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Milk Fat Depression in High-Yielding Cows: Reasons and Mitigation Strategies

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ABSTRACT

Milk fat depression (MFD) is a nutritional disorder primarily driven by dietary imbalances. In a high yield dairy cattle, fat is the main energy-driving nutrient. In MFD, there is a clear reduction in milk fat yield. Limited substrate availability due to alteration in rumen fermentation along with other factors like using coarse ration, high fermentable diets, or using supplements that affect rumen microbial population can cause MFD. This shrinks the profit margins for suppliers as MFD causes a significant decrease in value-added products. High-grain diets alter the rumen fermentation process, producing trans fatty acids (FA) that inhibit milk fat synthesis, which then leads to high propionate production, which decreases rumen pH and ultimately decreases acetate production, causing MFD. Balancing diet, Monitoring rumen pH, using inert fat, good feeding management, and eliminating environmental stressors can be helpful in the elimination of this disorder.

Keywords: Milk Fat Depression, MDF, Mitigation Stratagies

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Introduction

MFD is a metabolic condition where diet, gut bacteria, and tissue physiology intersect, leading to persistent milk fat decrease. This condition highlights the complex relationship between nutrition and milk composition, as nutritional changes considerably impact milk fat production. Mainly, cattle milk lipids are composed of triacylglycerol, which accounts for over 98% of lipids and contains glycerol and three FA with numerous carbon chain lengths [1]. MFD has been a documented issue for over 150 years, considered by a significant 50% drop in milk fat production without impacting total milk yield; when fat content drops, there is ultimately a decrease in the yield of butter, cream, and other products like cheese. As production efficiency declines, it leads to a diminished supply of profitable value-added products, thus shrinking profit margins for processors. To achieve the same output of butter and cream, milk requirement increases, which leads to either increased prices for consumers or reduced profitability of the processing companies. This condition is influenced by multiple factors, including modifications in rumen lipid metabolism, which may produce specific intermediates that hinder milk fat synthesis. Research has confirmed that certain dietary factors can change the rumen's microbial population and pH levels, thereby inducing the biohydrogenation (BH) processes of dietary FA. These dietary factors include the type of grain used, the volume and type of fat supplementation, the forage-to-concentrate ratio, and the specific type of forage employed, all of which can affect the rumen fatty acid metabolism [2]. This phenomenon typically affects ruminant animals, such as cows, when they consume diets high in fermentable carbohydrates or plant oils. Supplementing with a rumen-available methionine analog can lessen this risk. Furthermore, effective feeding management plays a vital role in preventing MFD [3].

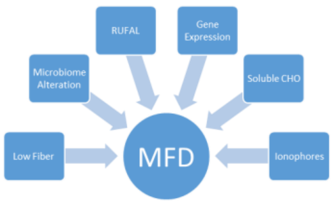

Fig. 1: Milk Fat Depression

Causes

1. Impact of rumen fermentation and diet on milk fat composition

The rumen's bacterial count is heavily influenced by the absorption and digestion rates of starch and neutral detergent fiber (NDF), along with the complete rumen microbiota and substrate availability. To maximize energy production, fermentation must be enhanced, but attention is necessary to prevent subacute ruminal acidosis. MFD happens more frequently with corn silage in contrast to meals made of haylage and with rapidly digesting starch sources, like corn with greater moisture content than dry milled corn, which offers a variety of carbohydrates and fiber that digests at different rates, is the safest method. Starch was substituted for sugar because consuming starch depresses risk without declining digestibility [4]. In addition to increasing milk production, increased grain feeding also has an adverse impact on milk fat content and changes the fatty acid profile. Specifically, grain feeding tends to increase propionate production and decrease acetate production, which can result in lower levels of shorter-chain FA with 6 to 16 carbons in milk, while increasing the levels of longer-chain unsaturated FA with 18-carbon. This shift in fatty acid composition can have significant effects on the overall quality and nutritional value of milk.

2. Influence of Rumen pH and monensin

Rumen pH fluctuations are likely linked to MFD because they activate a change in the bacterial population, encouraging the development of microbes that utilize other BH pathways. Regardless of a common statement, MFD can occur even when ruminal acidosis is not present. In fact, most cases of MFD occur in cows with normal rumen environments, without any specious signs of acidosis, highlighting that MFD is a distinct issue that can arise separately from acidosis [5]. The use of supplements in cow feed can innocently influence rumen microbial populations, with monensin, which is an ionophore and the most common modifier related to MFD. By changing the balance of bacteria in the rumen, monensin stimulus BH processes, which lead to an increased flow of BH intermediates. This, in return, can result in decreased milk fat production and changed fatty acid profiles. Generally, an increase in BH intermediates wouldn't be an issue, but monensin can improve the transport of specific intermediates, such as trans-10 and cis-12 conjugated linoleic acid (CLA), to the small intestine, increasing the risk of MFD. Even if only a small portion of dietary polyunsaturated fatty acids (PUFA) undergoes BH through these alternative pathways, monensin can still potentially boost the problem [6].

3. Impact of Polyunsaturated Fats on Biohydrogenation

The occurrence of unsaturated FA in the diet has a double influence on ruminal BH, changing both the microbial population and the quantity of substrate existing for BH. The kind and quantity of unsaturated fat, such as fish oil, regulates the fatty acid profile and its ruminal availability. The addition of grains, oils, and their byproducts to feed increases the hazard of MFD due to their high levels of linoleic acid, found in plant oils such as cotton, soy, and corn. The rate of ruminal availability differs widely depending on the source, with crushed sources, distillers' grains, and oil supplements releasing FA more slowly than cottonseed and whole-roasted soybeans. While secure fat supplements are offered, and fat is frequently added to increase diet energy density, saturated fat supplements like palmitic and stearic acid do not increase MFD hazard. However, calcium salts of FA in the rumen can adversely impact milk fat production. Although calcium salts do not offer entire rumen inertness, they do hold up the release of unsaturated fats in the rumen, lowering their adverse effect as compared to free oil. Conversely, the amount of their effectiveness depends on the specific features of the fat supplement and its influences on other dietary factors, making it critical to reflect these variables when measuring their assistance [7].

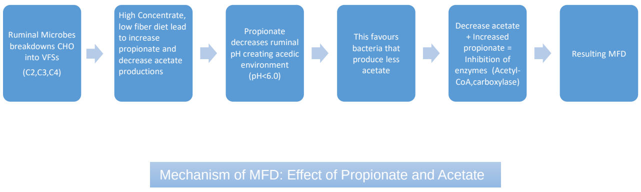

Fig. 2: Mechanism of MFD

Mitigations

1. Dietary Adjustments

Dietary constituents are skilled in adjusting the development of BH intermediates, which plays an important role in increasing MFD. These constituents interrelate within the rumen and change the balance and microbial activities of the rumen, considering how feed influences and assessing these factors to help manage diets to decrease MFD and recover overall milk fat production in dairy cows. Altering the diet to lower fermentability and PUFA content frequently leads to a momentous increase in milk fat synthesis. The use of rumen modifiers has become a common exercise for increasing milk fat production, and the addition of methionine precursor, 2-hydroxy-4-(methylthio)butanoate (HMTBA), has been confirmed to be mainly effective. This compound is identified for its ability to boost milk fat levels and, as a result, represents its substantial impact on overall milk production. Many studies on rumen fermentability of diet and methionine supplementations have shown that cows are at high risk of MFD because BH leads to increased fat production when HMTBA is added, thus possibly offering a solution to improve milk fat level in affected cows [8].

2. Feed Management

Subclinical rumen acidosis and MFD are frequently related to the practice of slug-feeding grains, where cows are fed great quantities of grains at uneven breaks, which can cause an unexpected load of fermentable carbohydrates in the rumen, leading to considerable variations in the rumen environment. However, Total Mixed Ration (TMR) feeds are formulated to provide reliable nutrition, which can alleviate this issue. Sharing the daily ration into four equal meals, spaced out six hours apart, led to a significant improvement in milk fat production. This feeding program resulted in a reduction in the levels of alternative BH FA, which are related to MFD, and a corresponding rise in both the quantity and concentration of milk fat. By distributing feed intake throughout the day, cows were able to uphold a more stable rumen environment, leading to a more fortunate fatty acid profile and improved milk fat production [9]. On the other hand, cows tend to sort and selectively eat more fermentable feed particles, especially after fresh feed is offered, leading to variable intake rates throughout the day. This can result in a threefold rise in fermentable organic matter intake early in the day. To alleviate this issue, feed management strategies can help distribute intake more equally throughout the day, creating a more reliable and balanced rumen environment. Checking continuous feed availability is essential, as continued periods without feed or access to feed can lead to overconsumption when feed is finally provided. Offering fresh feed can be a strong promoter for cows to eat, and providing it more frequently can help distribute their intake more uniformly throughout the day. In contrast to feeding once daily, providing multiple meals or continuous access to feed can help prevent gorging and promote a more balanced and consistent eating pattern, reducing the risk of MFD [10].

3. Sugar and Molasses in Dairy Rations

The mechanism behind molasses' influence on ruminal pH is thought to involve the stimulus of butyrate assembly, which in return raises blood flow to the rumen and may increase the absorption of volatile FA throughout the rumen epithelium. By making a more satisfactory ruminal environment, molasses supplementation can support optimal milk fat production and general cow health. Sugars can help as a major energy contributor in dietary rations of lactating dairy animals, facilitating a type of carbohydrates that degrade and are utilized efficiently by the rumen. The rapid collapse of sugars results in an immediate rush of energy, which is especially appreciated during times of high milk production or stress [11, 12]. The quick release of energy from sugars is critical for enhancing the nutritional intake of lactating dairy cows as it directly addresses their raised metabolic demands, supporting their health and performance during periods of high milk production. The valuable features of sugars in dairy rations are their ability to need only a small amount of enzymatic activity to cut the disaccharide bonds and contribute a well-organized energy source for rumen microbes that support their activity. It has been suggested that such use of sugars could be effective in alleviating ruminal pH and enhancing the digestibility of fiber [13]. This positive influence of combining sugars into dairy rations has the potential to decrease issues related to acidosis and also reduce the chance of MFD, thus supporting better rumen health and enhancing overall milk quality. Incorporating 5% molasses into a cow's diet can have a greatly positive impact on milk fat production and ruminal health, leading to improved milk fat yields. The increase in ruminal pH is particularly substantial, as it can help lessen the adverse effects of low ruminal pH, such as those associated with CLAMFI (conjugated linoleic acid- milk fat inhibitor) [14].

4. Utilizing effective fat supplements

Fat supplements are usually used in lactating cow diets to lessen MFD. These supplements include oilseeds (e.g., cottonseed, soybeans), vegetable oils, and distiller grains with soluble and commercially accessible fatty acid provisions (e.g., calcium salts of FA). The fatty acid composition of these supplements differs from that of stearic acid, which is higher in hydrogenated plant oil but minimal in plant oil. Oleic acid is mainly in animal fats, while linoleic acid is in plant oils. To classify fat supplements for dairy rations, they can be gathered based on their conclusion on ruminal fermentation and digestion. This group, mentioned as (rumen-inert) or (bypass) fats, contains calcium salts of FA and hydrogenated fats. Calcium salts are rich in palmitic or oleic acid, or in both, and typically originate from palm-derived FA [15]. These supplements are considered to avoid digestibility problems and are easily transported and mixed with other feed elements. By using these fat supplements, dairy farmers can efficiently lessen MFD, improve milk fat synthesis, and support overall cow health.

Conclusion

It is concluded that cows fed a highly fermentable diet, Excessive unsaturated fat, and fault in management are factors that cause MFD. BH theory is widely accepted, which suggests that unique FA intermediates produced during rumen BH of PUFA directly inhibit milk fat synthesis at the mammary gland, resulting in MFD. Enhancing milk fat production in dairy cows can be achieved through dietary modifications to lower fermentability and PUFA levels and the use of rumen modifiers like HTMBA to enhance milk fat levels. Proper feed management, including consistent feeding and avoiding slug feeding, can stabilize rumen pH and support milk fat synthesis. It doesn’t only depend on what feed is given but also on how the feed is provided, so the composition and size of feed should be kept in mind while offering feed.

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