	>0.20 OM, NDF
3 2004	Dairy Cows	60	HM Corn[1]	Dried Molasses	9% (+3.6 units)	8.3% (3.5 units)	<0.01 NDF, ADF
4 2004	Dairy Cows	60	HM Corn	Molasses	18.6% (+8.3 units)	14.9% (+7.4 units)	<0.01 NDF, ADF
5 2008	Dairy Cows	60	HM Corn + Corn Starch	Sucrose	13.4% (+7.7 units)	16% (+10.4 units)	0.04 NDF 0.13 ADF
6 2004	In Vitro	60	Corn Starch	Sucrose	7.3% (+4.8 units)	Not Measured	0.05 NDF
7 2010	Dairy Cows	42	Sorghum Sil. + Ground Corn	Molasses + Sucrose	0 (dietary sugar in diet = 12 %)	Not Measured	
8 2008a	Dairy Cows	45	Ground Corn	Molasses	0	0	
9 2013	Dairy Cows	49.4	Barley Sil. +, barley, corn	Whey (lactose)	0	0	
Average					8.1% (+4.25 units)	7.4% (+4.4 units)	

[1]HM Corn = high moisture corn
[2]Second trial listed in paper ad RDP%=0.122%BWT. First trial listed in paper was deficient in RDP and was not used in this article.

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Application: Feed between 1.4 and 2.0 pounds of added sugar to increase NDF and ADF digestibility in dairy cow diets. This requires feeding 4 to 5 pounds of QLF products. For dairy heifers and steers, feed 3 to 4 pounds of QLF products.

In trials where the replacement of starch with sugar improved NDF, ADF or OM digestion, one diet characteristics stands out. Those diets had more than 50% forage in the diet. When the diets contained less than 50% forage, fiber digestion was not improved. The impact of molasses on fiber digestibility can be explained by its sugar profile. The key sugars in molasses are sucrose, fructose and glucose. These three sugars when replacing starch in diets containing more than 50% forage improved NDF, ADF or OM digestibility. Lactose from whey permeate did not improve ADF or NDF digestibility compared to starch (Trial 9, table 1). There is a difference between lactose and the sugars in molasses on their impact on fiber digestibility. **Application:** To improve fiber digestibility use QLF liquid supplements containing a high amount of molasses. Since molasses is 75% DM, liquid supplements containing 62% DM or greater will contain high amounts of molasses.

Economic Assessment of Increasing NDF, ADF and OM Digestibility.

What is the value of increased NDF, OM or ADF digestibility? A one unit increase in forage NDF digestibility was associated with an increase of 0.51 pounds of milk and 0.55 pounds of 4.0% FCM. In diets containing more than 45% forage, (Trials 2, 3,4,5,6, and 9, table 1), NDF digestibility was increased an average of 5.3 units. This increase in NDF digestion should increase milk yield by 2.7 pounds and FCM yield by 2.9 pounds. At a milk price of $19/Cwt, milk income will be increased by 51 to 55 cents per cow/d. On a 305 d lactation, this increases the milk income per cow by $156 - $168 per year.

Based on the Ohio State equation for predicting TDN content of forages from NDFD (NRC, 2001), increasing the NDF digestibility (NDFD) by 5.3 units will increase the TDN content of the forage by 5 units. An increase of TDN% of 5 units increases the net energy content of the forage by 5.8 units. A haylage sample with a TDN% of 60% would have an NEL content of 0.61mcal/lb., but if you increase the TDN to 65%, the NEL content would be 0.663mcal/lb. This is an increase of 8% in the energy value of the haylage from increasing the NDFD. The NEL content of corn silage and mixed forages is related to their TDN content. If you increase the TDN content of mixed forages by 5 units, you increase the NEL content by 14%. For example increasing the TDN content from 60% to 65%, increases the NEL content from 0.52 to 0.61 mcal/lb. There is a similar relationship for corn silage. Increasing the TDN content of corn silage from 70% to 73% increases the NEL content by 6.8% (0.727mcal versus 0.78 mcal). The take home message is that in all cases increasing NDFD will increase the net energy content of forages. The magnitude of the change will vary with forage type,

Replacing part of the starch in the diet with molasses or sugar increased OM digestibility by 4.5 units (Trials 1, 2, table 1.) ADF digestibility was increased by 5.3 units (range 0 to 10.4 units) in diets containing more than 45% forage (Trials 3, 4, 5 and 9, table 1.). Increasing OM and ADF digestibility of forages will increase the usable energy content of these forages. The value of the additional energy content will depend on stage of production of the animal and forage type. For example increasing the ADF or OM digestibility of grass hay for beef cows in the winter will have great value because grass hay makes up such a high percentage of the diet. Increasing the ADF digestibility of corn stalks will have great value when feeding them to growing beef animals or dairy heifers. **Application:** Feeding 1.4 to 2.0 pounds of added sugar increases the NDFD by 5.3 units and this will increase the energy content of haylage by 8% plus increase the TDN content of the total diet. The predicted milk increase will be 2.9 pounds of 4.0% FCM. This increased milk has a value of 55 cents per cow/d at $19/Cwt., milk price. Feeding 4 to 5 pounds of QLF products per cow/d will improve milk efficiency (4.0% FCM per lb. of DMI) and the value of forage in the diet. When feeding grass hay or corn stalks using QLF products in the diet will increase the value of these feeds to the animal by increasing their usable energy content.

References Consulted

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