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THE EFFECTS OF RUMINAL ESCAPE PROTEIN OR FAT ON NUTRITIONAL STATUS OF PREGNANT WINTER-GRAZING BEEF COWS

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ABSTRACT

This study was designed to determine the influence of soybean meal supplementation, with or without additional ruminal escape protein or fat, on the nutritional status of pregnant winter-grazing beef cows. During two winters (Trials 1 and 2), approximately 60 prepartum beef cows grazed native foothills range each year. Cows were allotted randomly to five groups and supplemented (g/d) with either none (control); 570 soybean meal (SOY; 450 soybean meal plus 230 blood meal (SOY + BM); 140 soybean meal, 16 urea plus 450 corn gluten meal (SOY + CGM): or 570 soybean meal plus 210 animal fat (SOY + FAT). These supplements were designed to supply similar quantities of ruminal degraded protein while varying

in escape protein quantity and source (SOY + BM and SOY + CGM). Condition scores and body weights were determined at trial initiation (mid-December) and conclusion (early March). Eight blood samples obtained over 4 d during three periods (9, 4 and 1 wk prior to parturition) were analyzed for concentrations of glucose, urea nitrogen (N), total bilirubin, creatinine, albumin, total protein and cholesterol. Cows in the control treatment experienced the greatest BW loss in both trials. In Trial 2, escape protein tended to decrease ($P < .06$) BW loss compared to SOY, though loss tended to be greater ($P < .08$) with SOY + CGM than with SOY + BM. Escape protein can enhance nutritional status when supplemented with .6 kg/d of soybean meal.

INTRODUCTION

Pregnant beef cows grazing winter range forage may lose up to 5 kg BW/d (Pinney et al., 1972). Supplementation of grazed forage with .5 to 1 kg of soybean meal or cottonseed meal/d typically reduces prepartum weight loss (Lusby and Wagner, 1987). Supplementation with nonprotein nitrogen plus cereal grain also can reduce weight loss but its benefit usually is less than that resulting from supplementation with natural protein (Mies et al., 1967; Thomas et al., 1968).

Some of the response to soybean meal or cottonseed meal supplements may be due to ruminal escape protein. The gestating cow, compared to the nonpregnant cow, may have a higher requirement for glucogenic substrates (MacRae and Lobley, 1986). Escape protein may fulfill this need via gluconeogenesis. Petersen and Clanton (1981) supplemented winter-grazing pregnant cows with soybean meal or blood meal plus urea. They found that blood meal plus urea was inferior to an isonitrogenous soybean meal supplement as measured by cow BW loss.

This study was designed to determine the influence of soybean meal supplementation, with or without ruminal escape protein or fat,

on nutritional status of pregnant, winter-grazing beef cows. Nutritional status was defined as change in BW, condition score and specific blood metabolite concentrations.

DISCUSSION

Supplementation with protein resulted in a positive response in BW change in both years. Cows receiving supplemental escape protein responded in both trials with reduced body condition loss and in Trial 2 with reduced weight loss; in Trial 2, all cows were in greater negative energy balance compared to Trial 1 when cows gained BW. This response in Trial 2 is similar to that reported by Lindsay et al, (1982), who investigated a supplement containing both ruminally degraded and escape protein to a nonsupplemented control. They supplemented pregnant cows with a meat and bone meal, formaldehyde-treated cottonseed meal and fish meal supplement and obtained a positive weight change, whereas nonsupplemented cows lost BW. Differential response to similar supplement regimens in different years has been reported previously (Kartchner, 1981; Phillips and Vavra, 1981; STanton et al., 1983). The appearance of a year effect in this study probably was not a function of ambient temperature. Beverlin (1988) noted that mean daily temperature did not differ between these two years. However, forage was covered by snow in Trial 2 for longer periods than in Trial 1. There also appeared to be less forage available in Trial 2, possibly due to a drought during the preceding growing season (National Oceanic and Atmospheric Administration, 1985, 1986). In both trials, forage always was available for grazing. However, initial grazing and selection may have reduced the quality of available forage in the second half of the trial in Trial 2 more than in Trial 1. Analysis of diet samples from both years showed similar ADF content of esophaegeal extrusa, although extrusa CP was higher in Trial 2 (Miner and Petersen, 1989).

Given the digestible OM intakes of this study as discussed by Miner and Petersen (1989), microbial protein synthesis can be

estimated by using protein synthesis rates measured by Kropp et al. (1976) and Petersen et al. (1985). In turn, equations of NRC (1984) and Orskov (1982) can be used to calculate a metabolic protein requirement of gestating beef cows. These estimations indicate that cows in the SOY group may have been deficient in metabolically available protein in both Trials 1 and 2. Because ruminal ammonia concentration was above 5 mg/100 ml of ruminal fluid (Miner and Petersen, 1989) in Trial 1, additional ammonia N in the rumen would not be expected to increase microbial protein yield (Satter and Slyter, 1974). Consumption of escape protein may increase the quantity of metabolically available protein in two ways. First, the escape protein should contribute directly to the pool of available protein. Microbial yield also may be enhanced because of enhanced availability of growth-limiting organic acids supplied by slowly ruminally degraded protein sources.

Alleviation of BW loss would be expected if the amino acids derived from escape protein substituted for or complemented amino acids of tissue origin in meeting amino acid requirements (NRC, 1984). An increase in amino acid pool size also may improve the efficiency of acetate utilization derived from either ruminal fermentation or adipose tissue catabolism (MacRae and Lobley, 1986). This suggested mechanism may be important in the subclinical ketosis experienced during weight loss and low plasma glucose concentrations noted in both trials. If amino acids of dietary origin accumulate, then those amino acids that serve as precursors of oxaloacetate may be utilized as intermediates for oxidation of acetate in the tricarboxylic acid cycle.

Another possible effect of escape protein involves the animal's requirement for essential amino acids. In Trial 1, serum amino acid concentrations were measured on samples composited across sampling intervals within period 2 (Miner, 1986). Branched-chain amino acid concentration was highest ($P = .07$) in SOY + BM and SOY + CGM (.63, .58, .52, .49 and .48 umol/ml for SOY + BM, SOY + CGM, SOY + FAT, SOY and control, respectively), which, according to Lynch and Jackson (1986), may reflect reduced muscle catabolism.

Control (.08 umol/ml), SOY (.07 umol/ml) and SOY + FAT (.09 umol/ml) had intermediate concentrations of lysine in comparison to SOY + BM (.11 umol/ml), which was nearly double (P .05) that of SOY + CGM (.06 umol/ml). According to Ahmed (1982), who investigated methionine requirements in steers, SOY + CGM may have supplied a limiting essential amino acid that increased the use of lysine. For example, methionine may have been limiting because consumption of corn gluten meal did not affect methionine concentration. Corn gluten meal protein is relatively rich in methionine but relatively low in lysine compared to blood meal (NRC, 1982). Lysine probably was not limiting because lysine concentration was elevated when lysine-rich blood meal was fed. However, these results and interpretation should be viewed with caution because we did not measure concentration of amino acids reaching the small intestine.

Weight change by cows fed SOY + FAT was intermediate compared to SOY + BM and SOY + CGM. The animal fat in SOY + FAT may have increased the amount of soybean meal that escaped ruminal degradation, although in situ measurements did not indicate this (Miner and Petersen, 1989). Lipids have been used to protect protein sources from fermentation (Van Soest, 1982). Even though the cattle consuming the SOY + FAT received twice the quantity of supplemental TDN, added fat did not alter weight change or improve nutritional status as measured by blood metabolite concentrations. From this, we may conclude that energy in the form of fat was not limiting to cow performance. The probability that forage intake (Miner and Petersen, 1989) was higher in SOY + BM than in SOY probably accounts for a portion of the observed differences in weight change in Trial 2.

During Trial 1, the lower glucose concentrations at 4 wk compared to 9 wk prepartum may have been a result of the environmental conditions. Snow covered much of the forage during 4 wk but was nearly absent during 9 wk and 1 wk. Snow cover reduces forage availability and may reduce digestibility, the effect being greater for unsupplemented heifers than for heifers fed a soybean meal

supplement (Rittenhouse et al., 1970). In addition, mean ambient daily temperature was lower during 4 wk (-6.5°C) than for either 9 wk (-4.2°C) or 1 wk (1.1°C). Glucose turnover and oxidation are decreased dramatically in sheep during acute cold exposure; skeletal muscles oxidize glucose for thermogenesis and glucose supply is increased, probably due to increased glycogenolysis and gluconeogenesis (Sasaki and Weekes, 1986). Nevertheless, plasma glucose concentration has been shown to increase during cold exposure in most, but not all, cases (Sasaki and Weekes, 1986). Hence, our results may reflect the combined effect of snow cover and cold.

During Trial 2, glucose concentration in all S groups declined from 9 wk to 4 wk prepartum. This may reflect an increased fetal requirement for glucose and glucogenic substrate and is consistent with the linear decline in glucose with gestation observed by Prior and Scott (1977), Ferrell and Ford (1980) and Bull et al. (1984). Regulation of glucose concentration in the beef cow may be such that it falls below 50 mg/dl only in extreme situations.

Serum urea N concentration was higher in supplemented groups than in the control group in Trial 2 and higher in SOY + BM and SOY + CGM than SOY in both trials. This probably reflects the increased N supply of these diets and that most of the additional amino acids absorbed were deaminated by the liver and (or) fetus. An increased amino acid supply should increase the supply of glucogenic intermediates.

Albumin concentrations, an indication of protein status, in Trial 1 were below, and in Trial 2 were above, the normal range reported by Benjamin (1978). The decline with advancing gestation in Trial 2 is consistent with results of Bull et al. (1984).

Total bilirubin concentration, an indication of liver function during physiological distress, was much higher in Trial 2 when most

cows lost BW than in Trial 1 when most cows gained weight. In both trials, the concentration was within the normal range reported by Benjamin (1978). Concentration increased with advancing gestation in both trials, which is consistent with results of Bull et al. (1984), who found bilirubin to be increased by protein restriction in prepartum heifers. In Trial 2 SOY + BM had lower bilirubin than other treatments during 1 wk, indicating that cows in SOY + BM may have had a greater ability to cope with the demands of advancing gestation. Because bilirubin was higher during 4 wk than 1 wk prepartum of Trial 1, the hypothesis concerning environmental stress in 4 wk is supported.

Serum creatinine concentration, an indication of skeletal tissue catabolism, was higher in control than in other treatments in Trial 1; this is consistent with the response reported by Bull et al. (1984) to protein restriction. Creatinine concentration increased with advancing gestation, which also is consistent with results reported by Bull et al. (1984). This response in Trial 1 indicates that creatinine is more sensitive to facts associated with advancing gestation than to the environmental stress of 4 wk.

The SOY + FAT treatment elevated serum cholesterol concentration. Elevated cholesterol can be indicative of dietary lipid content or tissue catabolism. Increased lipid intake has been shown previously to elevate cholesterol (Talavera et al., 1985). With advancing gestation, cholesterol has been shown to decline in dairy cows (Blum et al., 1983) but to increase in beef heifers (Bull et al., 1984). Our study showed a decline in 1 wk prepartum compared to 9 wk and 4 wk in both years.

Even during Trial 1, when most cows gained BW, certain blood metabolites (glucose, creatinine, bilirubin) reflected nutritional stress in unsupplemented and supplemented animals. Body weight change was determined precalving. In both trials, subtracting fetal and placental weight from final cow weight would reveal that most cows were losing BW during these trials.

When supplemented with ruminally degraded protein, the addition of ruminal escape protein may provide enhanced resistance to environmental and physiological (pregnancy) stress, as demonstrated by the consistent responses measured by improved body condition change and lower total bilirubin concentrations. This study also suggests that supplemental escape protein may reduce body condition and weight loss in years when unsupplemented cows would lose 50 kg in a 75-d period. Further studies are required to understand the role that escape protein may have for the range beef cow in negative energy balance.

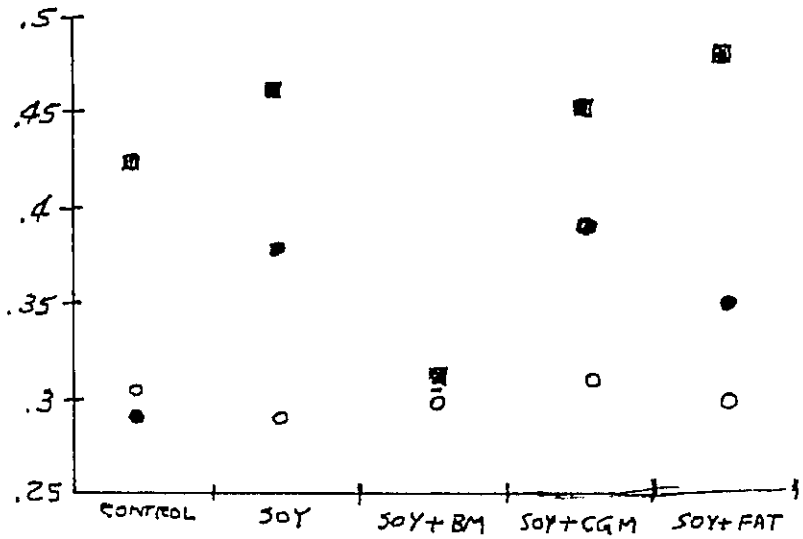

Figure 1. Trial 2 mean concentration of total bilirubin in gestating range cows. Periods represent sampling intervals in relation to weeks prior to parturition (Period 1, O = 9 wk; Period 2, ● = 5 wk and Period 3, ■ = 1 wk). Control = no supplement. SOY = soybean meal, SOY + BM = soybean meal plus blood meal. SOY + CGM = soybean meal plus corn gluten meal and SOY + FAT = soybean meal plus animal fat are the designations for supplement treatments. Supplement x week prior to parturition interaction. $P < .01$, SE = .03.

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TABLE 1. LEAST SQUARES MEANS FOR CALF BIRTH WEIGHT AND PRECALVING COW BODY WEIGHT AND CONDITION SCORE CHANGE (TRIALS 1 AND 2)

Trial and supplement[a]	BW change[b], kg	Condition score change[c]	Calf birth wt, kg
Trial 1			
Control	-1.9	-1.46	38.4
SOY	31.7	-1.18	38.1
SOY+BM	38.2	-.76	39.2
SOY+CGM	44.4	-.76	37.7
SOY+FAT	30.7	-.56	39.1
SE	7.04	.212	1.03
Trail 2			
Control	-46.4	-.95	37.8
SOY	-20.1	-.93	38.7
SOY+BM	-1.8	-.46	38.4
SOY+CGM	-15.0	-.69	39.2
SOY+FAT	-10.1	-.63	38.0
SE	5.37	.122	1.14

[a]SOY = soybean meal, SOY+BM = soybean meal plus blood meal, SOY+CGM = soybean meal plus corn gluten meal, SOY+FAT = soybean meal plus animal fat.

[b]Trial 1 and Trial 2: Control vs others, $P < .01$ and $P < .01$, respectively. Trial 2: SOY vs SOY+BM, SOY+CGM, $P = .06$; SOY+BM vs SOY+CGM, $P = .08$.

[c]Trial 1 and Trial 2: Control vs others, $P < .01$ and $P = .04$; SOY vs SOY+BM, SOY+CGM, $P = .03$ and $P < .01$ respectively.

TABLE 2. LEAST SQUARES MEANS FOR PRECALVING CONCENTRATIONS OF GLUCOSE, ALBUMIN, TOTAL PROTEIN, UREA NITROGEN, CREATININE, TOTAL BILIRUBIN AND CHOLESTEROL AS INFLUENCED BY SUPPLEMENT AND WEEK PRIOR TO PARTURITION (TRIAL 1)

	Supplement[a]					Week			
Metabolite	Control	SOY	SOY+ BM	SOY+ CGM	SOY+ FAT	9	4	1	SE
Glucose mg/dl[bc]	53.5	58.6	58.0	53.6	59.7	63.7	47.5	58.9	1.3
Albumin g/dl	2.4	2.7	2.9	2.7	2.8		2.8	2.7	.3
Total protein g/dl	7.9	7.8	7.8	7.9	7.5		7.8	7.7	.2
Urea nitrogen mg/dl[d]	7.7	6.3	9.0	9.8	6.2		6.4	9.2	1.2
Creatinine mg/dl[e]	1.9	1.8	1.6	1.6	1.5		1.6	1.8	.1
Total bilirubin[fg]	.13	.12	.06	.09	.10		.12	.08	.03
Cholesterol mg/dl[h]	96.7	113.6	95.3	90.3	142.3		108.8	106.5	7.2

[a]SOY = soybean meal, SOY+BM = soybean meal plus blood meal, SOY+CGM = soybean meal plus corn gluten meal, SOY+FAT = Soybean meal plus animal fat.

[b]Control vs other supplements, $P < .1$.

[c]Effect of week prior to parturition, $P < .01$.

[d]SOY vs SOY+BM, SOY+CGM, $P < .05$; SOY+FAT vs SOY+BM, SOY+CGM, $P < .05$.

[e]Control vs other supplements, $P < .05$.

[f]SOY vs SOY+BM, SOY+CGM, $P < .05$.

[g]Effect of week prior to parturition, $P < .05$.

[h]SOY+FAT vs SOY+BM, SOY+CGM, $P < .01$.

TABLE 3. LEAST SQUARES MEANS FOR PRECALVING CONCENTRATIONS OF GLUCOSE, ALBUMIN, TOTAL PROTEIN, UREA NITROGEN, CREATININE AND CHOLESTEROL AS INFLUENCED BY SUPPLEMENT AND WEEK PRIOR TO PARTURITION (TRIAL 2)

	Supplement[a]					Week			
Metabolite	Control	SOY	SOY+ BM	SOY+ CGM	SOY+ FAT	9	4	1	SE
Glucose mg/dl[bc]	54.0	56.1	57.0	56.0	57.7	58.6	55.4	54.1	1.6
Albumin, g/dl[c]	3.8	4.0	4.0	3.9	4.2	4.3	3.8	3.7	.3
Total protein, g/dl[c]	6.8	6.9	6.8	6.7	6.6	7.2	6.7	6.4	.2
Urea nitrogen, mg/dl[d]	7.1	10.5	12.7	12.5	10.3	9.9	10.5	11.4	1.0
Creatinine, mg/dl	1.8	1.9	1.8	1.8	1.9	1.8	1.9	1.9	.1
Cholesterol, mg/dl[e]	93.6	90.4	80.5	90.9	122.0	99.0	98.5	88.9	7.2

[a]SOY = soybean meal, SOY+BM = soybean meal plus blood meal, SOY+CGM = soybean meal plus corn gluten meal, SOY+FAT = Soybean meal plus animal fat.

[b]Control vs other supplements, $P < .10$

[c]Effect of week prior to parturition, $P < .05$

[d]Control vs other supplements, $P < .01$; SOY vs SOY+BM, SOY+CGM, $P < .05$; SOY+FAT vs SOY+BM, SOY+CGM, $P < .05$

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