Oxidant Stress and Inflammation in Over-conditioned Cows

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Assessing the body condition score (BCS) of dairy cows can be an aid to evaluate the effectiveness of dairy feeding programs. Body condition score changes throughout the lactation cycle and corresponds to changes in the cow’s energy balance (1). For example, the energy requirements for milk production beginning from early lactation and continuing to peak lactation often exceed the available energy from feed intake. As a consequence, body lipid reserves are mobilized to compensate for the shortage in energy needed to meet milk production demands and dairy cows lose condition. The net shortage in energy input relative to energy output is called negative energy balance (1). While adequate body fat reserves can promote milk production and health during times of negative energy balance, numerous studies have shown that obese cows have much higher risks of poor conception rates, metabolic problems, and increased susceptibility to a variety of infectious diseases (2-4).

Oxidant Stress, BCS, and Obesity

Similar to dairy cattle, obesity in humans is linked to a number of metabolic and infectious diseases. Recent studies have shown a correlation between high body mass index, body weight loss, and the development of oxidant stress in humans (5). Oxidant stress is a pathological state that results from an imbalance between the production of reactive oxygen species (ROS) and availability of host antioxidant defenses to convert ROS to less harmful molecules (6). The term ROS refers to oxygen-centered free radicals (including hydrogen peroxide, superoxide, and fatty acid hydroperoxides) that are produced during normal cell metabolism. These ROS have important physiological functions including the regulation of gene expression and contributing to the microbicidal activity of phagocytes. However, excessive accumulation of ROS during increased metabolic demands or during inflammation can cause damage to nucleic acids, proteins, and lipids. Therefore, oxidant stress can contribute to disease pathogenesis by causing damage to cells and enhancing inflammation in affected tissues. Indeed, evidence in humans suggests a positive correlation between obesity and a chronic low-grade inflammatory state (5). Visceral fat is a source of several pro-inflammatory cytokines, including tumor necrosis factor (TNF). The enhanced expression of this cytokine in obese patients can induce a pro-inflammatory environment and facilitate oxidative damage, leading to initiation and progression of disease (5).

It also has been suggested that oxidant stress in transition dairy cows is a contributing factor to increased susceptibility
to a variety of disorders including retained placenta, udder edema, milk fever, mastitis, and poor reproductive performance (7). While the mechanisms relating oxidant stress to dairy cattle disease susceptibility are not completely understood, recent studies showed a relationship between high BCS, greater BCS losses, and increased oxidant stress in transition cows (8). However, no information is available to establish a relationship between obese dairy cattle with oxidant stress and a pro-inflammatory state, which may be an underlying mechanism of increased disease susceptibility.

The Study

Recent studies at MSU’s College of Veterinary Medicine investigated the relationship between BCS with measures of oxidative status and TNF production in mid-lactation dairy cows. Cows were selected based on either a normal (2.5-2.7) or a high (>3.5) BCS using the standard 5-point scaling system. Plasma or peripheral blood mononuclear cell samples were analyzed for indices of oxidant stress and for the expression of TNF. Cows with a high BCS had significantly lower overall antioxidant potential when compared with normal BCS cows. This study identified for the first time that high BCS was associated with reduced levels of certain selenium-dependent antioxidant enzymes even when cows were supplemented with maximal allowable levels of selenium.

Conclusion

Changes in the oxidative state of over-conditioned cows also were accompanied by a significantly higher expression of TNF. Results from this study suggest that cows with a high BCS can experience oxidant stress in the absence of altered energy status such as that associated with the transition period. Increased TNF expression may be related to the pro-oxidant state of over-conditioned cows and possibly be a contributing factor to the enhanced susceptibility to disease in high BCS dairy cattle. While this study underscores the importance of monitoring BCS as a means to assess how well the diet meets the demands of milk production, it also emphasizes the need to consider total antioxidant requirements of dairy cattle at all stages of lactation.

References