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Effect of supplementing fat to pregnant nonlactating cows on colostral fatty acid profile and passive immunity of the newborn calf

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ABSTRACT

The objectives were to evaluate the effect of supplementing saturated or unsaturated long-chain fatty acids (FA) to nulliparous and parous Holstein animals (n = 78) during late gestation on FA profile of colostrum and plasma of newborn calves and on production and absorption of IgG. The saturated FA supplement (SAT) was enriched in C18:0 and the unsaturated FA supplement (ESS) was enriched in the essential FA C18:2n-6. Fatty acids were supplemented at 1.7% of dietary dry matter to low-FA diets (1.9% of dietary dry matter) during the last 8 wk of gestation. Calves were fed 4 L of colostrum within 2 h of birth from their own dam or from a dam fed the same treatment. Feeding fat did not affect prepartum dry matter intake, body weight change, or gestation length. Parous but not nulliparous dams tended to give birth to heavier calves if fed fat prepartum. Parous dams were less able to synthesize essential FA derivatives, as evidenced by lower desaturase indices, compared with nulliparous dams, suggesting a greater need for essential FA supplementation. The FA profile of colostrum was modified to a greater degree by prepartum fat feeding than was that of neonatal calf plasma. The placental transfer and synthesis of elongated n-3 FA (C20:5, C22:5, and C22:6) were reduced, whereas the n-6 FA (C18:2, C18:3, and C20:3) were increased in plasma of calves born from dams fed ESS rather than SAT. Supplementing unsaturated FA prepartum resulted in elevated concentrations of *trans* isomers of unsaturated monoene and diene FA, as well as C18:2n-6 in colostrum. Serum concentrations of IgG tended to be increased in calves born from dams fed fat compared with those not fed fat, and prepartum feeding of SAT tended to improve circulating concentrations of IgG in newborn calves above the feeding of ESS. Apparent efficiency of absorption of IgG was improved in calves born from dams fed fat, and SAT supplementation appeared more effective than supplementation with ESS. Feeding SAT prepartum may be of greater benefit based upon greater circulating IgG concentrations of calves after colostrum feeding. Feeding moderate amounts of saturated or unsaturated long-chain FA during the last 8 wk of gestation changed the FA profile of colostrum and plasma of neonates to reflect that of the supplements.

Key words: dairy calf, fatty acid, colostrum

INTRODUCTION

The inclusion of fat supplements during the late gestation period is controversial because of a potential decrease in DMI. Using the meta-analysis procedure involving 41 published studies, Onetti and Grummer (2004) reported that supplementing tallow or Ca salts of FA reduced DMI, and that selected hydrolyzed tallow FA tended to reduce DMI of lactating cows regardless of forage source. These prepartum concerns have been based primarily on potential negative carryover effects on postpartum DMI and some metabolic disorders associated with reduced DMI (Drackley, 1999). Saturated and unsaturated fats can affect DMI differently as influenced by amount of supplementation (Onetti et al., 2001) and degree of unsaturation (Relling and Reynolds, 2007). The effects of prepartum fat supplementation on colostrum production and on calf birth weight, FA status, and IgG absorption have received very little study.

Concentrations of the essential FA, C18:2n-6 and C18:3n-3, are much lower in plasma of 120-d-old fetuses compared with that of their ewes (Noble et al., 1985) and in leg muscle phospholipids of 23-kg bovine fetuses compared with that of their dams (Payne, 1978), which may indicate that a marginal deficiency of essential FA exists in the very young until colostrum and milk are consumed. Increased dietary provision of C18:2n-6 during the last 8 wk of gestation dramatically increased

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circulation of C18:2n-6 of the ewe and of the neonate, demonstrating that C18:2n-6 can be transferred to the fetus through placental tissue (Noble et al., 1978). However, the circulating concentration of the C18:2n-6 derivative, C20:4n-6, was not increased simultaneously in the ewe but was increased in the neonate, indicating that placental or fetal tissues were capable of synthesis of C20:4n-6 from C18:2n-6 (Noble et al., 1978). Therefore, the PUFA profile of neonatal calf plasma reflects both the maternal transfer of preformed PUFA and the synthesis of essential FA derivatives.

Adequate passive transfer (**APT**) of IgG from gut to circulation is crucial to minimize neonatal morbidity and mortality and strengthen calf immunity (Quigley and Drewry, 1998). Initially, the transportation of the pool of consumed IgG across the intestinal epithelium was documented to occur by nonselective pinocytosis (Lecce, 1965–1966). A major histocompatibility complex class I-related neonatal Fc receptor (**FcRn**) was discovered in rat enterocytes that aided in the selective transfer of colostral immunoglobulin across the neonate's intestine. Although IgG absorption by the ruminant is FcRn-independent, FcRn likely has a protective effect on circulating IgG to prevent their premature degradation and clearance from circulation across species (Cervenak and Kacskovics, 2009). About 30 to 35% of the FA in enterocytes are essential FA (Jacobi and Odle, 2012). In addition, cell function involves nanoscale microdomains enriched in cholesterol and glycosphingolipids called lipid rafts, which mainly contain saturated FA $\geq$16 carbons (Edidin, 2003). In mammals, glycosphingolipids can make up 30 to 40 molar % of total lipid in the apical plasma membrane of epithelial cells of the small intestine (Degroote et al., 2004). Supplementing long-chain FA prepartum in the saturated and unsaturated forms may influence the FA profile of enterocytes that could affect the transfer of immunoglobulin to plasma of calves. Strategic supplementation of FA in late gestation might change the fluidity of enterocyte membranes, modifying their endocytic activity in addition to potentially modifying the activity of FcRn in the intestine.

The hypothesis of this study was that supplementing prepartum diets with saturated FA or C18:2n-6 would modify the FA profile of colostrum and plasma of newborn calves and that prepartum supplementation of C18:2n-6 would improve efficiency of IgG absorption. Therefore, the objective was to evaluate the effect of supplementing SFA enriched in C18:0 and Ca salts of FA enriched in C18:2n-6 to Holsteins in late gestation on the FA profile of colostrum and plasma of newborn calves and production and transfer of IgG for improving calf immunity.

MATERIALS AND METHODS

Adult Animal Management and Dietary Treatments

The experiment was conducted at the University of Florida's dairy farm (Hague, FL). All procedures for animal handling and care were approved by the University of Florida's Animal Research Committee. Nonlactating, pregnant nulliparous (n = 28) and pregnant parous (n = 50) Holsteins were enrolled in the study starting at 8 wk before their calculated parturition date.

Three dietary treatments were the following: no fat supplementation (Control), 1.7% of dietary DM as mostly free SFA supplement (**SAT**, Energy Booster 100, Milk Specialties, Dundee, IL), and 2.0% of dietary DM as Ca salts of FA supplement enriched with essential FA (**ESS**, Megalac R, Church and Dwight, Princeton, NJ). Fat supplements replaced citrus pulp in the control treatment. Feedstuffs used in the diets were selected for their low concentrations of FA (1.87% of DM) and C18:2n-6 (0.38% of DM; Table 1). The caloric density of the 2 fat-supplemented diets was the same and they were both greater than that of the control diet (Table 1). All dietary treatments were isonitrogenous. Stearic acid made up 49.9% of the FA in the fat supplement in the SAT treatment, whereas C18:2n-6 was not detected (Table 1). The ESS supplement contained 27.4% C18:2n-6 and 4.5% C18:0 of the total FA. The concentration of C16:0 was similar in both supplements.

Between wk −8 and −4 relative to calving, animals were housed in sod-based pens and fed as separate groups according to their dietary treatments. At wk 4 before the expected calving date, animals were moved to a sod-based pen equipped with Calan gates (American Calan Inc., Northwood, NH), and daily DMI was measured individually. Animals were weighed using a digital scale at 8 and 4 wk before the calculated parturition date and at calving. At the same time, body condition was scored by the same person using a 5-point scale divided into 0.25-point increments (Elanco, 1996).

Prepartum diets were prepared as a TMR and offered once daily (1000 h). Feed offered was adjusted daily to achieve 5 to 10% orts. Orts were collected and weighed daily. A sample of bermudagrass silage was collected once a week and analyzed for DM by drying in a forced-air oven at 55°C for 48 h to maintain the formulated DM ratio of forage to concentrate (Table 1). Silage samples collected once weekly were dried and ground through a 1-mm screen using a Wiley mill (Arthur H. Thomas, Philadelphia, PA) and composited every 4 wk. Samples of concentrate mixtures were collected once weekly and composited monthly. Forage and concentrates were analyzed for ash (600°C for 2