Thermogenesis, Blood Metabolites and Hormones, and Growth of Lambs Born to Ewes Supplemented with Algae-Derived Docosahexaenoic Acid

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IMPACT STATEMENT

Neonatal lamb mortality is a major factor affecting profitability in the sheep industry, and lamb thermogenesis is a key element in neonatal lamb survival. Increased lamb vigor has been reported when ewes were supplemented during late gestation with algae-derived docosahexaenoic acid (DHA); however, the effects of DHA on lamb thermogenesis and immunocompetence have not been investigated. The results of this experiment indicate that supplementing ewes during late gestation and early lactation with algae-derived DHA in the diet did not affect BW, serum metabolites and hormones, or body temperature of lambs in response to cold exposure, but resulted in greater concentrations of IgG in the colostrum. Supplementation of diets of ewes during late gestation and early lactation adversely affected growth and development of lambs early in lactation.

SUMMARY

Eighty twin-bearing Targhee ewes (ages 2 to 5 yr; 68.5 ± 3 kg) were assigned randomly to 1 of 2 supplement treatments to determine the effects of feeding docosahexaenoic acid (DHA) to ewes during late gestation and early lactation on lamb thermogenesis, serum metabolites and hormones, and lamb growth. Supplement treatments were 12 $g \cdot ewe^{-1} \cdot d^{-1}$ of algae-derived DHA (DHA Gold Advanced Bionutrition Corp., Columbia, MD; algae-derived DHA); and no algae-derived DHA (control). Lamb rectal temperature, glucose, NEFA, cortisol, leptin, and birth weights did not differ between treatments. The BW at 38 d was greater (P = 0.03) for lambs born to control ewes than for lambs born to algae-derived DHA-supplemented ewes; however, the colostrum of algae-derived DHA-supplemented ewes had a greater specific gravity (P = 0.05) than for control ewes.

INTRODUCTION

Hypothermia and starvation are major causes of neonatal lamb mortality. Newborn lambs rely on brown adipose tissue (BAT) to prevent hypothermia. The effects of DHA on BAT have not been studied. Lambs born to ewes fed 12 $g \cdot ewe^{-1} \cdot d^{-1}$ of DHA during late gestation had greater vigor scores than lambs born to ewes fed no DHA (Pickard et al., 2008); however, indices of lamb thermogenesis were not measured.

PROCEDURES

All animal procedures were approved by the Montana State University Agricultural Animal Care and Use Committee.

Ewe Selection and Management. Eighty twin-bearing Targhee ewes (ages 2 to 5 yr; initial BW of 68.5 ± 3 kg) were stratified by age and assigned randomly to 1 of 2 treatment diets. Ewes were transported from the Bair Ranch in Martinsdale, MT to the Montana State University Fort Ellis facilities near Bozeman on February 2, 2009, where they were confined in a dry lot with access to shelter. Ewes had ad libitum access to water and grass hay (10% CP), trace minerals (Westfeeds Inc., Billings, MT), and salt (mixed 1 part to every 2 parts trace mineral) during late gestation.

Treatments. Supplements were formulated by Westfeeds (Billings, MT) to be isocaloric

and isonitrogenous, and to be individually fed daily at 0.9 kg/ewe on an as-fed basis. Ewe treatments were algae-derived DHA (DHA Gold; Advanced Bionutrition Corp., Columbia, MD) at a rate of 12 g·ewe^{-1}·d^{-1}, which resulted in 2.2 g of DHA·ewe^{-1}·d^{-1}, and no algae-derived DHA (control). The algae-derived DHA was included in the daily supplement. Diets were individually fed (40 ewes/treatment) daily during the last 30 d of gestation (beginning March 6, 2009) and pen-fed (6 pens/treatment with 6 or 7 ewes/pen) during the first 38 d of lactation (beginning April 15, 2009).

Lambing Management. Ewes were observed every 15 min, 24 h/d during lambing season. When ewes were observed in labor, they were visually monitored constantly until parturition. After parturition, individual ewes and her lambs were placed in a pen (1.5 m^2) for 60 min to allow maternal bonding but without nursing. At 30 min after lambing, lamb sex and birth weight were recorded, and umbilical cords were clipped and dipped in iodine. After 24 h, ewes and lambs were moved to mixing pens, and at 48 to 60 h, they were moved to pens (65 m^2) in groups of 5 or 6 ewes/pen for the duration of the study (38 ± 7 d).

Data Collection and Sample Analyses. At 1 h after lambing, lambs and ewes were blood sampled (10 mL) via jugular puncture using nonheparinized Vacutainer tubes (Becton Dickinson, Franklin Lakes, NJ), and lamb thermogenesis was measured as described by Dafoe et al. (2008). Each lamb was fitted with a rectal temperature sensor connected to a data-logger (HH506RA, Omega Engineering Inc.). After an initial temperature recording, both twin lambs were placed into crates (183 cm^2) in a dry cold environmental chamber (0°C) for 30 min; rectal temperatures of each lamb were recorded automatically every minute. Lambs were removed from the cold chamber, and a blood sample was collected via jugular puncture, after which the lambs were warmed for 15 min at room temperature and returned to their dam. A final blood sample was collected from each ewe and lamb on the last day of the study.

Statistical Analyses. Data were analyzed as a completely randomized design using the GLM and Mixed procedures (SAS Inst. Inc., Cary, NC). Temperature data were analyzed as repeated measures using the mixed procedure of SAS; compound symmetry covariance structure was specified. Colostrum, milk data, ewe and lamb blood metabolite data were analyzed using the GLM procedure of SAS. The models included the effects of supplement treatment, lambing date, lamb sex, and birth weight; sampling time was included for temperature data. Ewe was the experimental unit for blood metabolite, colostrum, and anti-PI_3 data, so lamb BW measurements, temperatures, and blood metabolite data were averaged to calculate lamb values per ewe. After lambing, treatments were maintained but imposed on groups of ewes. Therefore, pen was the experimental unit for milk and lamb growth data. When a significant ($P < 0.10$) treatment *F*-test was observed, means were separated using the LSD procedure.

RESULTS AND DISCUSSION

Rectal temperature, glucose, NEFA, cortisol, and leptin concentrations of lambs did not differ ($P > 0.11$) between algae-derived DHA and control lambs (Figure 1).

Percentage of fat and total solids were greater ($P < 0.05$) in colostrum of control ewes than in algae-derived DHA-supplemented ewes; however, colostrum of algae-derived DHA-supplemented ewes contained a greater percentage of lactose ($P = 0.03$) and had a greater specific gravity ($P = 0.05$) than that of control ewes, indicating a greater IgG concentration.

Lamb BW on May 18 (38 d ± 7 d) was greater ($P = 0.03$) in lambs born to control than in lambs born to algae-derived DHA-supplemented ewes. Conversely, ewe BCS were greater in algae-derived DHA- than in control-supplemented ewes ($P = 0.05$) by 38 d after lambing.

Docosahexaenoic acid is an important fatty acid in neural and visual development in infants (Horrocks and Yeo, 1999; Cunnane et al., 2000), and it has been shown to increase lamb

vigor (Capper et al., 2006; Pickard et al., 2008) in other studies. Thus, it seems likely that DHA has more of a neurological benefit rather than an energetic benefit. Although energy status (thermogenesis), serum metabolites and hormones, and BW at 38 d (±7 d) of age were measured in the present study, factors associated with brain and nervous system developments were not. Future experiments should address these factors with respect to supplementation of late-gestation ewes with DHA.

REFERENCES

Capper, J.L., R.G. Wilkinson, A.M. Mackenzie, and L.A. Sinclair. 2006. Polyunsaturated fatty acid supplementation during pregnancy alters neonatal behavior in sheep. J. Nutr. 136:397–403.

Cunnane, S.C., V. Francescutti, J.T. Brenna, and M. A. Crawford. 2000. Breast-fed infants achieve a higher rate of brain and whole body docosahexaenoate accumulation than formula-fed infants not consuming dietary docosahexaenoate. Lipids 35:105–111.

Dafoe, J. M., R. W. Kott, B. F. Sowell, J. G. Berardinelli, K. C. Davis, and P. G. Hatfield. 2008. Effects of supplemental safflower and vitamin E during late gestation on lamb growth, serum metabolites, and thermogenesis. J. Anim. Sci. 86:3194–3202.

Horrocks, L. A., and Y. K. Yeo. 1999. Health benefits of docosahexaenoic acid (DHA). Pharmacol. Res. 40:211–225.

Pickard, R. M., A. P. Beard, C. J. Seal, and S. A. Edwards. 2008. Neonatal lamb vigour is improved by feeding docosahexaenoic acid in the form of algal biomass during late gestation. Animal 2:1186–1192.

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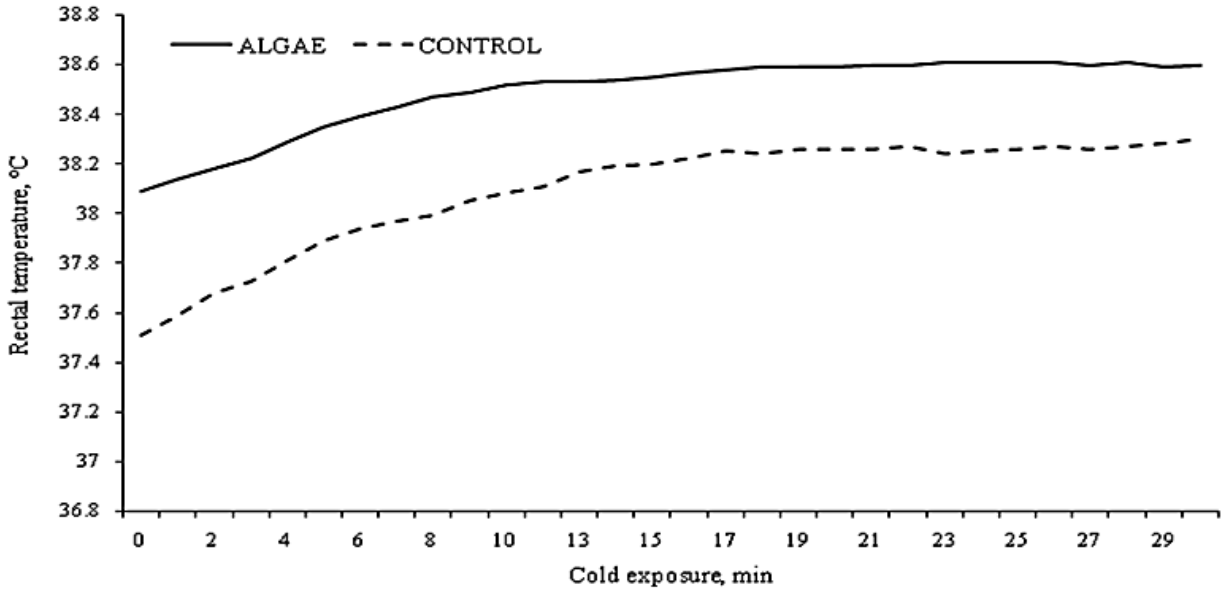

Figure 1. Least squared means of rectal temperature for 44 twin lamb pairs exposed to 0 or -15°C for 30 min 1 h after birth. Treatments within isocaloric and isonitrogenous supplements were: 1) 12 g/ewe daily DHA Gold (Advanced Bionutrition Corporation, Columbia, MD) containing 2.2 g of DHA, in the form of algal biomass (ALGAE), and 2) no DHA (CONTROL). The SEM for differences = 0.22°C. Rectal temperatures of lambs from ewes supplemented with ALGAE were greater at time 0 ($P = 0.07$) and time 1 ($P = 0.08$), but did not differ at any other time ($P > 0.11$). Proc Mixed repeated measures evaluated the effects of time, treatment (trt), trt x time interaction. None of these factors differed ($P > 0.11$), with the exception of time ($P < 0.0001$).