Indian J. Anim. Nutr., 19(3) 191-198, 2002

Indian Journal of Animal Nutrition

EFFECT OF FEEDING RUMEN PROTECTED NUTRIENTS ON MILK PRODUCTION IN CROSSBRED COWS

M.R. GARG, P.L. SHERASIA, B.M. BHANDERI, S.K. GULATI* AND T.W. SCOTT*

Research and Development Group, Animal Nutrition and Feed Technology National Dairy Development Board, Anand - 388 001, Gujarat, India

(Received on March 26, 2002)

ABSTRACT

In one trial (Trial I), 16 Crossbred cows (HF x Jersey) were divided into two groups of 8 each, based on milk yield, fat % and stage of lactation. Animals in both groups were fed similar basal ration. In addition to basal ration, animals in control group were fed 1.0 kg untreated sunflower meal (CP 28%) and in experimental group 1.0 kg protected sunflower meal (CP 28%, UDP 74% of CP, NDIN 0.17%, ADIN 0.31%). Average increase in milk yield (kg), fat and protein (%) in experimental group were 1.1 (P<0.05), 0.2 and 4.3 (P<0.05), respectively. Net average daily income increased by Rs. 9.61 on feeding 1.0 kg protected sunflower meal in lactating cow. In another trial (Trial II), 20 crossbred cows (HF x Jersey) were divided into two groups of 10 each and all animals were fed similar basal ration. Animals in experimental group were fed 1.0 kg bypass fat/protein supplement (Fat 32-33%, CP 25-26%, NDIN 0.46%, ADIN 0.21%). Degree of fat protection was 79 per cent of the total, whereas protein protection was 80 per cent of total CP. Average increase in milk yield in experimental group was 1.1 kg (p<0.05). Fat and protein % increased by 0.6 (p<0.01) and 0.4 (p<0.05) respectively. Net average daily income increased by Rs. 10.18 on feeding 1.0 kg protected fat/protein supplement in lactating cows. In the present study, supplementation of protected protein and protected fat/protein in the ration of milch cows was economical.

Key words: Bypass protein, Bypass fat, Undegradable protein, Rumen degradable protein, Sunflower meal, Crossbred cows

In recent years two important factors have influenced the approaches in formulating diets with the use of protected protein and energy sources. The first is the global impact of economic pressure to substantially and continually improve the efficiency of milk

*CSIRO Livestock Industries, PO Box 136, North Ryde, NSW 1670, Australia

production. The second is the need to improve the quality of the derived ruminant products to meet consumer needs. This has resulted in the development of ruminants that require increased quantities of essential nutrients, such as specific amino acids and extra energy in the form of long-chain fatty acids, to achieve their genetic potential. In many instances, essential nutrients are inadequately supplied by the normal process of microbial metabolism in the rumen (Clarke, 1975). For milk production, the composition of amino acids leaving the abomasum is deficient in the essential amino acids like lysine and methionine (Hogan, 1975). To address these concerns procedures have been developed to protect by-product nutrients such as proteins and lipids, to avoid the usual breakdown and binding processes that occur in the rumen especially ruminal protein (Ferguson, 1975) while the role of protected fats has been reviewed by (Scott and Ashes 1993). The protection of these essential nutrients have been shown to enhance the productivity of ruminants. This study observes the effect of feeding protected protein and fat in feeds on the quantity and quality of milk in lactating crossbred cows.

Table 1 Chemical composition (% DM) of feeds and fodder and daily DMI during the trials

Particular	Maize green	Paddy straw	Jowar straw	Oat silage	Cattle feed	Total DM intake (kg/day)
Chemical compositon						
OM	93.53±0.01	83.41±0.03	93.03±0.01	91.54±0.02	87.82±0.01	
CP	7.01±0.03	3.82±0.01	5.12±0.01	6.54±0.01	22.60±0.13	
EE	0.43±0.00	1.00±0.00	1.40±0.01	2.57±0.01	3.09±0.01	
NDF	61.10±0.15	67.7±0.11	61.78±0.16	61.54±0.14	20.25±0.16	
ADF	40.38±0.11	50.41±0.12	41.68±0.12	38.70±0.13	12.27±0.12	
Cellulose	32.70±0.10	40.16±0.05	32.70±0.12	33.42±0.14	9.06±0.10	
HC	20.72±0.06	17.29±0.05	20.10±0.10	22.84±0.16	7.98±0.12	
ADL	4.35±0.02	2.74±0.01	4.12±0.01	3.81±0.02	1.44±0.01	
Total Ash	7.85±0.02	14.56±0.09	5.81±0.03	8.87±0.05	10.34±0.08	
Silica (S)	3.33±0.01	7.51±0.01	4.86±0.01	1.47±0.00	1.77±0.00	
NDIN	0.28±0.00	0.24±0.00	0.24±0.00	0.27±0.00	0.21±0.00	
ADIN	0.11±0.00	0.16±0.00	0.10±0.00	0.08±0.00	0.10±0.00	
Daily DM Intake (kg)						
			Trial I			
Control	3.86±0.00	4.66±0.01	---	4.77±0.00	6.43±0.00	19.72±0.01
Experiment	3.71±0.01	4.50±0.01	---	4.80±0.00	6.65±0.00	19.66±0.01
			Trail II			
Control	3.63±0.00	---	4.74±0.00	---	5.49±0.00	13.86±0.00
Experiment	3.87±0.01	---	4.80±0.01	---	6.71±0.00	15.38*±0.01

* *(P<0.05)*

MATERIALS AND METHODS

Trial I was conducted on 16 crossbred cows (HF x Jersey), yielding 10-14 kg milk per animal per day. Animals were divided into two groups of 8 each, based on milk yield, fat % and stage of lactation. All animals in both the groups were fed similar basal ration, comprising 15 kg green maize fodder, 5 kg paddy straw and 15 kg oat silage. Concentrate mixture was given according to level of milk production, to meet the maintenance and production requirements (NRC, 1989). The chemical composition of feeds and fodder was carried out as per AOAC (1984). Feeds and fodder were also tested for NDF, NDIN, ADF, ADIN, cellulose, hemicellulose, acid detergent lignin as per Goering and Van Soest (1970). In addition to basal ration, animals in control group were fed 1.0 kg untreated sunflower meal (CP 28%) and animals in experimental group were fed 1.0 kg protected sunflower meal (CP 28%, UDP 74% of CP). The trial was conducted for a four weeks period. Sunflower meal was treated with aldehyde in sealed chambers where it underwent formation of complexes, resisting degradation in the rumen (Ashes *et al.*, 1995; Gulati *et al.*, 1999). The protein meal was tested for degree of protection using *in vitro* rumen incubation procedure. Known quantity of feed material was incubated for 24 h in strained rumen liquor, anaerobically at 38^0 C (Ashes *et al.*, 1997; Chalupa and Sniffen, 1996; Stern *et al.*, 1994). The protein degradation was measured by analyzing ammonia nitrogen level in strained rumen liquor, at the end of incubation (Scott and Ashes 1993; Gulati *et al.*, 1997b; 1999a). Protected and unprotected sunflower meals were analyzed for critical amino acids by ion-exchange chromatography (Connell *et al.*, 1987).

Table 2 Critical amino acids and fatty acids available for absorption at small intestine on feeding bypass and fat/protein supplement,

Critical amino acids/fatty acids	Unprotected sunflower meal (g/kg)	Protected sunflower meal (g/kg)	Unprotected fat (g/kg)	Protected fat (g/kg)
Cysteine	0.73	1.84	0.27	1.09
Methionine	0.52	1.31	0.25	0.98
Isoleucine	1.33	3.32	0.71	2.85
Leucine	2.02	5.06	1.21	4.86
Phenylalanine	1.25	3.12	0.74	2.96
Lysine	1.14	2.85	0.78	3.12
Histidine	0.67	1.69	0.46	1.85
Arginine	2.34	5.85	1.12	4.47
Total amino acids	10.00	25.04	5.54	22.18
Oleic acid (C 18:1 cis)	---	---	8.40	133.20
Linoleic acid (C 18:2)	---	---	4.20	66.30
Linolenic acid (C 18:3)	---	---	1.40	21.90

Trial II was conducted on 20 crossbred cows (HF x Jersey) yielding 10-12 kg milk per animal per day. Animals were divided into two groups of 10 each, based on milk yield, fat % and stage of lactation. Animal in both the groups were fed similar basal ration, comprising 15 kg green maize fodder and 5 kg jowar straw. Concentrate mixture was given according to level of milk production (NRC, 1989). In addition to basal ration, animals in experimental group were fed 1.0 kg protected fat / protein (Fat 32-33%, CP 25-26%, NDIN 0.46%, ADIN 0.21%). In the bypass feed supplement, degree of bypass fat was 79 per cent of total, whereas, protected protein was 80 per cent of total CP (Palmquist 1984). Each treatment was given for a period of four weeks. Fatty acid composition of feed was measured by Gas-Chromatograph (Ashes *et al.*, 1992). The degree of protection of fat was determined by the extent of hydrogenation of the unsaturated fatty acids (Gulati *et al.*, 1997a, 1999b, 2000).

The milk yield, fat and protein per cent of individual animals was recorded in both the experiments for entire trial period. The milk samples were analyzed for fat (IS: 1224, 1977) and protein (IS: 1479, 1961). The data were analyzed statistically (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

Analysis of feeds and fodder reveals that the NDIN and ADIN contents were very low. Thus, cell wall bound nitrogen level was non-significant in all the feeds and fodder offered to animals during trial period. Since animals in trial I were fed similar ration, there was no significant difference in the daily DM intake in the two groups. However, in trial II animals only in experimental group were fed one kg protected fat/protein supplement, therefore total DM intake was significantly ($p<0.05$) higher compared to control group (Table 1).

Lysine and methionine are reported to be the most limiting amino acids for milk production (Schwab, 1995; Xu *et al.*, 1998). Approximately 0.95 g of methionine is present in one litre of milk. On feeding one kg unprotected sunflower meal, methionine availability would be only 0.52 g, whereas, from one kg protected sunflower meal, it will be 1.31 g. On protection, availability of limiting amino acids increased significantly. Similarly on protecting fat, availability of unsaturated fatty acids like oleic acid ($C_{18:1}$ cis), linoleic acid ($C_{18:2}$), and linolenic acid ($C_{18:3}$) also increased significantly (Table 2). Higher level of essential fatty acids in butter fat could be beneficial for the consumer from physiological requirements point of view.

On feeding 1000g untreated sunflower meal in control group and 1000g treated sunflower meal in experimental group, daily average milk yield in kg was 14.1±0.26, 15.2±0.28, fat % 4.4±0.10, 4.6±0.14 and protein % 3.2±0.00, 3.5±0.01, respectively (Table 3). There was an increase in daily milk yield, fat and protein % in experimental group (Kunju *et al.*, 1992: Ashes *et al.*, 1995 and Sampath *et al.*, 1997). Increase in milk yield (kg) and protein % was higher ($P<0.05$) in experimental group. Significant improvement in milk yield and composition on feeding protected protein was also reported earlier in crossbred cows (Clarke, 1975; Garg, 1998a). Similar trend in results was found by other workers on feeding bypass protein (Ashes *et al.*, 1995; Santos *et al.*, 1998). Hamilton *et al.* (1992) also observed the effect of formaldehyde treated sunflower meal on milk production in grazing cows. Economics of milk production on feeding 1.0 kg protected sunflower meal was also calculated. It was observed that on feeding 1.0 kg protected sunflower meal, net average daily income increased by Rs.9.61 per animal per day.

Table 3 Daily average milk yield, fat and protein per cent on feeding 1.0 kg bypass protein and 1.0 kg bypass fat/protein supplement

	1.0 kg bypass protein feed		1.0 kg bypass fat protein feed	
Parameter	Control	Experiment	Control	Experiment
Milk yield (kg)	13.4 - 15.6	14.5 - 15.8	9.8 - 12.0	11.3 - 13.0
Mean±SE	(14.1±0.26)	(15.2*±0.28)	(11.2±0.32)	(12.3*±0.34)
Fat (%)	4.1 - 4.6	4.3 - 4.8	3.8 - 4.3	4.2 - 4.8
Mean±SE	(4.4±0.10)	(4.6±0.14)	(4.0±0.10)	(4.6**±0.12)
Protein (%)	3.1 - 3.3	3.3 - 3.6	3.0 - 3.3	3.3 - 3.6
Mean±SE	(3.2±0.00)	(3.5*±0.01)	(3.1±0.00)	(3.5*±0.00)

**(P<0.05) **(P<0.01)*

Economic analysis of feeding 1.0 kg bypass protein and fat supplement

1.0 kg bypass protein feed

Average value of 14.1 kg milk in control group with 4.4% fat (@ Rs. 8.00 per kg) = 112.77
Average value of 15.2 kg milk in experimental group with 4.6% fat (@ Rs. 8.14 per kg) = 123.88
Increase in gross income per animal per day = Rs. 11.11
Additional feeding cost = Rs. 1.50
Increase in daily income = Rs. 9.61

1.0 kg bypass fat/protein feed

Average value of 11.2 kg milk in control group with 4.0% fat (@ Rs. 6.69 per kg) = 74.94
Average value of 12.3 kg milk in experimental group with 4.6% fat (@ Rs. 8.14 per kg) = 100.12
Increase in gross income per animal per day = Rs. 25.18
Cost of 1.0 kg bypass fat feed = Rs. 15.00
Increase in daily income = Rs. 10.18

On feeding 1000g bypass fat/protein feed in experimental group, daily average increase in milk yield (kg) was 1.1 (P<0.05). The average fat % increased by 0.6 (p<0.01) and average increase in protein % was 0.4 (P<0.05), thus, there was a significant effect of supplementing bypass fat/protein on milk production, fat and protein per cent. Similar results were obtained in Australia where cows are grazed at pasture and supplemented with protected nutrients at the time of milking (Scott and Ashes, 1993; Ashes *et al.*, 1995; Garg and Mehta, 1998b). It was further observed that on feeding 1.0 kg protected fat/protein, net average daily income increased by Rs.10.18 per animal per day, (Table 4).

It is concluded that supplementation of 1.0 kg protected fat/protein in the ration of crossbred cows, yielding 10-14 kg milk per day may be economical and this may help in increasing the net daily income per animal and also improved the level of essential fatty acids in butter fat.

ACKNOWLEDGEMENT

The authors are grateful for the financial support of Australian Centre for International Agricultural Research (ACIAR) and technical support of Commonwealth Scientific and Industrial Research Organisation (CSIRO) under the project code ASl/PN97/115.

REFERENCES

AOAC. (1984) Official methods of Analysis (14th Edn.) Association of Official Analytical Chemists,Washington, DC

ASHES, J.R., GULATI, S.K. and SCOTT, T.W. (1995) The role of rumen protected proteins and energy sources in the diet of ruminants. In: Animal Science Research and Development. (Ed, Ivan, M., center for food and animal research agriculture and agri-foods Canada). pp 177

ASHES, J.R., GULATI, S.K. and SCOTT, T.W. (1997) Potential to alter the content and composition of milk fat through nutrition. Presented at the American Dairy Science Meeting. *J.Dairy Sci.* **80:**2204

ASHES, J.R., ST-VINCENT WELCH, P., GULATI, S.K., SCOTT, T.W., BROWN, G.H. and BLAKELY, S. (1992) Manipulation of the fatty acid composition of milk by feeding protected Canola seeds. *J.Dairy Sci.* **75(4):** 1090

CHALUPA, W. and SNIFFEN, C.J. (1996) Protein and amino acid nutrition of lactating dairy cattle today and tomorrow. *Anim. Feed Sci. and Tech.* **58:** 65

CLARKE, J.H. (1975) Lactational responses to post ruminal administration of protein and amino acids. *J. Dairy. Sci.* **36:** 1178

CONNELL, P.J., GULATI, S.K. and ASHES, J.R. (1987) Improved techniques in the measurement of amino acids and amino sugars in rumen anaerobic fungi. *Proc. Nutr. Soc. Aust.* **12:** 92

FERGUSON, K.A. (1975) The protection of dietary proteins and amino acids against microbial fermentation in the rumen. In; Digestion and Metabolism in the Ruminant. Eds, I.W., Mc Donald and A.C.I., Warner.pp. 448

GARG, M.R. (1998a) Role of bypass protein in feeding ruminants on crop residue based diets. *Asian Australasian J. Anim. Sci.* **11:** 107

GARG, M.R. and MEHTA A.K. (1998b) Effect of feeding bypass fat on feed intake, milk production and body condition of Holstein Friesian cows. *Indian J. Anim. Nutr.* **15(4)**:242

GOERING, H.K. and VAN SOEST, P.J. (1970) Forage fibre analyses (apparatus, reagents, procedures and some applications), ARS U.S. Dept. Agr. Handbook, No. 379, Superintendent of Documents, U.S., Guvernment of Printing Office, Washington, DC 20402

GULATI, S.K., ASHES, J.R. and SCOTT, T.W. (1997a) Assessing the degradation of fat supplements in the ruminants. *Anim. Feed Sci. & Tech.* **64:** 127

GULATI, S.K., BYERS, E.B., BYERS, Y.G., ASHES, J.R. and SCOTT, T.W. (1997b) Effect of feeding fat supplements on the fatty acid composition of goat milk. *Anim. Feed Sci & Tech.* **66:** 159

GULATI, S.K., ASHES, J.R. and SCOTT, T.W. (1999a) Optimizing the nutritional value of oilseed proteins for ruminants. (90th American Oil chemists Society Conference (AOCS) INFORM, Vo1,10, no.541

GULATI, S.K., ASHES, J.R. and SCOTT, T.W. (1999b) Dietary induced changes in the physical and nutritional characteristics of butter fat. Lipid Technology, Ed; PJ Barbes and Associates, (UK). (January). Pp 10-13

GULATI, S.K., KITESSA, S.M., ASHES, J.R., FLECK E., BYERS, E.B., BYERS, Y.G., SCOTT, T.W. (2000) Protection of conjugated linoleic acids from ruminal hydrogenation and their incorporation into milk fat. *Anim. Feed. Sci. and Tech.* **86:** 139-148

HAMILTON, B.A., ASHES, J.R. and CARMICHAEL, A.W. (1992) Effect of formaldehyde treated sunflower meal on the milk production of grazing cows. *Aust. J. Agric. Res.* **43:**379

HOGAN, J.P. (1975) Quantitative aspects of nitrogen utilization in ruminants. *J. Dairy Sci.* **58:** 1164

Indian Standards Methods of test for dairy industry Part-1, Chemical Analysis of Milk, IS: 1224 Part-I, (1977) Indian Standards Institute, New Delhi

Indian Standards Methods of test for dairy industry Part-1, Chemical Analysis of Milk, IS: 1479 Part-II, (1961) Indian Standards Institute, New Delhi

KUNJU, P.J.G., MEHTA, A.K. and GARG, M.R. (1992) Feeding of bypass protein to crossbred cows in India. *Asian Aust. J. Anim Sci.* **5:** 107

NRC (1989) "Nutrient Requirements of Domestic Animals," "Nutrient Requirements of Dairy Cattle," 6th Edn. National Academy of Science-National Research Council, Washington, DC

PALMQUIST, D.L. (1984) Use of fats in diets of lactating dairy cows. In: J. wiseman, ed. Fats in Animal Nutrition. Butterworth, London, U.K. pp 357

SAMPATH,. K.T., PRASAD, C.S., RAMCHANDRA, K.S., SUNDARESHAN, K. and SUBBARAO, A. (1997) Effect of feeding undegradable dietary protein on milk production of crossbred cows. *Indian J. Anim. Sci.* **67(8):** 706-708

SANTOS, F.A.P., SANTOS J.E.P., THEURER, C.B., and HUBER, J.T. (1998) Effects of rumen undegradable protein on dairy cow performance; a 12 years literature review. *J. Dairy Sci.* **81:** 3182-3213

SCHWAB, C.G. (1995) Rumen protected amino acids-their role in nutrition of high producing dairy cows. In animal Science Research and Development: Moving towards a New Century. M. Ivan, Editor. Ottawa, Canada

SCOTT, T.W. and ASHES, J.R. (1993) Dietary lipids for ruminants. *Aust. J. Agric Res.* **44:** 495

SNEDECOR, G.W. and COCHRAN, W.G. (1968) Statistical Methods, 6th edn., Oxford and IBH Publishing Company, Calcutta

STERN, J.W., VARGA, G.A., CLARK, J.L., FIRKINS, J.L., HUBER, J.T. and PALMQUIST, D.L. (1994) Metabolic relationships in supply of nutrients for milk protein synthesis. Evaluation of chemical and physical properties of feeds that effect protein metabolism in the rumen. *J. Dairy Sci.* **77:** 2762

XU, S., HARRISON, J.M., CHALUPA, W., SNIFFEN, C., JULIEN, W., SATO, H., FUVIEDA, T., WATANABE, K., VEDA, T., and SUZUKI, H. (1998) The effect of ruminal bypass lysine and methionine on milk yield and composition of lactating cows. *J. Dairy Sci.* **81:** 1062-1077