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Effect of supplementing essential fatty acids to pregnant nonlactating Holstein cows and their preweaned calves on calf performance, immune response, and health

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ABSTRACT

The objective was to evaluate the effect of supplementing saturated or unsaturated fatty acids (FA) during late gestation of cows and during the preweaning period of calves on growth, health, and immune responses of calves. During the last 8 wk of pregnancy, Holstein cattle (n = 96) were fed no fat supplement (control), a saturated FA (SFA) supplement enriched in C18:0, or an unsaturated FA supplement enriched in the essential FA linoleic acid. Newborn calves were fed a milk replacer (MR) with either low linoleic acid (LLA; coconut oil) or high linoleic acid (HLA; coconut oil and porcine lard) concentration as the sole feedstuff during the first 30 d. A grain mix with minimal linoleic acid was offered between 31 and 60 d of life. At 30 and 60 d of life, concentrations of linoleic acid in plasma were increased in calves born from dams supplemented with essential FA compared with SFA (44.0 vs. 42.5% of total FA) and in calves consuming HLA compared with LLA MR (46.3 vs. 40.8% of total FA). Total n-3 FA concentration was increased in plasma of calves fed HLA compared with LLA MR (1.44 vs. 1.32%) primarily due to increased α-linolenic acid. Prepartum supplementation with SFA tended to improve dry matter intake (48.8 vs. 46.7 kg) and improved average daily gain (0.50 vs. 0.46 kg/d) by calves without affecting efficiency of gain or circulating concentrations of anabolic metabolites or hormones. Increasing mean intake of linoleic acid from approximately 4.6 to 11.0 g/d during the first 60 d of life increased average daily gain (0.50 vs. 0.45 kg/d) without a change in dry matter intake, thus improving feed efficiency (0.63 vs. 0.59 kg of gain/kg of dry matter intake). Improved weight gain in calves fed HLA MR was accompanied by increased or tendency to increase plasma concentrations of glucose (92.7 vs. 89.9 g/dL) and insulin-like growth factor I (59.5 vs. 53.2 g/dL), increased hematocrit (36.0 vs. 34.4%) and concentration of blood lymphocytes (4.61 vs. 4.21 × 10^3/μL), lowered plasma concentrations of acid-soluble protein (78.8 vs. 91.3 mg/L) and blood platelets (736 vs. 822 × 10^3/μL), and increased production of IFN-γ by peripheral blood mononuclear cells at 30 d of age (48.1 vs. 25.6 pg/mL), possibly indicating an earlier development of the immune system. Partial replacement of coconut oil with porcine lard in MR improved calf performance and some aspects of immunity.
Key words: calf, linoleic acid, growth, immunity

INTRODUCTION

The essentiality of linoleic acid was discovered by Burr and Burr (1930) in pioneer studies performed with rats fed fat-free diets and supplemented with chemically methylated linoleic acid or linoleic acid in naturally occurring oils. Those authors identified the symptoms of long-term linoleic acid deficiency, specifically poor growth, dermatitis, poor reproduction, and death. Later, a serum ratio of C20:3n-9 to C20:4n-6 exceeding 0.2 was recommended as an indicator of linoleic acid deficiency in humans (Holman, 1978). However 13 yr later, the same author (Holman et al., 1991) cautioned researchers of applying the C20:3n-9-to-C20:4n-6 ratio as a sole index of essential FA (**EFA**) status. Recently, the historical research quantifying the linoleic acid requirement has been called into question because investigators did not include α-linolenic acid in the experimental diets, which likely made the diets deficient in 2 FA (Cunnane and Guesnet, 2011). In addition, efforts should be made to establish FA intakes that optimize animal health rather than identifying minimal amounts that are sufficient only for growth (Cunnane and Guesnet, 2011).

Dairy calves fed increasing amounts of linoleic acid in their milk replacer (**MR**) had increased linoleic acid concentration in various lipid classes of plasma, but ADG did not reflect intake of linoleic acid (Jenkins et al. 1985; Jenkins and Kramer, 1986). Likewise, beef

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calves suckling cows fed diets containing high-linoleate safflower seeds (11.8% of dietary DM) had greater plasma concentrations of linoleic acid (Lake et al., 2006b) and glucose (Lake et al., 2006a) compared with those fed no oilseeds or high-oleate safflower seeds; however, ADG was unchanged (Lake et al., 2005). It is very possible that calf performance was unaffected in those studies by increased intake of linoleic acid because control calves were of adequate linoleic acid status. If calves received sufficient amounts of linoleic acid in utero, from colostrum consumption, or from their basal diet after birth, or a combination of them, benefits from consuming more linoleic acid would not be realized. These studies evaluated increasing intake of linoleic acid on calf performance but did little to evaluate the effect of dietary linoleic acid on circulating concentrations of metabolites and markers of immunity as well as symptoms of diseases. With the increased knowledge of the metabolism and mechanisms of action of linoleic acid, such as its apparent proinflammatory effect (Calder, 2005), future research with EFA should include effects on health and immunity. Recent studies (Ballou and DePeters, 2008; Ballou et al., 2008) have focused on the effect of dietary n-3 FA on different aspects of functional immunocompetence and health of preweaned dairy calves, whereas similar research involving n-6 FA is lacking. In a recent review article, Jacobi and Odle (2012) discussed the potential benefits of including medium-chain FA or PUFA in milk on intestinal health of neonates. Including PUFA in the milk formula for piglets after an intestinal insult improved digestive recovery more rapidly than in piglets fed C16:0 and C18:1n-9; feeding C20:4n-6 had particularly beneficial healing effects on the gut.

Changing formulations of the dam diet toward the end of gestation can influence the metabolic profile and immune status of the newborn calf. Feeding more energy to pregnant Holstein cows during the last 3 wk of gestation increased concentrations of blood glucose and phagocytosis by blood neutrophils of calves and decreased concentrations of blood haptoglobin of calves in the first week of life (Osorio et al., 2013). The type of energy fed prepartum, specifically the FA profile of the energy supplement, may influence the metabolism of the newborn calf.

Therefore, our hypothesis was that calves born to dams not supplemented with EFA in late gestation would respond (improved health and growth) to a greater extent to EFA supplementation than calves born to dams fed diets supplemented with EFA. The objective was to determine whether intake of energy and or of differing long-chain FA in late gestation would influence metabolic profile, immune status, health, and growth of calves consuming diets enriched in medium-chain FA or EFA (primarily linoleic acid) during the first 2 mo of life.

MATERIALS AND METHODS

Prepartum Diets and Adult Cattle Management

The experiment was approved by the University of Florida Animal Research Committee (Gainesville) and conducted at the University of Florida dairy farm. Pregnant nulliparous (n = 35) and previously parous (n = 61) Holstein animals were blocked by parity and enrolled in the study starting at 8 wk before their calculated parturition date.

The basal prepartum diet was formulated to have low concentrations of total FA (1.87% of DM), linoleic acid (0.38% of DM), and α-linolenic acid (0.21% of DM; Table 1). Prepartum cattle were fed 1 of the following 3 diets: (1) no fat supplement (control), (2) 1.7% of dietary DM as SFA supplement (Energy Booster 100; Milk Specialties Co., Dundee, IL), or (3) 2.0% of dietary DM as Ca salts of FA enriched with EFA supplement (Megalac R; Church & Dwight Co. Inc., Princeton, NJ). The proportion of C18:0 in the SFA supplement was 49.9%, whereas linoleic and α-linolenic acids were not detected (Table 2). The EFA supplement contained 4.5% C18:0, 27.4% linoleic acid, and 2.3% α-linolenic acid (total FA basis; Table 2). The concentration of C16:0 was similar in both fat supplements (Table 2). Dietary concentrations of C18:0 were 0.06, 0.86, and 0.14%; of linoleic acid were 0.38, 0.37, and 0.83%; and of α-linolenic acid were 0.21, 0.21, and 0.24% (DM basis) in control, SFA, and EFA diets, respectively (Table 1). Fat supplements partially replaced citrus pulp. The diets containing SFA and EFA supplements were isocaloric and greater than that of the control diet. All diets were isonitrogenous (Table 1). Prepartum housing and feeding management practices were described in Garcia et al. (2014).

Preweaning Diets and Calves Management

Pregnant animals were monitored for signs of initiating parturition every 30 min between 0530 to 1530 h and then every 2 h between 1530 and 0530 h. Within 3 h of birth, calves were weighed, ear tagged, and the umbilical cord was disinfected with 10% Betadine solution (Purdue Frederick Co., Norwalk, CT). Calves were housed temporarily in individual pens (1 × 1 m) equipped with a heat lamp before moving to individual wire enclosures (1 × 1.5 m) bedded with sand, between 6 to 16 h of age.

Within 2 h of birth, dams were milked with a cowside vacuum pump. Colostrum quality was recorded using