# The Source of Milk Fat is a Source of Insight

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Of the components of milk, milk fat is energetically the most expensive, and can account for 50% of milk energy. Understanding the sources of milk fat can help provide valuable insight into the nutritional and energetic status of the cow or herd.

The source of milk fat is primarily categorized into three groups: de novo, preformed, and mixed.

## De Novo

De novo fatty acids are synthesized in the mammary gland from non-fatty acid precursors, are 16 carbons (C16) or less, and contribute roughly 50% of milk fatty acids. These fatty acids are generated through a lipogenic pathway that requires activation of a primer (acetate) and then sequential additions of more carbons which come from acetate, butyrate, or ß-hydroxybutyrate (BHB). Of interest, BHB can either come from rumen wall oxidation of butyrate to BHB, or from BHB generated from the liver by ketogenesis. This mammary gland use of BHB as a milk fat precursor explains why cows with ketosis, or hyperketonemia, often have greater milk fat. Elongation typically stops at 16 carbons and the process requires several enzymes that are subject to regulation by dietary and rumen conditions.

## Preformed

In contrast to de novo fatty acids, preformed fatty acids are fatty acids that are taken up from the blood as such, and then incorporated into triglyceride or other lipids in the mammary gland and contribute to milk fat. Preformed fatty acids can come from dietary lipids or from fatty acids mobilized from adipose tissue and are 16 carbon or greater. Of the preformed fatty acids, roughly 80% are from dietary lipids and 20% are from mobilized body lipids; however, this proportion is greatly shifted in postpartum cows when mobilization of fatty acids from adipose tissue is elevated. Dietary fatty acids are subjected to rumen biohydrogenation, a bacterial process that sequentially saturates the fatty acids before they pass to the small intestine for absorption. Under ideal conditions, most of the fatty acids leaving the rumen are saturated; however, there are many situations when long chain, unsaturated fatty acids are available for absorption post-rumenally. Preformed fatty acids mobilized from adipose tissue are predominately C16:0, C18:0, and C18:1.

## Mixed

Milk fatty acids that are 16 carbon long can come from preformed or de novo origin and cannot be differentiated by length only. These fatty acids are long chain fatty acids ($\geq$C16) and may already be unsaturated and contain double bonds.

Determining a cow's milk fatty acid profile can give us insight into rumen and metabolic conditions that cow is experiencing. As expected, there is a shift in relative proportions of these fatty acid groups as cows start lactation in negative energy balance and then progress into peak and mid-lactation (Figure 1). These are expected changes, but we can only detect them on an individual cow or pen-basis since at the herd-level, the bulk tank represents a mix of cows across different stages in lactation.

For example, we expect to see an increased proportion of long chain fatty acids (>C16) in postpartum cows because of increased mobilization of fatty acids from adipose tissue. Within a group of postpartum

cows, we may also be able to observe specific cows that have greater short chain fatty acids from de novo fatty acid synthesis in cows that may have sub-clinical ketosis and more BHB available to the mammary gland as a precursor for fatty acid synthesis.

Figure 1. Contribution of de novo fatty acids (≤C16; orange), preformed fatty acids (≥C16; gray), or mixed fatty acids (C16; blue) to milk fat in first lactation cows across Holstein herds in the top 20% of ECM.

We can also observe the impact of nutrition on the milk fatty acid profile. Depending on the underlying cause, milk fat depression also elicits characteristic changes in milk fatty acid profiles. In cases that result in incomplete biohydrogenation of fatty acids in the rumen, bioactive fatty acids can leave the rumen and suppress de novo milk fat synthesis in the mammary gland and we can observe a decrease in short chain fatty acids.

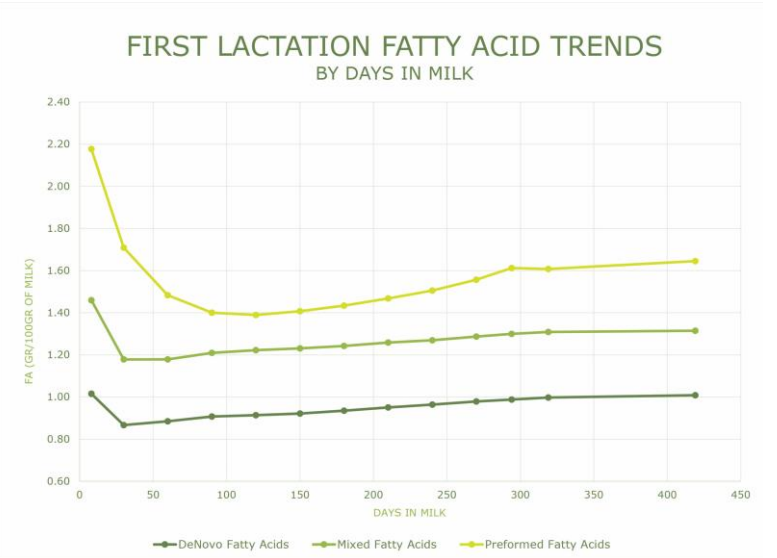


*Figure 1 First lactation top 20 percentile ECM 3X Holstein herds de novo, mixed and preformed fatty acid trend by days in milk*

If understanding the profile of milk fat can provide valuable insight, how can we characterize it? Historically, this is by exaction, methylation, and gas chromatography (GC) analysis of the fat which is a very time-consuming laboratory process. In the last few years, advances in milk analysis by fourier-transform infrared (FTIR) spectroscopy has led to the ability to quantify fatty acids in milk. While the detailed proportion of fatty acids in milk determined by FTIR doesn't match the profile determined by GC, it has been proven useful in monitoring shifts in the groups of fatty acids (ex. de novo, preformed, unsaturation, etc).

The recent advances in FTIR analysis in milk, have enabled VAS to develop a product called RumINSIGHT which provides information on milk fatty acids based on FTIR data during routine milk sampling. Whether we are considering a tool like KetoMonitor or RumINSIGHT, these milk diagnostics can provide valuable insight when taken together with additional cow and farm information.