EFFECTS OF ENERGY LEVEL, PROTEIN LEVEL AND PROTEIN SOURCE ON STEER FEEDLOT PERFORMANCE[1]

J.I. Sultan, F.L. Fluharty & S.C. Loerch
Department of Animal Science and
Ohio Agricultural Research and Development Centre,
Ohio State University, Wooster, OH 44691, USA

Seventy-nine Angus x Hereford crossbred steers (avg. wt. 348 kg) were used to determine the effects of energy level, protein level and protein source on performance of growing steers. The experiment was a completely randomized 2 x 2 x 2 factorial. Diet main effects were: low energy (70% ensiled corn stover) vs high energy (46% ensiled corn stover); low protein (9.5%) vs high protein (12%); and soybean meal vs blood meal. Steers were housed and fed individually during the 50 day growth trial. No interactions ($P<0.01$) were detected among energy level, protein level or protein source. High energy diets improved ($P<0.01$) rate of gain 62% and feed intake 21% compared to low energy diets. Increasing protein level improved ($P<0.03$) rate of gain by 20% and feed intake by 5.4%. Use of blood meal, which is a high ruminal escape protein supplement, increased ($P<0.15$) rate of gain by 9% without affecting feed intake compared to supplemental soybean meal. Results of this trial suggest that increasing protein level to 12% of the diet and the use of a ruminal escape protein source improves performance of steers when they are fed diets containing 46 to 70% corn stover.

INTRODUCTION

Effects of feeding ruminants protein sources differing in ruminal degradability have been reviewed (Chalupa, 1975; Clark, 1975). A substantial amount of research on utilization of slowly degradable protein sources has been conducted (Merchen *et al.*, 1979; Stock and Klopfenstein, 1979; Loerch *et al.*, 1983). Performance was improved when growing cattle were fed medium energy diets supplemented with slowly degradable protein sources. However, when low or high energy diets were fed, cattle often did not respond to protein sources which escape ruminal degradation. Interactions of dietary energy level and rumen protein degradation were reported by Loerch and Berger (1981). They suggested that soybean meal degradability in the rumen is reduced to a level similar to that of meat and bone meal when high energy diets are fed. In another study, Loerch (1985) reported the effect of meat and bone meal supplementation of diets varying in level of energy and suggested that slowly degradable protein sources are not effective in improving cattle performance unless protein is the limiting factor for growth. Thus energy level may affect protein requirement and the requirement for aruminal escape protein source. The objective of this study was to determine effects of

[1]Salaries and research support provided by State and Federal Funds appropriated to the Ohio Agric. Res. and Div. Center, Ohio State Univ: Journal No. 325-91. Research and the senior author were supported in part by a fellowship from the Food and Agriculture Organization of the United Nations.

energy level (70% corn stover vs 46% corn stover), protein level (9.5% vs 12%), and protein source (soybean meal vs blood meal) on steer feedlot performance. Corn was used to vary the energy content of the diets.

MATERIALS AND METHODS

Animals and experimental diets: Seventy-nine Angus x Hereford crossbred steers (avg. wt. 348 kg) were fed a low energy diet (70% ensiled corn stover, DMB) or a high energy diet (46% ensiled corn stover, DMB). Corn was used to vary the energy content of these diets. Low or high energy diets were supplemented with either soybean meal or blood meal at two levels of protein (9.5 vs 12%). Low energy diets had approximately 2.34 Mcal/kg of metabolizable energy (ME), while high energy diets were formulated to contain 2.62 Mcal/kg of ME. Urea (0.3%) was added to all diets to provide a readily available source of rumen NH_3-N. Supplemental protein sources provided 30-48% of total dietary protein in low energy - 9.5% protein diets and 15-37% of protein in high energy - 12.0% protein diets, respectively. Ingredient and chemical composition of the experimental diets is shown in Table 1.

Management of steers: The steers were housed and fed individually for the 50-day growth trial. The steers were allowed to eat *ad libitum* and were fed once daily. Steers were weighed without shrinking on two consecutive days to determine initial and final weights. Weights were also taken on day 24. Average daily gain (ADG), dry matter intake (DMI) and gain to feed (G/F) ratios were determined.

Chemical analysis: Feeds were analysed for DM, OM and N content (macro-Kjeldhal) (AOAC, 1984). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by methods of Van Soest and Robertson (1980).

Statistical analysis: Feed intake, ADG and G/F were analysed by analysis of variance procedures, for a completely randomised design using the general linear model procedure of SAS (1988). Sum of squares were partitioned to test effects due to protein level, energy level, protein source and all possible interactions.

RESULTS AND DISCUSSION

As no interactions were detected among protein level, energy level or protein source, the results shown in Table 2 are presented for main effects. Chemical analysis of the diets revealed some variation in actual CP content. Low protein diets varied from 9.07 to 9.42% CP and high protein diets varied from 11.42 to 12.36% CP. This variation resulted from differences in expected vs actual protein levels in the basal ingredients and fluctuation in the DM content of ensiled corn stover. Rate of gain was improved ($P<0.01$) 62% for steers fed high energy diets containing 46% corn stover compared with those fed low energy diets containing 70% corn stover (1.02 vs 0.63 kg/day, respectively). Steers fed 12% protein diets had 20% greater ($P<0.01$) ADG than steers fed 9.5% protein diets. Like energy and protein level, protein source also affected the rate of gain of steers. Steers fed supplemental blood meal (BM) gained approximately 9% faster ($P<0.01$) compared with steers fed soybean meal.

Feed intake was lower ($P<0.01$) for steers fed 70% corn stover diets than for those fed 46% corn stover diets. Likewise, steers receiving 9.5% protein diets consumed less ($P<0.03$) feed than those receiving 12% protein diets. No difference ($P<0.15$) in DMI existed due to source of supplemental protein. Gain/feed was 37%

Table 1. Ingredient and chemical composition of diets fed to steers

Ingredients	70% corn stover				46% corn stover			
	Soybean meal		Blood meal		Soybean meal		Blood meal	
	9.5% CP[a]	12% CP	9.5% CP	12% CP	9.5% CP	12% CP	9.5% CP	12% CP
	% Dry matter basis							
Corn stover ensiled	70.00	70.00	70.00	70.00	46.00	46.00	46.00	46.00
Corn ground	21.15	15.15	23.95	20.83	47.90	41.90	49.34	46.20
Soybean meal	5.86	11.86	-	-	3.01	9.00	-	-
Blood meal	-	-	3.07	6.18	-	-	1.57	4.71
Urea	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.03
Trace mineralized salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Dicalcium phosphate	1.50	1.50	1.50	1.50	1.00	1.00	1.00	1.00
Limestone	0.60	0.60	0.60	0.60	1.20	1.20	1.20	1.20
Selenium	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Vitamin A	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Vitamin D	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Chemical composition								
Organic matter	95.66	95.33	96.07	95.82	96.59	96.19	96.79	96.49
Crude protein	9.11	11.51	9.42	12.26	9.07	11.42	9.30	12.30
Neutral detergent fibre	58.50	58.76	57.65	57.10	44.00	44.58	43.92	44.00
Acid detergent fibre	35.81	36.27	35.16	35.04	24.60	25.09	24.30	24.16
Metabolizable energy (Mcal/kg)	2.35	2.32	2.36	2.34	2.64	2.61	2.63	2.62

[a]Crude protein

greater ($P<0.01$) for steers fed high energy diets compared with those fed low energy diets. Likewise, high protein diets improved ($P<0.02$) G/F compared to the low protein diets, and steers fed diets supplemented with blood meal had approximately 13% greater ($P<0.05$) G/F than steers fed diets supplemented with soybean meal.

energy diets had improved weight gain and feed efficiency. Protein level and source are more critical when ruminants are fed crop residue based diets (Loerch, 1985). In the present trial, supplementation improved feed intake and steer gains. Because corn stover has a low protein content, supplemental protein comprises a large proportion

Table 2. Effects of protein and energy level and protein source on steer performance

Item	Energy level		Protein level		Protein source		
	70% stover	46% stover	9.5%	12%	SBMa	BMb	SE
No. of steers	40	39	40	39	30	40	
Initial weight (kg)	347.4	348.2	347.9	347.7	348.0	347.0	
Gain (kg/day)	0.63	1.02	0.75	0.90	0.79	0.86	0.04[cde]
Feed intake (kg/day)	6.34	7.67	6.82	7.19	7.06	6.95	0.12[cd]
Grain/feed (kg/kg)	0.097	0.133	0.107	0.123	0.108	0.122	1.08[cdf]

[a] Soybean meal; [b] blood meal; [c] energy level effect ($P<0.01$); [d] protein level effect ($P<0.03$); [e] protein source effect ($P<0.15$); [f] protein source effect ($P<0.05$).

When diets high in NDF and low in fermentable carbohydrates are fed, generally intake is depressed. Freer and Campling (1965) reported that diets high in fibre decrease voluntary intake. Low quality forages and crop residues have a high lignin content present in the secondary cell wall (Van Soest, 1982) and lignin is a component of dietary fibre which negatively affects or limits forage digestibility. In the present trial, lower voluntary intake of the low energy diets significantly affected the ADG and subsequently lowered G/F compared to the high energy diets. High energy diets contained 47% corn, which provided a greater amount of readily available substrate to rumen microbes and improved intake and diet digestibility. As a result, steers fed high

of total dietary protein. Thus, source of supplemental protein becomes more important.

In addition, the relatively low energy content of corn stover results in high rumen pH which increases rumen digestion of soybean meal protein and decreases its efficiency of utilization. Rumen degradation of blood meal is not greatly affected by rumen pH (Loerch *et al.*, 1983), thus blood meal provides more rumen escape protein and is used more efficiently than soybean meal.

REFERENCES

AOAC. 1980. Official Methods of Analysis. (12th Ed.) Association of Official Analytical Chemists, Washington, DC.

Chalupa, W. 1975. Rumen and protection of proteins and amino acids. J. Dairy Sci. 28: 1198.

Clark, J.H. 1975. Nitrogen metabolism in ruminants: Protein solubility and rumen bypass of protein and amino acids. In: Protein Nutritional Quality of Foods and Feed, Part 2. Mercel Dekker Inc., New York, p. 261.

Freer, M. and R.C. Campling. 1965. Factors affecting the voluntary intake of food by cows. The behaviour and reticular motility of cows given diets of hay, dried grass, concentrates and ground, and pelleted hay. Br. J. Nutr. 19: 195-207.

Loerch, S.C. and L.L. Berger. 1981. Feedlot performance of steers and lambs fed blood meal, meat and bone meal, dehydrated alfalfa and soybean meal as supplemental protein sources. J. Anim. Sci. 53: 1198.

Loerch, S.C., L.L. Berger, G. Gianola and G.C. Fahey, Jr. 1983. Effects of dietary protein source and energy level on *in situ* nitrogen disappearance of various protein sources. J. Anim. Sci. 56: 206.

Loerch, S.C., L.L. Berger, S.D. Plegge and G.C. Fahey, Jr. 1983. Digestibility and rumen escape of soybean meal, blood meal, meat and bone meal and dehydrated alfalfa nitrogen. J. Anim. Sci. 57: 1037.

Loerch, S.C. 1985. Effects of slowly degradable protein sources on performance of feedlot cattle under various feeding systems. Nutr. Rep. Int. 32: 1229.

Merchen, N.R., T. Hanson and T. Klopfenstein. 1979. Rumen bypass of browers dried grains protein. J. Anim. Sci. 49: 192.

SAS. 1988. SAS/Stat User's Guide for Personal Computers Release 6.03. Statistical Analysis System Institute, Carry, NC.

Stock, R. and T. Klopfenstein. 1979. Feeding value of blood meal and meat meal as protein supplements for ruminants. J. Anim. Sci. 48: (Suppl. 1): 121.

Van Soest, P.J. and J.B. Robertson. 1980. Systems of analysis for evaluating fibrous feed. In: Standardization of Analytical Methodology of Feeds. W.J. Pidgen, C.C. Balch and M. Grahm (Ed.). Int. Dev. Res. Center, Ottawa, Canada.

Van Soest, P.J. 1982. Refractory and Inhibitory Substances. In: Nutritional Ecology of the Ruminant. O and B Books Inc., Corvallis, Oregon, USA.