Linoleic acid: Main driver in milkfat depression

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AT A GLANCE

Meta-analysis shows dietary supplementation of linoleic FA to lactating dairy cows can reduce DM intake, milkfat yield and milkfat concentration with a concomitant reduction in 4% fat-corrected milk.

Early in the 20th century, researchers found that fat-free diets had adverse effects on growth in rats. This newly discovered "factor" was suspected to be a vitamin which they labeled at the time vitamin F. It was later on that the unknown substance was identified not as a vitamin but a combination of essential unsaturated fatty acids (FA), with linoleic acid being the predominant one. Since then, their effect on brain function, immune response and skin health has been documented extensively. The reason is: The body is unable to desaturate fatty acids beyond one double bond (oleic), making the presence of linoleic (two double bonds) and linolenic (three double bonds) essential in the diet of livestock and humans.

Modern research has found that under certain altered rumen environmental conditions in dairy cows, biohydrogenation of linoleic acid can follow alternate pathways which generate specific intermediaries, such as the trans-10, cis-12 conjugated linoleic acid (CLA) and trans-10 C18:1. Once absorbed, these metabolites are carried to the mammary gland, where they reduce milkfat synthesis by interfering with the expression of genes that code lipogenic enzymes and key regulatory molecules. So, yes, polyunsaturated fatty acids are needed in the diet – and yes, under certain rumen fermentation conditions, too much will reduce the production of milkfat.

Vegetable oils, such as those found in common feeds and some fat supplements, vary in contents of oleic, linoleic and linolenic acids. The main feedstuffs included in diets fed to dairy cows under confinement contain significant amounts of linoleic acid in their composition. Corn grain and related feedstuffs (i.e., corn silage, high-moisture corn, distillers dried grains) all contain oil, of which nearly 50% of its fatty acid composition is linoleic acid. Oil contained in soybeans and its co-products also show high levels of linoleic acid (about 50% total FA). Conversely, canola is rich in oleic acid, whereas linolenic is the predominant FA in most grass and legume forage species.

Fat is the milk component most easily modified by the diet, with possible changes of up to three percentage units. Nutrition and feeding management represent the environmental factors with the greatest impact on milkfat, and it can be used to alter its fatty acid composition. Traditionally, the concept of rumen unsaturated fatty acid load (RUFAL) is used to reflect the total amount of rumen-unprotected unsaturated FA ingested daily and their potential to trigger milkfat depression. The RUFAL index is calculated as the sum of the three primary unsaturated FA consumed by dairy cows: oleic, linoleic and linolenic acid. However, researchers from Université Laval, Québec, Canada recently reported that dietary oleic and linolenic, as components of RUFAL, do not have the same detrimental effects on milkfat content as linoleic. Further, another meta-analysis conducted by French researchers suggested a greater negative effect on milkfat concentration by soybean oil (higher in linoleic acid) versus canola oil (higher in oleic acid).

It is well established in the literature that feeding free vegetable oils rich in oleic acid results in

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greater milkfat secretion than does feeding linoleic-rich oils. A Pennsylvania State University study in 2017 reported that compared with conventional, high-linoleic acid variety extruded soybean meal, an extruded high-oleic acid variety soybean meal increased milkfat concentration and tended to increase fat yield. Similarly, a study in 2006 showed milkfat depression by high-linoleic acid safflower oil but no effect on milkfat by high-oleic acid sunflower oil.

Numerous experiments have studied the use of vegetable oils in dairy cow diets to alter milkfat synthesis, but we could find no reports directly examining the effects of linoleic consumption. Using a meta-analysis approach, our group recently evaluated the effects of dietary linoleic intake on lactating dairy cow performance and milk composition. Our database included 51 treatment diets obtained from 14 peer-reviewed articles published from 2000 to 2019 in which supplemental corn or soybean oils were added into dairy diets.

The inclusion levels of vegetable oils varied from zero to 7.4% on a dry matter (DM) basis, and linoleic acid intake ranged from 143 to 760 grams per day (averaged 442.3 grams per day). We observed that increasing linoleic acid intake linearly decreased DM intake (**Figure 1**) and 4% fat-corrected milk (FCM) (**Figure 2**). This decrease in DM intake could have been related, in part, to a negative effect of dietary unsaturated fat on ruminal fermentation and fiber digestion. Another mechanism to explain this hypophagic effect may be related with satiety-inducing gut peptides; increasing circulating levels of cholecystokinin and glucagon-like peptide-1 were observed previously

FIGURE 1 Effects on DM intake

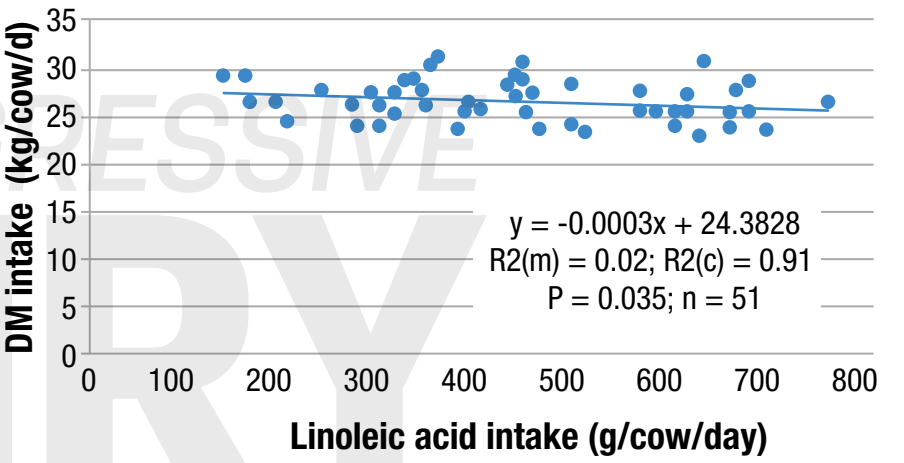
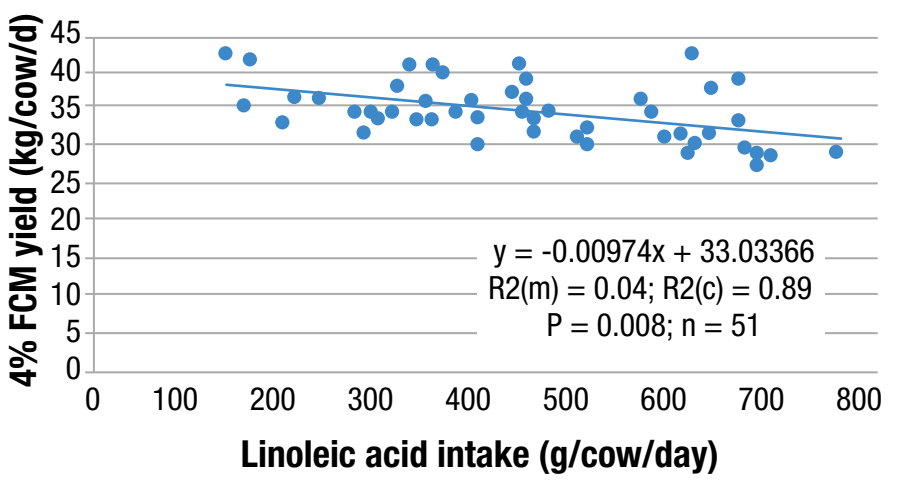


FIGURE 2 Effects on 4% fat-corrected milk



when cows consumed diets rich in polyunsaturated FA.

Fat supplements are often used in dairy rations to increase their energy density. However, it is well documented that increasing the amount of polyunsaturated FA contained in the diet can reduce milkfat yield through the production of specific biohydrogenation intermediates in the rumen. This meta-analysis shows milkfat concentration decreases in response to linoleic acid intake at a rate of 0.18 percentage points per 100 grams of linoleic acid consumed (**Figure 3**). According to these results, milkfat depression can be predicted by the changes in linoleic acid consumption using the regression formula:

$$y = -0.0018x + 4.0070$$

Where "y" is milk content in percentage points and "x" is the cow daily intake of linoleic acid in grams. Due to a reduction in milkfat concentration, it was expected that total production of milkfat