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Influence of conjugated linoleic acids and vitamin E on biochemical, hematological, and immunological variables of dairy cows during the transition period

S. Schäfers,* D. von Soosten,* U. Meyer,* C. Drong,* J. Frahm,*[1] A. Tröscher,† W. Pelletier,† H. Sauerwein,‡ and S. Dänicke*
*Institute of Animal Nutrition, Friedrich-Loeffler-Institut (FLI), Federal Research Institute for Animal Health, Bundesallee 50, 38116 Braunschweig, Germany
†BASF SE, Chemiestraße 22, 68623 Lampertheim, Germany
‡Institute of Animal Science, Physiology & Hygiene Unit, University of Bonn, Katzenburgweg 7, 53115 Bonn, Germany

ABSTRACT

The objective of this experiment was to determine the effects of conjugated linoleic acid (CLA) and vitamin E as well as their interaction on biochemical and hematological variables and on leukocyte populations and their functionality. We assigned 59 German Holstein cows between the 2nd and 9th lactation to 4 dietary groups in a 2 × 2 factorial design with the factors CLA and vitamin E. Six weeks before calving the cows had a BCS of 3.7 to provoke a higher risk of developing ketosis, which might impair their immune function. Blood samples for analyses were taken on d −42, −14, −7, −3, 1, 3, 7, 10, 14, 21, 28, 35, 42, 56, and 70 relative to parturition. Furthermore, peripheral blood mononuclear cells were cultured on d −42, −7, 1, 7, 14, 28, and 70 relative to calving. Most variables were characterized by a high variation between d 7 antepartum and d 7 postpartum. Treatments did not elicit any effect, with the exception of vitamin E, which increased serum urea concentrations and decreased monocyte percentages. Haptoglobin, aspartate-aminotransferase, red blood cell count, leukocyte percentage and populations, as well as peripheral blood mononuclear cells were influenced by parity. In conclusion, the impairment of immune function caused by calving was more severe in cows in ≥3rd parity than in younger cows. However, neither vitamin E nor CLA supplementation was successful to stabilize parity or parturition related variance in hematological and immunological traits.

Key words: dairy cow, conjugated linoleic acid, vitamin E, immune function

INTRODUCTION

During the transition period, 3 wk before until 3 wk after calving (Grummer et al., 1995), dairy cows are subjected to various endocrinological and metabolic changes. According to Mallard et al. (1998), these changes are accompanied by a decreased immune response. As a consequence, production diseases show the highest incidence in early lactation (Goff and Horst, 1997; LeBlanc et al., 2006). As Lacetera et al. (2005) described, cows, especially over-conditioned cows, are prone to immune suppression and resulting health disorders. After parturition, transitional dairy cows are in a state of a negative energy balance (Grummer et al., 1995) due to the onset of lactation and a decreased DMI. This negative energy balance is accompanied by lipid mobilization, leading to elevated blood concentrations of fatty acids. Due to a relative small amount of oxaloacetate, fatty acids can only partly be metabolized by the liver and, consequently, ketone bodies are produced. Schulz et al. (2014) proved that over-conditioned cows at calving are more prone to lipomobilization and have higher fatty acid concentrations as a result. Contreras and Sordillo (2011) discovered that the function of neutrophils and leukocytes might be impaired due to increased concentrations of fatty acids and ketone bodies. Lacetera et al. (2004) observed in heifers that enhanced fatty acid concentrations decreased proliferation as well as secretion of antibodies and cytokines of lymphocytes. According to Scalia et al. (2006), high fatty acid concentrations are associated with respiratory burst activities, leading to a decreased cell viability and increased necrosis rates in PMNL in vitro. Furthermore, the chemotaxis of leukocytes is impaired by high concentrations of BHB in vitro (Suriyasathaporn et al., 1999). Hoeben et al. (1997) investigated the influence of normal and subketotic BHB concentrations on the respiratory burst activity of PMNL in vitro and observed that it is impaired by high BHB concentrations. It is

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[1]Corresponding author: jana.frahm@fli.de

consequently suggested by Hoeben et al. (1997) that elevated BHB concentrations might be partly responsible for the higher incidence of infections during the transition phase. Sordillo and Aitken (2009) proposed that oxidative stress might be another risk factor further impairing the immune system in dairy cows. Oxidative stress is defined as the imbalance between the production of different reactive oxygen species (**ROS**) and the antioxidant mechanisms in the organism (Betteridge, 2000). According to Miller et al. (1993), damage of lipids, proteins, polysaccharides, and DNA molecules might occur as a result of oxidative stress and might therefore be responsible for altered cell functions. On the other hand, the production of different ROS by the PMNL is a physiological protection mechanism against infectious diseases. According to Dahlgren and Karlsson (1999), this reaction is mediated by the NADPH oxidase; however, the ROS production in transition cows is elevated up to a certain level, where the antioxidant mechanisms might be depleted (Sordillo and Aitken, 2009). Additionally, it has been observed that high-conditioned cows are especially vulnerable to oxidative stress during the transition period (Bernabucci et al., 2005). Vitamin E has been proven to elicit antioxidant activities by reacting with peroxyl radical and thereby protecting polyunsaturated fats (Burton and Traber, 1990). According to Rimbach et al. (2002), vitamin E influences different inflammatory cell signaling pathways and acts as a ligand at the peroxisome proliferator activating receptor (**PPAR**)-γ, whereby it is involved in the expression of different antioxidative enzymes (Nakamura and Omaye, 2010). Bassaganya-Riera et al. (2002) and O'Shea et al. (2004) reported that CLA interact with PPAR-γ as well. According to Chen et al. (2012), supplementation with CLA leads to an enhanced storage of vitamin E in the tissue. Furthermore, CLA may increase the secretion of vitamin E via milk (Gessner et al., 2015) and raise the vitamin E transport capacity of cholesterol (Schäfers et al., 2017b). Studies in humans (Albers et al., 2003; Song et al., 2005) showed that CLA neither affects lymphocyte populations nor does it influence the proliferation of unstimulated or concanavalin A (**Con A**)-stimulated peripheral mononuclear blood cells (**PBMC**; Nugent et al., 2005). Kelley et al. (2002) reported no alteration after supplementation with both CLA isomers on the white blood cell profile in mice. Renner et al. (2013) observed that CLA inhibited proliferation of PBMC dose dependently.

Our objective was to evaluate ex vivo and in vivo the influence of CLA and vitamin E on biochemical and hematological variables, as well as on populations and functionality of immune cells from dairy cows during the transition period. As we have shown, CLA increases the transport capacity of lipoproteins, resulting in higher vitamin E concentrations per lipoprotein. Consequently, we hypothesized that a combined treatment with CLA and vitamin E would attenuate the reduction of vitamin E in the blood, which is caused by reduced cholesterol concentrations shortly after parturition. In addition, we aimed to compare the ability of pluriparous cows from different parities to cope with the stress caused by the event of parturition.

MATERIALS AND METHODS

The study was conducted at the experimental station of the Institute of Animal Nutrition, Friedrich-Loeffler-Institut in Braunschweig, Germany. The experiment was carried out in accordance with the German Animal Welfare Act approved by the LAVES (Lower Saxony State Office for Consumer Protection and Food Safety, Germany).

Experimental Design

The whole study design is presented in detail in Schäfers et al. (2017a). Briefly, 59 pluriparous German Holstein cows were allocated to 4 treatment groups 8 wk antepartum (**a.p.**). We used an animal model established by Schulz et al. (2014), consisting of a high concentrate proportion a.p., a high BCS at calving, and a decelerated increase of concentrate proportion postpartum (**p.p.**), a combination suitable to induce susceptibility to lipomobilization. The treatment groups received either 8.4 g of *trans*-10,*cis*-12 and 8.4 g of *cis*-9,*trans*-11 CLA/d (BASF Lutrell; CLA group, n = 16) or 2,327 IU of vitamin E/d (BASF Lutavit E 50; **VE** group, n = 15) or both supplements (CLA + VE, n = 12). The control group (**CON**; n = 16) as well as the vitamin E group received a control fat supplement for caloric balance. All supplements were given from d 42 a.p. until d 70 p.p. During the whole experiment, animals were provided ad libitum with a standardized partial mixed ration by self-feeding stations (type RIC, Insentec B.V., Marknesse, the Netherlands). The different concentrates were administered via computerized self-feeding stations (Insentec B.V.). The ingredients and chemical composition of the feedstuffs are presented in Table 1. The study was divided into 3 periods: period 1 from d 42 a.p. until the day of calving, period 2 from calving until d 21 p.p., and period 3 until d 70 p.p.

Experimental Animals

In the CON group, 10 cows were in the 2nd (**Pa 1**) and 6 cows in the 3rd or higher parity (**Pa 2**). In the