EFFECTS OF PREPARTUM HIGH LINOLEIC SAFFLOWER SEED SUPPLEMENTATION FOR GESTATING EWES ON COLD TOLERANCE AND SURVIVABILITY OF LAMBS

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INTRODUCTION

Mortality of newborn lambs due to cold stress is a problem during winters and cold, wet springs. Cold and cold-induced starvation account for 50% of perinatal lamb deaths (Samson and Slee, 1981). Lambs produce 50 to 60 % of their heat through shivering and 40 to 50% through non-shivering thermogenesis (Alexander and Williams, 1968). Brown adipose tissue (BAT), present in most infant mammals, is the origin of the non-shivering portion of thermogenesis. Lambs are born with almost 100% BAT, unlike other species, such as humans and rats which are born with brown and white adipose tissue (WAT; Gemmel et al., 1972; Alexander and Bell, 1975). Uncoupling protein-1 (UCP1), also known as thermogenin, is specific to BAT and is the thermogenic agent.

Nutrition, particularly dietary fat, has been shown to influence BAT composition and activity. Research with steers (Cook et al., 1972) and lambs (Gibney and L'Estrange, 1975) utilizing feedstuffs high in linoleic acid resulted in increased linoleic acid content of specific brown fat stores. Brown adipose tissue relies on linoleic acid as a major fuel for heat production (Lammoglia et al., 1999a). Supplementation of sunflower and linseed oil (high in linoleic and linolenic acid) to rats increased the thermogenic capacity of BAT in by 75% and doubled the content of UCP1 (Nedergaard et al., 1983). Supplemental polyunsaturated fatty acids supplemented to rats increased thermogenic activity of BAT (Oudart et al., 1997).

Because cold stress is initiated as soon as the lamb leaves the temperature controlled uterine environment upon parturition, the optimal period for enhancing the thermogenic potential of the lamb would be prior to parturition. However, few studies have examined the effects supplemental fat to the gestating ewes on the neonatal lamb. Budge et al. (2000) demonstrated ewes well-fed (150% metabolic requirement) during the final 65 d of gestation had lambs with 22% more UCP1 abundance and twice the thermogenic activity in BAT as lambs from ewes fed at 100% requirement. It is not known whether such increases would result in a more cold tolerant lamb. Lammoglia et al. (1999a,b) fed high linoleic safflower seeds to heifers during the last third of gestation and calves were better able maintain body temperature when exposed to cold compared to calves from dams fed conventional supplements.

High linoleic safflower seeds may be an feasible dietary source of linoleic acid for livestock. Seeds from the high linoleic varieties can contain up to 80% linoleic acid. In addition, the seed, because of the high oil content, is a high energy feed and a good source of rumen degradable protein, making it a good source of supplemental nutrients. The objectives of this study were to determine if feeding high linoleic safflower seed as a fat source to gestating ewes increases the cold tolerance, overall survivability, and performance of lambs.

PROCEDURES

These projects were conducted at the North Dakota State University Hettinger Research Extension Center located just west of Hettinger, ND. Average high and low temperature during supplementation were 0 and -12.8°C (yr 1) and -0.7 and -12.2°C (yr 2), respectively. During lambing, average high and low temperatures for yr 1 were 7.9 and -5.6°C and -6.8 and -17.8°C for yr 2, respectively.

Approximately 45 d prior to anticipated lambing date, 122 (yr 1; 75.8 ± 7.6 kg initial weight) and 112 (yr 2; 75.8 ± 7.6 kg initial weight) gestating ewes were allotted randomly to one of two dietary treatments (4 pens/treatment). Pregnancies were verified with real-time ultrasound. Ewes were fed diets formulated to contain either 1.9 (low fat; LF) or 4.6% (high fat; HF) dietary fat. Diets were delivered via a 10 ft self-feeder with feed access on both sides as a total mixed ration and diets were calculated to be isocaloric and isonitrogenous. In addition to finely chopped alfalfa hay, rolled safflower seeds (32% fat; 80% linoleic acid) were supplemented in HF, while solvent extracted safflower meal was used as protein source in LF supplement. Energy was balanced in LF with corn (Table1). In yr 1 all pens were offered equal amounts of feed. Ewes were allowed to consume free choice trace mineralized salt block. Animals were housed in 10 X 100 ft pens with access to a 10 X 30 ft covered barn.

At the onset and conclusion of supplementation, ewes were weighed and body condition was scored (BCS) using a five point scoring system (1 = emaciated, 5 = obese). Upon lambing, birth weights were recorded. Lamb mortality was recorded and separated by cause: born dead, pneumonia, or starvation. Lambing rates were calculated by dividing number lambs born per pen by number ewes per pen. In calculating mortality, number lambs died (total or of a certain cause) per pen were divided by total lambs born per pen. Surviving lambs were weighed at weaning. Lambs weaned per ewe was calculated by dividing number of lambs surviving until weaning per pen by number of ewes per pen. Sum of weaning weight of lambs per pen were divided by number of ewes per pen to find lbs weaned per ewe.

Table 1. Diet and nutrient composition of gestating ewes fed low or high fat diets (DM basis).

	Treatment	
Ingredient, %	LF	HF
Alfalfa hay, ground	78.3	81.6
Corn, dry rolled	14.0	5.5
Safflower meal, solvent extruded	6.6	2.5
Molasses, dry	1.1	0.4
Safflower seeds, rolled	—	10.0
Nutrient composition, %		
Dry matter	81.35	81.72
Organic matter	91.74	91.12
Crude protein	17.45	17.78
Ca	0.96	1.18
P	0.38	0.26
Fat	2.8	5.7
ME[a], Mcal/kg	2.24	2.27

[a]Metabolizable energy; calculated.

RESULTS AND DISCUSSION

Ewe Performance

Data was combined across years for all variables. Ewes consumed an average of 3.22 and 2.60 kg dry matter daily per year respectively. Body condition at the onset (3.66 ± 0.03; P = 0.45; Table 2) and conclusion (3.92 ± 0.02; P = 0.46) of supplementation was similar for LF and HF fed ewes. Differences in initial (78.7 _ 0.6; P = 0.25) and final BW (95.0 _ 0.9; P = 0.22) were not detected. Lack of difference in body weight and condition were expected as both diets provided equal amounts of energy. These results are in agreement with Lammoglia et al. (1999a) feeding isocaloric and isonitrogenous diets including safflower seeds to heifers. Three treatment diets containing different types of oilseeds did not cause differences in heifer body condition or weight over a control diet similar in energy and protein concentration (Bellows et al., 1999). Similar results have been seen with mature cows (Lammoglia et al., 1997). De Fries et al. (1998), however, observed increased body condition with no change in BW of cows fed isocaloric and isonitrogenous diets containing rice bran following calving.

Table 2. Effect of safflower supplementation on ewe performance.

	Treatment			
Item	LF	HF	SEM[a]	P[b]
Weight, lb				
Initial	174.0	171.6	1.3	0.25
Final	210.5	206.8	2.0	0.22
Body condition score[c]				
Initial	3.68	3.65	0.03	0.45
Final	3.93	3.91	0.02	0.46

[a]Standard error of the mean; n = 4.
[b]Probability of a greater F statistic.
[c]1=emaciated, 5=obese

Lamb Birth Weight, Mortality, and Weaning Performance

Birth weights of lambs were not different (P = 0.24; Table 3) probably due to the energy equality in the dietary treatments. Additional energy provided to the dam during the last trimester has been hypothesized to stimulate greater fetal growth. The current results agree with supplemental fat studies in beef females (Bellows et al., 1999; Espinoza et al., 1995). Lambs from HF dams had higher survivabilities (P = 0.03). There was no difference in numbers of lambs born dead; however, more (P = 0.03) lambs from LF dams died due to starvation and tended to die from pneumonia (P = 0.07).

Lambs are most susceptible to hypothermia from birth to five hours of age and again 12 to 36 hours after birth (Eales et al., 1982). Stott and Slee (1985) state, "A viable lamb must, therefore, be vigorously homeothermic at birth and possess sufficient energy reserves." Therefore, methods imposed during fetal development to increase the thermogenic capacity and energy reserves of the lamb at the onset of parturition could decrease mortality due to cold stress in the first 36 hours after birth. The present study showed lambs had greater survivabilities when dams had been fed a high linoleic safflower during the last 45 days of gestation.

There was no difference in weaning weights across treatments (P = 0.18; Table 3). Bellows et al. (1999) saw a tendency of fat supplementation to heifers during the last 65 d of pregnancy to increase WW of calves. Calves from HF supplemented dams have had increased WW (Espinoza et al., 1995); however, fat supplementation was continued after parturition and during lactation. Due to higher mortality at parturition, number of lambs weaned per ewe was lower for the LF treatment (P = 0.02).

Table 3. Influence of dietary treatment of dam on lamb birth weight, mortality, and weaning weight.

	Treatment			
Item	LF	HF	SEM[a]	P^b
Birth weight, kg	5.7	5.6	0.09	0.24
Lambs per ewe	1.63	1.76	0.06	0.13
Mortality, % of total lambs born	21.68	11.57	2.94	0.03
Born dead, % of total lambs born	3.24	5.78	2.18	0.43
Starvation, % of total lambs born	15.38	5.79	2.79	0.03
Pneumonia, % of total lambs born	1.74	0.00	0.63	0.07
Weaning weight, kg	19.2	17.8	0.68	0.18
Lambs weaned per ewe	1.17	1.47	0.04	0.02
Lamb weight weaned per ewe, kg	21.4	24.8	1.5	0.12

[a]Standard error of the mean; n = 4.
[b]Probability of a greater F statistic.

CONCLUSIONS

Results from this experiment suggest feeding high linoleic safflower seed to ewes during the last 45 days of gestation increases lamb survivability at parturition. Increasing number of lambs born live and weaned suggests an economic benefit from supplementation. Further research is necessary in eliciting the mechanism by which survival is increased and identifying types of fat sources which cause such a response.

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