

Endocrine Function of Adipose Tissue in Dairy Cows during the Per Parturient Period

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Abstract

The role of Adipose Tissue (AT) in metabolism extends far beyond just energy storage, proving to be much more intricate than originally thought. In addition to its involvement in lipid metabolism, AT plays a critical role in regulating glucose balance, amino acid metabolism, and inflammatory processes. The discovery of leptin in 1994 led to the realization that AT could secrete signaling molecules known as adipokines, which act in autocrine, paracrine, and endocrine manners. Moreover, AT can respond to various signals from other tissues via its receptors, integrating into broader physiological control systems throughout the body. The secretome of differentiated human adipocytes includes over 400 distinct proteins. However, in dairy cows, the understanding of the time-course changes in adipokines during the transition from pregnancy to lactation is mainly limited to m-RNA data, with protein-level characterization hindered by limited analytical methods and poorly validated assays. Besides protein-based adipokines, small molecules like steroids are also secreted by AT. Steroids, being lipophilic, are stored in AT, but more recently, AT has been shown to not only store but also metabolize and even synthesize steroid hormones *de novo*. In high-yielding dairy cows, AT undergoes significant mobilization due to the increased energy demands of lactation. However, it remains unclear whether this process affects the steroidogenic capabilities of AT, particularly during the common loss of body fat. Most research on AT in transition dairy cows focuses on subcutaneous fat, with little attention given to other fat depots. This review aims to summarize the changes in adipokine mRNA and, where available, protein expression over time relative to calving in high-yielding dairy cows, considering factors like parity, body condition, diet, feed supplements, and health issues. Additionally, it will provide insights into the steroidogenic pathways in dairy cow AT and highlight differences between fat depots where possible.

Keywords: Metabolism • Energy storage • Lipid metabolism • Glucose homeostasis • Amino Acid (AA) metabolism • Inflammatory processes • Leptin • Adipokines • Endocrine signaling • Paracrine signaling • Autocrine signaling • Receptors

Introduction

Adipose Tissue (AT) serves more than just as an energy reservoir; it is recognized as an endocrine organ that produces factors involved in regulating lipid balance, insulin sensitivity, glucose metabolism, fat distribution, and inflammation [1]. The signaling molecules secreted by AT, known as adipokines, encompass cytokines, hormones, growth factors, chemokines, complement factors, and a variety of other proteins. Beyond proteins, AT also releases lipids, metabolites, noncoding RNAs, and extracellular vesicles, all of which contribute to the maintenance of overall systemic balance. Additionally, steroid hormones, owing to their lipophilic nature, are stored in AT, where they can be metabolized or converted into other steroids, depending on the enzymes present [2]. These processes have significant metabolic impacts, particularly during early lactation in cows. Trayhurn and Wood proposed the term "adipokinome" to describe the collective proteins and lipids in AT, aligning with the concept of biological omics approaches. Adipokines are crucial for both the intra-tissue communication within AT and the endocrine interactions between AT and other tissues [3,4].

Description

In high-yielding dairy cows, the period surrounding parturition involves significant physiological and metabolic changes. Energy demands rise rapidly due to the start of lactation, compared to pre-calving levels. As a result, many high-yielding dairy cows enter a state of Negative Energy Balance (NEB) at the beginning of lactation, prompting the mobilization of body reserves, primarily from Adipose Tissue (AT) and muscle [5]. Lipolysis during this time leads to elevated levels of Free Fatty Acids (FFA) in the bloodstream, which can contribute to metabolic disorders such as fatty liver and ketosis. Cows with larger fat stores in late lactation experience more pronounced mobilization of AT in the subsequent lactation, and over-conditioned cows tend to consume less Dry Matter (DM) due to the effects of circulating FFAs and the resulting ketone bodies. The increased lipolysis around parturition also impacts the immune system and reproductive health of dairy cows. Both *in vitro* and *in vivo* studies have shown that elevated FFA and β -hydroxybutyrate (BHB) levels directly affect various immune cells. Additionally, excessive hepatic triglyceride accumulation can lead to fatty liver in early-lactating cows. The heightened lipolysis in early lactation likely originates from different adipose tissue depots, with retroperitoneal AT showing a higher lipolytic capacity compared to subcutaneous AT. Furthermore, depot-specific differences in AT have been observed during homeorhetic adaptations in the periparturient period, which should be taken into account when studying endocrine responses and adipose energy metabolism at the onset of lactation [6].

Conclusions

Beyond its role in energy storage, Adipose Tissue (AT) is recognized for producing signaling molecules known as adipokines. These adipokines are crucial for communication between cells within AT, acting in an autocrine or paracrine manner, and they also facilitate endocrine signaling with other tissues such as the liver and skeletal muscle. As a result, they influence a wide range of systems and metabolic processes in the body. This review summarizes

current research on several key protein-based adipokines that may have important roles in dairy cows, particularly during the transition from late pregnancy to early lactation. AT also releases lipid-based adipokines, with endocannabinoids and steroids being the main focus of this review. While research into the role of AT in the metabolism of these lipids and their systemic significance is still in its early stages, lipid adipokines are likely to be more accessible for analysis compared to protein adipokines. This is particularly true given the rapid advancement of lipidomics techniques. However, interpreting systemic changes in adipokine levels remains complex due to the fact that both protein and lipid adipokines can be produced by tissues other than AT.

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