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# Role of Animal Nutritional Factors and Insulin in Milk Fat Depression

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## Description

Numerous nutritional and non-nutritional elements significantly influence milk fat synthesis, contributing to the considerable variability observed in dairy herds. The animal's ability to produce milk fat hinges largely on the availability of substrates necessary for lipid synthesis, sourced directly from the diet, ruminal fermentation or adipose tissue reserves.

### Production eficiency

The release of non-esterified fatty acids from adipose tissues is pivotal in meeting the energy demands of milk synthesis, consequently affecting the composition of milk lipids, particularly during early lactation. This process is tightly regulated by insulin and catecholamines and can be indirectly influenced by various factors such as diet composition, lactation stage, genetics, endotoxemia and inflammation. Environmental factors like heat stress also impact adipose tissue mobilization and milk fat synthesis, primarily through endotoxemia and an immune response-induced elevation in plasma insulin levels.

The central role of insulin in regulating lipolysis is paramount for comprehending how nutritional and non-nutritional factors influence milk fat synthesis, especially during early lactation and situations where mammary lipid synthesis relies heavily on adipose-derived fatty acids.

Understanding the intricate regulation of milk fat synthesis can optimize milk fat yield in commercial settings. This review underscores the pivotal role of insulin in directing adipose-derived fatty acids towards the mammary gland. Strategies enhancing insulin secretion, particularly during early lactation, warrant attention. Additionally, interventions that modulate the immune response may bolster milk fat yield by amplifying insulin levels triggered by dietary or heat stress-induced immune system activation.

Lastly, the multifaceted nature of milk fat synthesis regulation and its implications on theories surrounding milk fat depression are explored, providing insights into potential avenues for further research and practical application.

The complexity of milk fat surpasses that of all other edible fats in human diets, boasting a diverse array of lipid types with varying molecular configurations, Fatty Acid (FA) chain lengths and degrees of saturation. Being the most variable component of milk, fat plays a pivotal role in determining milk quality for processing, thereby significantly influencing production efficiency and profitability on dairy farms. Consequently, optimizing milk fat yield through strategic approaches holds the potential to enhance production efficiency in dairy operations. Several factors influence milk fat synthesis in dairy animals, including diet composition, lactation stage and genetic potential. Among these factors, nutritional considerations emerge as crucial short-term regulators of milk fat synthesis, although their efficacy may be contingent upon interactions with other factors, such as lactation stage.

### Milk fat depression

Milk Fat Depression (MFD) arises from a complex interplay of various lipids from diverse sources, including the diet, rumen microbiota, neutral lipid reserves from Adipose Tissue (AT) and *de novo* synthesis in the mammary gland. The onset of MFD, a phenomenon recognized for nearly two centuries, has garnered extensive research attention. Bioactive compounds, particularly rumen Bio-Hydrogenation (BH) derived trans-10, cis-12 Conjugated Linoleic Acid (CLA), have been identified as pivotal contributors to MFD. However, the variability of milk fat response extends beyond BH, encompassing dietary lipid provision, ruminal fermentation by-products and fatty acid flux from adipose tissue modulated by insulin action. While the glucogenic-insulin theory implicates insulin in MFD, its role is contested due to inconsistent observations of decreased flux of AT-origin fatty acids in many MFD cases. Nonetheless, as discussed herein, BH and insulin may not be mutually exclusive theories but rather complementary mechanisms, each elucidating different facets of milk fat variation under varying conditions. Indeed, previous discourse has posited that both trans-10, cis-12 CLA and insulin synergistically promote nutrient flow towards adipose reserves and away from mammary fat synthesis.

Insulin emerges as a pivotal player in nutrient partitioning across tissues, particularly during early lactation when low insulin action facilitates AT lipolysis and augments the flux of Long-Chain Fatty Acids (LCFAs) to mammary tissue to meet the demands of milk production. Notably, various nutritional and non-nutritional factors exert influence on insulin concentrations, thereby modulating milk fat synthesis.