Improving rumen function with hydroxy analogue of methionine

Optimising rumen function in dairy cows is crucial for maintaining a rich and diverse microbial population, enhancing microbial protein synthesis, and directing fermentation and metabolism toward efficient pathways.

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Microbial crude protein synthesis meets most of the cows' amino acid requirements, offering a relatively well-balanced amino acid profile. In terms of fermentation pathways, the biohydrogenation (BH) of unsaturated fatty acids (UFA) plays a significant role in determining milk quality and composition.

Research indicates that specific dietary conditions like diets high in starch or UFA can disrupt the normal BH pathway, leading to increased trans fatty acid production, which in turn reduces milk fat content.

By incorporating rumen efficiency into feeding strategies, we can directly influence animal performance and production efficiency, as well as milk quality and composition—factors that ultimately impact both profitability and environmental sustainability.

HYDROXY ANALOGUE OF METHIONINE: MORE THAN JUST A METHIONINE

2-hydroxy-4-(methylthio) butanoic acid, also known as the hydroxy analogue of methionine (HMTBa), is a widely used methionine source in animal nutrition. Unlike DL-methionine (DL-Met), HMTBa has a hydroxyl group on its second carbon atom (Fig. 1), giving it unique properties in how it is absorbed and its stability during ruminal fermentation.

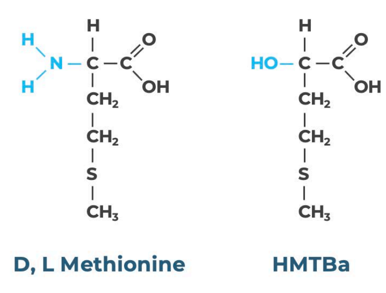
While rumen-protected DL-Met is absorbed in the small intestine, HMTBa is primarily absorbed through passive diffusion across the rumen wall and omasum and then converted into biologically active L-Met in tissues like the kidneys and liver.

DL-Met requires added protection to ensure stability in the rumen. The chemical structure of HMTBa provides greater protection from rumen degradation, eliminating an additional stage during the manufacturing process. A stable, granular form of HMTBa suitable for pelleted feeds known as MHA Feed Additive from Novus contains 84% HMTBa.

In studies and commercial conditions, MHA Feed Additive (hereafter referred to as HMTBa) from Novus delivers methionine efficiently, functioning both as a bypass methionine source and to enhance rumen activity. Approximately 40% of the methionine equivalent contained in HMTBa bypasses the rumen and converts it to metabolisable methionine.

This benefits the cow by supporting milk yield, protein content, and overall diet optimisation.

Fig. 1. Comparison of the molecular structure of DL-Methionine and HMTBa.



The remaining 60% is utilised by rumen microbes, improving rumen fermentation efficiency by supporting microbial diversity, increasing microbial protein synthesis, and maintaining normal BH of dietary fatty acids.

This helps prevent milk fat depression and promotes higher milk fat content, making HMTBa an efficient and versatile methionine source for dairy cows.

THE IMPORTANCE OF NORMAL WHEN IT COMES TO THE RUMEN

Milk fat content is a key determinant of milk price and the profitability of dairy farms. Under European feeding conditions, values above 4% are possible and economically desired, but many farms experience issues with low milk fat content, often ranging between 3.6% and 4.0% and sometimes even dropping below 3.6%. Not being able to reach and sustain optimal fat content yield leads to lower milk prices and reduced income.

Milk fat depression (MFD) is characterised by a significant decrease in milk fat yield, sometimes up to 50% below the cow's genetic potential, without affecting the overall milk yield or other milk components. MFD commonly occurs in ruminants fed diets high in fermentable carbohydrates (for example, starch) or diets rich in UFA.

These diets can alter the rumen BH of linoleic acid (C18:2), leading to reduced milk fat synthesis in the mammary gland—a phenomenon known as diet-induced or BH-induced MFD.

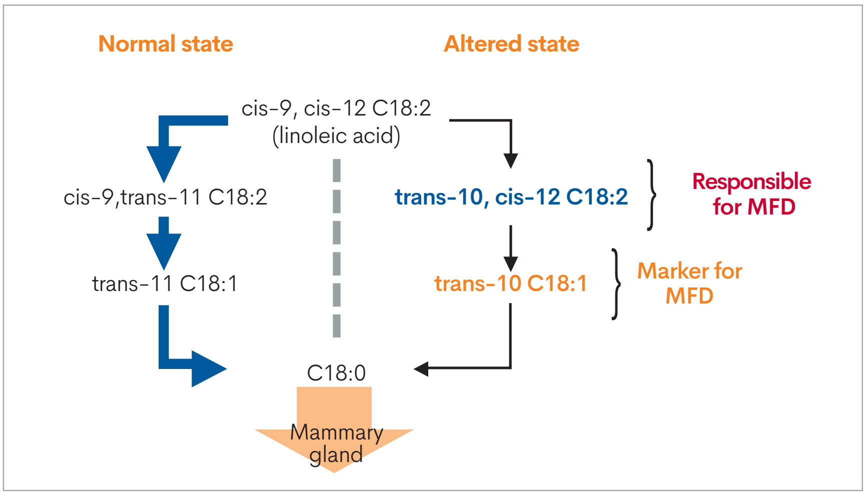


Fig. 2. Biohydrogenation pathways of linoleic acid showing the relationship between the altered biohydrogenation pathway of linoleic acid and the fatty acid causing milk fat depression.

This condition indicates suboptimal rumen fermentation, which impairs rumen efficiency. As illustrated in Fig. 2, linoleic acid (LA) undergoes two main BH pathways in the rumen: normal and altered. While both occur, the normal pathway typically predominates.

However, the altered pathway produces trans-10, cis-12 C18:2, a fatty acid absorbed in the intestine that is known to suppress milk fat synthesis. Because its concentration in the milk is low, it is difficult to measure.

The trans-10 C18:1—a product of further BH—has a higher concentration, and because there is an established relationship with trans-10, cis-12 C18:2 is often used as a marker for MFD.

In the normal BH pathway of LA, fewer fatty acids that cause MFD are produced. MFD can be triggered by increased intake of LA, which leads to higher levels of trans-10 and cis-12 C18:2. Feedstuffs that are used in European diets and can increase LA intake include fresh grass, oil-rich seeds and byproducts, and extruded linseed.

Additionally, high levels of rapidly fermentable carbohydrates like starch can decrease the rumen pH and impact the microbial population, which shifts the BH pathway from normal to altered, posing a risk for MFD.

Researchers at Penn State University in the U.S. conducted multiple experiments with dairy cows under conditions that pose a risk for MFD fed high-yielding cows a sequence of diets with increasing MFD risk. The cows were initially fed a low-risk diet for 7 days, followed by moderate- and high-risk diets for 17 and 4 days, respectively. Reducing neutral detergent fibre (NDF) and increasing UFA increases the risk of altered BH.

The NDF content was reduced from 32 to 29% on a dry matter basis, while UFA rose from 2.2% to 3.8% to 4.45% through the addition of oil. All this resulted in an increase in starch content in the diets, increasing from 27% to 30%. As shown in Fig. 3A, milk fat content decreased in cows on the moderate- and high-risk diets, while those supplemented with 25g of HMTBa maintained stable milk fat levels.

HMTBa supplementation also resulted in lower concentrations of the trans-10 C18:1 isomer in milk, suggesting that HMTBa inhibits the shift to the altered BH pathway in the rumen (Fig. 3B).

Other studies confirmed these findings, showing that HMTBa consistently stabilised milk fat content and reduced trans-10 C18:1 levels. HMTBa is shown to optimise ruminal fermentation by sustaining rumen microflora diversity and maintaining normal BH, thereby increasing milk fat content under MFD conditions.

HMTBa also reduces the activity of microbes associated with the trans-10 C18:1 isomer, effectively preventing the shift to the altered BH pathway that leads to MFD.

MICROBIAL CRUDE PROTEIN MAKES A DIFFERENCE

The precise mechanism by which HMTBa influences the rumen microbiota remains unclear. However, HMTBa was found to increase the abundance of certain cellulolytic bacteria and also stimulate rumen fermentation as indicated by volatile fatty acid concentrations.

The stimulatory effect of HMTBa on bacterial protein synthesis has been demonstrated in two studies. A quadratic increase in both bacterial nitrogen outflow and the efficiency of bacterial nitrogen synthesis in an in vitro continuous culture system was observed.

To complement this in vitro data with in vivo data, the effect of different levels of HMTBa on microbial protein synthesis in cows was evaluated. With reticular sampling and microbial protein labelled using 15N. Results showed a linear increase in microbial protein production. This resulted in microbial protein synthesis increasing from 2,281g/d without HMTBa in the diet to 2,438g/d with dietary addition of 0.10% HMTBa (dry matter basis), representing an increase of 157g or 6.9%.

Additionally, they found an increase in the concentration of odd- and branched-chain fatty acids, including C15:0, C17:0, antesio-C17:0, and C17:1 in the milk fat, which are positively related to rumen function and microbial protein synthesis in the rumen. This was supported in another experiment by an increase in odd- and branched-chain fatty acid content in the milk with HMTBa when feeding cows with high-risk for MFD.

In conclusion, this indicates a stimulatory effect of HMTBa on ruminal microbes, supporting the notion that feeding cows HMTBa as MHA Feed Additive can enhance rumen efficiency and positively impact milk fat production. ■

References are available from the author on request

Fig. 3. Effect of feeding HMTBa vs. Control on milk fat content (A) and trans-10 C18:1 in milk fat (B) when feeding low-, moderate- and high-risk diets for MFD. † P<0.10; * P<0.05 shows statistical differences between control and HMTBa.