

Understanding and Troubleshooting Milk Fat Depression in Dairy Herds¹

Leandro F. Greco and José E.P. Santos²

Introduction

Fat and milk protein are the most valuable milk components. Several factors can contribute to change the proportion and total amount of fat and protein in the milk. The most common include genetic makeup, environment, health, and nutrition. The fat content in milk can be altered positively or negatively by dietary changes. Diets formulated to maximize milk production utilize a high proportion of concentrates and/or a high content of specific fatty acids. Sometimes, these energy-rich diets can exert negative effects on milk fat, causing low milk fat syndrome, widely known as milk fat depression (MFD). Several theories have been put forth to explain the cause of MFD and to suggest how to avoid the problem. The objectives of this publication are to review some of the dietary factors that induce MFD and explain how to troubleshoot this problem.

Milk Fatty Acids and Concentration of Fat in Milk of Dairy Cows

Milk fat is present primarily as triacylglycerols containing fatty acids with different lengths of carbon chains and different degrees of saturation. Fatty acids with a carbon chain length from 2 to 8 carbons are called short-chain, from 10 to 12 carbons are called medium-chain, from 14 to 18 carbons are called long-chain, and more than 18 carbons are called very-long-chain. These same fatty acids can be classified according to the number of double bonds in the carbon chain as saturated (no double bonds),

monounsaturated (a single double bond), and polyunsaturated (more than 1 double bond). Finally, the configuration of the double bond in the carbon chain can vary. Double bonds can be present in the native *cis* configuration in which the hydrogen atoms are on the same side of the carbon chain or in a *trans* configuration in which the hydrogen atoms are on opposite sides of the carbon chain. Unsaturated fatty acids with a *trans* double bond, also called *trans* fats, are normally present in milk because they are synthesized by bacteria living in the rumen of cows.

Fat appears in milk through two major routes:

- 1) Fat consumed by the cow or stored in the adipose tissue is absorbed into the bloodstream. The mammary gland then moves these fats from the blood directly into milk. About half of the 16-carbon fatty acids and all longer-chain fatty acids in milk come from the diet or fat reserves.
- 2) The mammary gland can synthesize short- and medium-chain fatty acids by pulling compounds from the blood that were produced in the rumen during fermentation of feed by resident microorganisms.

When dairy cows develop MFD, the synthesis of the shorter-chain fatty acids is compromised. As a result, the proportion of fatty acids having up to 16 carbons in the milk fat decreases more dramatically than those fatty acids with 18 or more carbons (Table 1). Therefore, MFD is characterized primarily by a reduction in fat synthesis by

1. This document is AN261, one of a series of the Animal Sciences, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date June 2011. Visit the EDIS website at <http://edis.ifas.ufl.edu>.
2. Leandro Greco, PhD student, and José E.P. Santos, associate professor, Department of Animal Science, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.

the mammary gland. Several theories have been proposed to explain the physiology behind this reduction in fat synthesis.

Milk Fat Depression Theories

Milk fat depression is generally observed when dairy cows are fed diets containing a high proportion of concentrates (particularly readily fermented sources of starch), a low proportion of forages or forages that are finely chopped, and a moderate to high proportion of unsaturated fatty acids.

The first theory suggested that microorganisms in the rumen do not produce enough acetic and butyric acids so that the mammary gland synthesizes less fat to put into the milk. This theory was largely based on the knowledge that feeding high grain/low forage diets produces a less proportionate amount of acetic acid and a greater proportionate amount of propionic acid. Further research disproved this theory.

A second theory suggested that the greater proportionate amount of propionate produced when cows are fed high grain diets resulted in a greater amount of glucose produced by the liver. This, in turn, increases the hormone insulin in blood, which partitions nutrients away from the mammary gland in favor of muscle and fat tissues. This theory was rejected after studies demonstrated that cows given insulin did not suffer from MFD.

A more current theory is that the combination of high grain and high unsaturated fatty acids in the diet causes the microorganisms in the rumen to produce more *trans* fatty acids. Some of these *trans* fats have suppressive effects on fat synthesis in the mammary gland. This theory was confirmed after scientists induced MFD by infusing these *trans* fats directly into the abomasum of dairy cows.

Low forage, high concentrate diets cause the rumen fluid to be more acidic, which alters the microbial population because some bacteria are sensitive to acidic conditions. The shift in rumen microflora favors accumulation of *trans* fatty acids that can depress milk fat synthesis after absorption into the blood.

Avoiding Milk Fat Depression

Within a given herd, environment and nutrition are likely to explain most of the variation in bulk tank milk fat content from day to day. In hot climates, the summer months typically result in depression in milk fat concentration (Figure 1). Although the exact mechanisms are not entirely

clear, it is thought that reductions in milk fat during hot months are the result of changes in eating patterns of dairy cows and reduced buffering capacity of saliva because of panting. It is also possible that increased body temperature during heat stress might have a direct effect on fat synthesis by the mammary gland. Therefore, proper cooling of cows is critical for producing milk in hot environments. This requires shade, forced ventilation, and evaporative cooling.

Because the two basic conditions for MFD are the consumption of polyunsaturated fatty acids and an acidic ruminal environment, measures to minimize milk fat depression should focus on identifying the nutritional components (diet formulation or dietary management) that favor those two conditions.

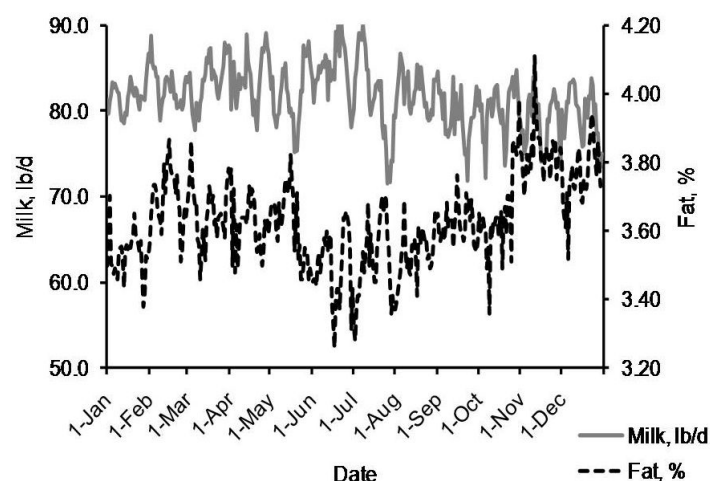


Figure 1. Daily milk production (lb/cow/day) and bulk tank fat content (%) throughout the year in two large dairy herds in the southwestern United States.

Dietary Unsaturated Fatty Acids

Polyunsaturated fatty acids are commonly present in dairy cattle diets. Vegetable oils present in grain byproducts and oilseeds as well as fish oil from fishmeal are common sources of unsaturated fatty acids implicated with MFD. The contribution of high-fat byproducts can be more problematic given the variability in composition of some of them. Increased use of distiller's grains from either corn or sorghum, which have between 8% and 14% crude fat, has been the culprit causing MFD on many farms. In order to minimize the risk of MFD, the amount of polyunsaturated fatty acids present in the diet should be controlled. In many cases, the total dietary fat in lactating cow rations should be less than 6% of the dry matter, and less than 3% is suggested to be unsaturated fatty acids.

Balancing Dietary Carbohydrates

Excessive amounts of fermentable carbohydrates, particularly starch, can depress rumen pH and favor MFD. Most lactating cow diets contain approximately 35%–40% non-fiber carbohydrates of which 70%–75% is from starch, with the remainder provided by sugars and soluble fiber. Excessive starch feeding (i.e., diets with > 28% starch) predisposes cows to MFD. This is particularly important when the starch source is rapidly fermentable in the rumen, such as that from extensively processed grains (steam-flaking or finely ground) or grains harvested with high moisture (high-moisture corn).

On the other hand, diets that provide sufficient fiber, particularly from forages with long particle size that stimulate cud chewing and saliva production, maintain a more stable rumen environment and favor milk fat synthesis. Typical dairy cattle diets contain 40%–55% forage, and the dietary fiber (neutral detergent fiber) from forage sources should make up at least 20% of the dietary dry matter, in most cases. When high-fiber byproducts are used in the diet to replace forage fiber, it is prudent to increase the total amount of dietary fiber at the same time that dietary starch is reduced. This is because the fiber in byproducts does not have the same ability to stimulate cud chewing and salivation as forage fiber.

Buffer and Alkalinizing Agents

Sodium bicarbonate and sesquicarbonate are rumen buffers commonly used in diets of dairy cattle to improve milk fat synthesis. Sodium bicarbonate is typically fed at 0.7%–1% of the diet dry matter to neutralize the organic acids produced in the rumen. This makes the rumen fluid less acidic, thereby minimizing the risk of MFD. Concurrent with buffers, feeding of alkalinizing agents such as magnesium oxide to increase dietary magnesium content to 0.35%–0.40% of the diet dry matter also tends to favor milk fat synthesis.

Ionophores

Diets for lactating dairy cows in many countries can be supplemented with ionophores to improve feed efficiency and minimize the risk of ketosis. In the United States, the ionophore monensin is typically fed to lactating cows at 5.5–11 mg per lb of feed (12–24 ppm) on a dry basis. Because ionophores kill some of the populations of rumen microorganisms, it shifts the rumen microflora favoring populations that produce more *trans* fatty acids. When ionophores are combined with diets high in starch and in unsaturated fatty acids, the risk for MFD substantially

increases. Therefore, it is prudent to evaluate ionophore feeding practices when dietary circumstances favor greater use of starch and fat sources.

Feeding Management

Although diet composition is key in preventing MFD, feeding management and diet presentation to cows cannot be neglected. Preventing slug feeding by minimizing competition in the feed bunk is critical, which allows less dominant cows to consume feed that has not been sorted through by more dominant cows. As space in the bunk is reduced, cows increase their eating rate to compensate for less time available for eating. Also, proper presentation of diet minimizes sorting against longer particles. Although mixing of diets should preserve long particles, particularly forages, the length of long particles should not be excessive. Excessive long forage particles (usually longer than the muzzle of the cow) favor sorting against them. Use of wet ingredients, such as silages and wet byproducts (as well as feeding of molasses), tends to favor agglomeration of feed particles and prevent sorting.

References

- Bauman, D.E., and J.M. Griinari. "Nutritional Regulation of Milk Fat Synthesis." *Ann. Rev. Nutr.* 23 (2003):203-27.
- Griinari, J.M., D.A. Dwyer, M.A. Mcguire, D.E. Bauman, D.L. Palmquist, and K.V.V. Nurmela. "Trans-octadecenoic Acids and Milk Fat Depression in Lactating Dairy Cows." *J. Dairy Sci.* 81 (1998):1251–61.
- National Research Council. *Nutrient Requirements of Dairy Cattle* 7th rev. ed. Washington, D.C.: Natl. Acad. Sci., 2001.

Table 1. Content and fatty acid profile of milk fat of mid-lactation Holstein cows fed diets that differ in the ability to induce milk fat depression (MFD)¹.

	Diet ²	
	Low risk of MFD	High risk of MFD
Milk fat		
%	3.58	2.49
lb/day	2.31	1.50
Fatty acids, % of reported fatty acids		
4–14 carbons	24.5	23.1
16 carbons	36.0	25.0
18 carbons	39.5	51.8

¹ Adapted from Griinari et al. (1998).

² Low risk MFD = diet containing 50% forage and supplemented with 3.8% mostly saturated free fatty acids; High risk MFD = diet containing 20.8% forage and supplemented with 4% corn oil.