Using High Oleic Soybeans in Dairy Diets

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Introduction

Monitoring Income Over Feed Cost (IOFC) for dairy herds has been a longstanding metric used to evaluate the economics of feeding programs. One of the reasons for its popularity is that it is relatively straightforward to calculate in most situations and data from the Cornell Dairy Farm Business Summary and Analysis program indicates that it consistently accounts for about 50% of the variability in overall farm profitability (Karszes, personal communication). Work that we have done within the PRO-DAIRY discussion group program to identify key factors contributing to variance in IOFC suggests that milk and milk component yields account for about 50% of the variance, feed efficiency (ECM/DMI) accounts for an additional 25% of the variance, and cost per pound of TMR dry matter accounts for only 10% of the variance. In total, these three factors account for 85% of the variance in IOFC in herds that we have studied, and milk component yields are by far the biggest influence on IOFC.

Most of the dairy industry in the U.S. has been paid using multiple component pricing for more than 20 years, with the value of fat, protein, and other solids determined on a monthly basis. During most of the early part of that time and until about 2015, milk protein was more valuable than milk fat on a per pound basis. Starting in about 2016 and continuing until today with few exceptions, the value of milk fat has been greater than milk protein. Data from the Producer Price Forecast prepared by Upstate Niagara Cooperative https://www.membership.upstateniagara.com/_membership_payprices.asp accessed 9/12/24 indicates that the value of fat and protein averaged $2.96/lb and $1.90/lb, respectively for 2023. Including projections, the values for fat and protein are expected to be $3.41/lb and $1.66/lb, respectively for 2024. Thus, while both fat and protein are very meaningful contributors to the milk check, there is clearly reward for strategies that boost milk fat and penalty for things that decrease milk fat percentage and yield.

Factors That Affect Milk Fat Production

Research conducted over the past 25 years has dramatically enhanced our understanding of factors that affect milk fat production. Primary non-nutritional factors include genetics and seasonality (Salfer et al., 2019), but nutritional factors play a major role in modulating milk fat production (Bauman et al., 2011). Among these are unsaturated fatty acid load and biohydrogenation in the rumen along with factors that contribute to altered biohydrogenation resulting in the production of unique bioactive fatty acids that directly downregulate genes related to lipogenesis in the mammary gland.

Biohydrogenation pathways under "normal" and "altered" ruminal metabolism are described in Figure 1. Key risk factors for milk fat issues include the amount and availability of linoleic acid and factors that contribute to the "isomerase shift" causing the bacteria to convert linoleic acid to the milk fat depressing *trans*-10, *cis*-12 conjugated linoleic acid (CLA) rather than the *cis*-9, *trans*-11 CLA. These risk factors include decreased rumen pH either because of diet formulation or feeding behavior factors such as slug feeding in overcrowded group situations, mycotoxins, and other undetermined factors.

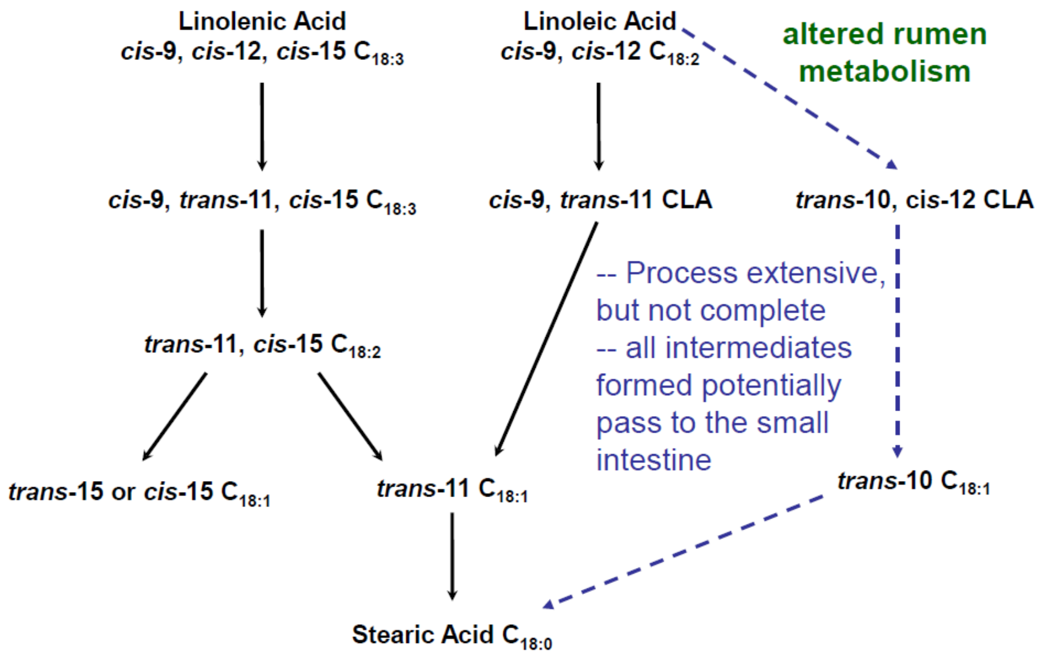

Figure 1. Biohydrogenation pathways during normal and altered ruminal fermentation. Adapted from Bauman and Griinari (2003).

Corn and conventional soybeans typically contain linoleic acid at 50 to 60% of their total fatty acid content (Cornell Net Carbohydrate and Protein System v. 6.5.5; CNCPS) and as such lactating cow diets based heavily on corn silage, other corn products, and soy products can approach or exceed 400 g/d and it only takes 2 to 3 grams of the *trans*-10, *cis*-12 CLA escaping the rumen to meaningfully decrease milk fat. Because of the concern over too much linoleic acid in the rumen affecting milk fat, nutritionists have commonly limited inclusion rates of conventional full-fat soybeans to no more than 3 to 5 lbs per cow per day.

High oleic soybeans have been produced by genetic modification (Wilson, 2012), resulting in much higher oleic acid and much lower linoleic acid content than conventional soybeans. Feed library values for conventional soybeans would be ~23% of total fatty acids as oleic acid and ~54% of total fatty acids as linoleic acid; high oleic soybeans would have ~76% of total fatty acids as oleic acid and ~7% as linoleic acid. This would mean that there is inherently less risk for negative impacts on milk fat by feeding high oleic acid soybeans compared to conventional, and I am aware of nutritionists feeding upwards of 7 to 8 lbs per cow per day of high oleic soybeans.

However, inherently less risk doesn't mean no risk. Interestingly, there are negative relationships between oleic acid intake and milk fat. McCarthy et al. (2018) reported, from data collected in a cross-sectional observational study involving 79 Holstein herds in the Northeast and Upper Midwest, that increasing oleic acid intake was associated with lower milk fat percentage whereas, also interestingly, linoleic acid intake was not. In a controlled feeding study evaluating the independent and combined effects of oleic acid and linoleic acid on milk fat, He et al. (2012) determined that linoleic acid was more potent than oleic acid at decreasing milk fat; however, there was a negative relationship between oleic acid intake and milk fat.

Studies Feeding High Oleic Soybeans to Lactating Dairy Cows

Lopes et al. (2017) fed cows one of three soybean sources varying in FA profile and processing method in diets with forage base of mostly corn silage. Treatments were "Extruded conventional soybean meal; ether extract 8.7% with 15% of FA as oleic and 54% as linoleic"; Extruded high oleic soybean meal; ether extract 8.4% with 73% of FA as oleic"; and "whole roasted high oleic soybeans with 20% ether extract". Total dietary ether extract averaged ~4.0% and were very similar across treatments. They reported similar DMI and milk yield across treatments, but milk fat percentage was increased for cows fed the two high oleic soy treatments compared to the conventional soybean meal control (~ 3.75 vs. 3.55%).

Weld and Armentano (2018) conducted two experiments to evaluate the role of high oleic soybeans in diets for dairy cattle. In their first experiment, they fed whole conventional vs. whole high oleic soybeans, both raw (unroasted). Total dietary ether extract was ~ 5.0%. In this study there were no overall effects of treatment on outcomes, but there were some relatively minor parity interactions between primiparous and multiparous cows on milk fat percentage and yield. In a second experiment, they assigned cows to either a low-fat control diet or one of four treatments: ground raw conventional soybeans, ground raw high oleic soybeans, whole raw conventional soybeans, and whole raw high oleic soybeans. Of note is that the ether extract content of the low-fat control was 3.2% whereas the four other treatments were between 6.3 and 7.1% ether extract. Further, the starch content was relatively high (~30%) and particle size of the TMR was very small, particularly for the diets containing ground soybeans (~70% of the TMR was on the 4-mm screen and pan). Not surprisingly, milk fat percentage was low for the control (3.25%) and higher for ground high oleic vs. ground conventional (3.50 vs. 3.09%). Milk fat percentage was similar among the two whole soybean treatments.

Most recently, the group at Michigan State has conducted studies evaluating high oleic acid soybeans in diets for lactating dairy cattle. In the first study, Bales and Lock (2024a) fed roasted and ground high oleic soybeans at 0, 8, 16, and 24% of diet dry matter, replacing soybean meal and soyhulls as the high oleic soybeans increased. Diets were isonitrogenous, but as inclusion rate of the high oleic soybeans increased, total fatty acids increased linearly from ~2.6 to 5.7% of diet DM and NDF decreased from about 29 to 27% of diet DM. Diets contained about 45% forage, predominantly from corn silage.

As high oleic soybean inclusion rate increased, DMI decreased linearly, milk yield increased quadratically, yields of ECM increased linearly, yields of milk fat increased linearly, and yields of protein were quadratically affected such that it increased when high oleic soybeans were fed at the 8% level but plateaued thereafter. Feed efficiency (ECM/DMI) was increased linearly with greater inclusion rates of high oleic soybeans.

In a second experiment, Bales and Lock (2024b) sought to compare the effects of feeding raw versus roasted high oleic soybeans and also to determine whether adding additional ruminally undegradable protein to a diet containing raw high oleic soybeans would improve performance. They had a control without added soybeans with a total dietary fatty acid content of 2.8%. They had two treatments with high oleic soybeans added at the 16% of dietary DM level – one raw and one roasted. They had a fourth treatment in which raw high oleic soybeans were fed and in which soyhulls were replaced by expeller soybean meal. Diets were isonitrogenous but the total fatty acid content of the three treatments with high oleic soybeans added ranged from 4.9 to 5.1%. Dry matter intakes were increased in all three soybean treatments compared to the control. Yields of milk and milk fat were increased in the soybean treatments compared to the control, but the greatest increases occurred in the cows fed roasted high oleic soybeans. Feed efficiency was increased in cows fed the soybean treatments. From my perspective, this study clearly reinforces the need to roast high oleic soybeans for maximum feeding value.

Nicholson et al. (2024) conducted an economic analysis for inclusion of high oleic soybeans in diets for dairy cattle. They used results from the Lopes et al. (2017) study and the two studies described in Weld and Armentano (2018) and results from two unpublished studies. In general, they demonstrated positive economic responses from inclusion of high oleic soybeans, with most responses in the $0.12 to $0.20 per cow per day range. I believe that the methodology that these authors used was sound; however, in two of the five studies there was clearly milk fat depression that was being at least partially rescued by the inclusion of the high oleic soybeans. In surveying the available literature, I think that the only time one might expect a milk fat response is in a case where there is some milk fat depression with elevated linoleic acid supply and availability in the rumen as a risk factor.

Summary

The availability of high oleic soybeans offers the opportunity to feed more whole soybeans than conventional with inherently (but not zero) risk for milk fat issues. One should not routinely expect increased milk fat percentage if there is not evidence of milk fat depression, so the opportunity may be to examine whether or not there are ways to decrease feed cost. Roasting high oleic soybeans greatly increases their feeding value by increasing the ruminally undegradable fraction. Until these become widely available as feed ingredients in feed mills, this is largely an opportunity for a farm to utilize “extra” acres or partner with a crop farm or purchase as a commodity.

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