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IFAS Extension

AN264

Omega-3 Fatty Acids Control Immune Stress in Dairy Cattle[1]

Lokenga Badinga and Cristina Caldari-Torres[2]

Introduction

Modern dairy cows experience varying degrees of immunological problems from about 3 weeks before calving to 3 weeks after calving. These problems can lead to diseases and poor reproductive performance, but can be reduced by preventive management. Recent research has suggested new ways that long-chain *omega*-3 polyunsaturated fatty acids (*omega-3* PUFA) could control immune function in mammals. *Omega*-3 fatty acids are a group of essential unsaturated fatty acids that have a final carbon-carbon double bond on the third carbon from the methyl end of the fatty acid. Adding supplemental *omega*-3 fatty acids to the diets of humans has been shown to reduce cardiovascular diseases and to help with some aspects of rheumatoid arthritis. However, little is known about the short- or long-term effects of adding long-chain *omega*-3 PUFA to the diets of dairy cows. Such a practice may improve their immunity. Understanding how *omega*-3 PUFA affect the immune functions of dairy cattle may lead to the development of producer-friendly feeding strategies that will decrease the incidence of diseases and improve reproductive efficiency in newly freshened dairy cows.

Sources of *Omega*-3 PUFA

Flaxseed oil is one of the richest sources of the essential fatty acid known as alpha-linolenic acid (ALA), which is an important *omega*-3 PUFA that has been successfully used for production of *omega*-3-enriched dairy and meat products. After ALA is digested and absorbed, it can be lengthened to form eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids, two important long-chain *omega*-3 PUFA. These two long-chain PUFA are also found abundantly in fish oil and have been shown to decrease cardiovascular and immune diseases in humans.

Roles of *Omega*-3 PUFA in the Control of Inflammation

Inflammation is a protective mechanism that dilutes, isolates, and eliminates the cause of injury and repairs tissue damage resulting from the injury. Inflammation is vital because it ensures that defense cells and molecules are concentrated rapidly at the site of microbial invasion or tissue damage and protect against any microbial invasion that often occurs at the site. However, an excessive and/or prolonged inflammatory response can cause problems and is sometimes more harmful than what causes the response.

The beneficial role of *omega*-3 PUFA related to inflammatory diseases and health has been known for many years. Both ALA and long-chain *omega*-3 PUFA help combat serious heart problems and immune disorders in humans. Thus, feeding *omega*-3 PUFA supplements to dairy cows could strengthen the immune systems of cows and improve

1. This document is AN264, one of a series of the Animal Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date July 2011. Visit the EDIS website at http://edis.ifas.ufl.edu.

2. Lokenga Badinga, associate professor, Department of Animal Sciences; and Cristina Caldari-Torres, postdoctoral associate, Department of Dairy Science, Virginia Tech, Blacksburg, VA; Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611.

the well-being of the people who consume milk from such cows.

Effect of Supplemental *Omega*-3 PUFA on Inflammatory Biomarkers in Dairy Cattle

Supplementing rations of dairy cows with *omega*-3 PUFA increases the concentration of these fatty acids in their tissues and alters the concentrations of inflammation indicators in the blood, such as prostaglandin $F_{2\alpha}$ and tumor necrosis factor-α (TNF-α). It is not fully known if these effects of *omega*-3 PUFA can improve the health and breeding efficiency of high-producing dairy cows. A recent study conducted in our laboratory (Caldari-Torres 2009; Figure 1) showed that supplementing cow diets with ALA and EPA could decrease the inflammatory response. This research involved using a compound called Concanavalin A (Con A) to cause an inflammatory response in blood cells from cows and then monitoring the response with an indicator of inflammation called TNF-α. As shown in Figure 1, EPA, a long-chain *omega*-3 PUFA, was more effective than its parent molecule, ALA, and DHA in reducing TNF-α production by blood cells. This is very beneficial because TNF-α is a cytokine that is highly responsible for promoting systemic inflammation immediately following tissue damage and bacterial invasion. These results are similar to those reported in humans and rodents and indicate that *omega*-3 PUFA can be used to improve the overall health of high-producing dairy cows, which are prone to immune deficiency soon after calving. Similar to its reported effect in humans, the main effect of *omega*-3 PUFA on the immune system of dairy cattle may vary depending on the composition of the diet and the physiological status of the cow.

Implications for the Dairy Industry

After calving, several immune functions — such as white blood cell proliferation and production of disease-fighting antibodies — are depressed in dairy cows. Thus, development of new feeding strategies in which the fatty acid composition of the diet is manipulated in order to prevent immune suppression after calving should contribute to decreased infection and disease in dairy cows. Preliminary results in the laboratory indicate that ALA and EPA can decrease immune stress as shown by decreased TNF-α production in cultured blood cells from cows. If these results can be repeated in the field, then strategic supplementation of early-lactation dairy cows with selected *omega*-3 PUFA may lead to improved health and reproductive efficiency. Such improvements may ultimately lead to an annual savings of over $2 billion dollars through improved reproductive efficiency and reduced veterinary costs of postpartum metabolic disorders. These savings would undoubtedly improve the sustainability and profitability of U.S. dairy operations.

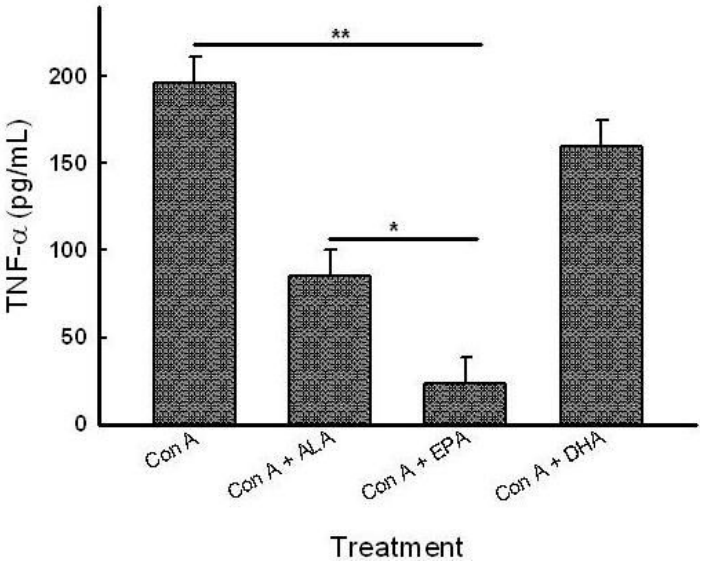

Figure 1. Effects of n-3 fatty acids on TNF-α production by bovine blood cells. Asterisks indicate that connected means are statistically different at $P < 0.05$ (*) or $P < 0.01$ (**).

References

Caldari-Torres, C. "Effects of Long-chain Fatty Acids on Production, Metabolism and Immunity of Holstein Cows." Ph.D. dissertation, University of Florida, 2009.