Effect of Feeding Graded Levels of Undegraded Dietary Protein on Voluntary Intake, Milk Production and Economic Return in Early Lactating Crossbred Cows

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ABSTRACT : Fifteen lactating crossbred cows were randomly allotted to three groups of 5 each, and fed three isoproteinous concentrate mixture varying in RDP and UDP ratios, viz. 71: 29 (T1) and 58: 42 (T2) and 44: 56 (T3), along with green maize and wheat straw given as 2/3 and 1/3 of total roughage respectively, for a period of 120 days. The DM intake (kg/d) differed significantly ($p<0.01$) among the treatments as well as among the fortnights over a period of 120 days. DMI (kg/d) progressively increased from first to eighth fortnight in all the treatments. The daily DMI (% BW) was significantly ($p<0.01$) lower in T1 (2.37) than those of T2 (2.82) and T3 (2.67). The body weights of cows decreased up to 4th fortnight in T1 and up to 3rd fortnight in T2 and T3, then it showed an increasing trend till the end of the experiment in all the treatments. Cows in T1 lost 10 kg body weight but cows in T2 and T3 gained 23 and 12 kg the body weight, respectively. Both the milk and FCM yield differed significantly ($p<0.01$) among the fortnights. The FCM yield increased up to 2nd fortnight in all the treatments and thereafter, the FCM yield declined gradually as the lactation advanced. The FCM yield (kg/d) was significantly ($p<0.05$) higher in T3 (10.47) than in T2 (9.81) and T1 (9.68), however, milk yield, SCM yield and milk energy yield did not differ among the treatments as well as among the fortnights. Fat and protein % in milk increased as the lactation advanced. However, fortnightly SNF % in milk showed an irregular trend. The % fat, protein, SNF and total solids in milk differed significantly ($p<0.01$) among the fortnights. The % fat and protein in milk varied significantly ($p<0.01$) among the treatments, being lowest in T1 and highest in T3. The feed efficiency for milk production showed a non-significant variation among the treatments as well as among the fortnights, but increased with the increase in UDP level. It is concluded that by increasing the UDP level from 29 to 56 per cent of CP in the diet of medium producing cows, the milk production increases and cost of milk production reduces. ***(Asian-Aust. J. Anim. Sci. 2001. Vol 14, No. 8 : 1118-1124)***

Key Words : Undegraded Dietary Protein, Voluntary Intake, Milk Production, Economic Return, Crossbred Cows

INTRODUCTION

According to ARC (1984) and NRC (1988), the alternative system for protein quality and its requirement for ruminants is based on the fact that the dietary crude protein has two factions viz. rumen degradable protein (RDP) and undegraded dietary protein (UDP). The ruminants have the requirement for both these protein factions, depending upon the age and live weight of the animal and the type and level of production. For high yielding cows, the microbial protein entering post-ruminally may not be sufficient to meet the amino acid requirements, particularly when they are in negative energy balance, and in such cows, UDP must be given for efficient utilization of body reserves (Ørskov and Reid, 1985). The escape of high quality protein from ruminal degradation may increase milk yield either directly or indirectly (Clark, 1975). The direct role may be through either increased supply of limiting amino acid(s) to mammary gland for protein synthesis or through enhanced gluconeogenesis in liver, resulting in increased supply of glucose to mammary gland for lactose synthesis. The indirect role may be mediated through altered hormonal status, especially increased concentration of plasma growth hormone (GH), which causes nutrient partitioning in favour of growth and milk production, and away from the fat deposition (Sartin et al., 1985). Moreover, the negative energy balance in high yielding cows in early lactation leads to increased plasma GH level and decreased plasma insulin level, and such a situation favours fat mobilization from adipose tissues (Walli and Mudgal, 1988). Dietary modifications which lead to increased availability of amino acids in the intestines, may even induce the secretion of GH for increased mobilization of body fat, thereby causing a proper balance of various nutrients, viz., amino acids, glucose and fatty acids for optimum milk synthesis in mammary gland. The importance of feeding ruminants with rumen escape protein to optimize nitrogen utilization for productive purposes has been well recognized the world over by many researchers (Cohick et al., 1986; Kurilov and Popov, 1989; Broderick et al., 1990; King et al., 1990; Kumar and Walli, 1994; Chaturvedi and Walli, 1999).

In India, the average milk yield of crossbred cows is not very high and most of them can be categorized as medium yielders. The optimum level of UDP in the diet of Indian cows for economic responses is not clear. Therefore, the present investigation was undertaken to investigate the effect of feeding graded levels of undegraded dietary

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protein on voluntary intake, milk production and economic return in lactating crossbred cows.

MATERIALS AND METHODS

Animals and diets

Fifteen crossbred (Karan Friez and Karan Swiss) cows averaging 460 kg body weight and within 40 to 60 days postpartum were selected from the herd maintained at NDRI, Karnal. The cows were randomly divided into three groups of five animals each and were allocated for three different treatments (T1, T2 and T3) in a randomized block design. The average milk yield at the beginning of the experiment was 9.70±0.91, 9.55±1.92 and 9.75±1.66 in T1, T2 and T3, respectively. Three isoproteinous concentrate mixtures viz., T1, T2, T3 varying in RDP and UDP content were formulated (table 1). Prior to formulation of various concentrate mixtures, the values of RDP and UDP in concentrate ingredients were calculated using their CP and effective CP degradability (ECPD) values reported by Chaturvedi and Walli (1995). Accordingly, the percent CP, RDP and UDP contents were 11.00, 8.31 and 2.69; 44.50, 31.86 and 12.64; 30.50, 11.53 and 18.97; 50.00, 11.20 and 38.30, and 13.80, 11.12 and 2.68, respectively for barley, GNC (groundnut cake), SECSC (solvent extracted cotton seed cake), MGM (maize gluten meal) and WB (wheat bran). Effective protein degradability of the composite concentrate mixtures was assumed to be the sum of the protein degradability of the individual feed ingredients. The total digestible nutrients (TDN) contents of concentrate mixtures in T1, T2 and T3 were calculated using published NRC values for the TDN of feed ingredients. The RDP and UDP contents of maize fodder and wheat straw were calculated using their CP degradability values (Sampath et al., 1989; Wadhawa et al., 1993). The concentrate mixtures were more or less isocaloric in nature. All the animals were fed their roughage dry matter through wheat straw and green maize in the proportion of 1:2, respectively. The concentrate mixtures pertaining to different treatment i.e. T1, T2 and T3 were fed in quantities so as to balance the energy and crude protein requirements of the animals as per NRC (1988).

Lactation trial

The lactation studies were conducted for a period of four months. The concentrate was fed thrice daily during each milking, and the roughage was also fed thrice daily i.e. in the morning, at noon and in the evening. Water was offered *ad lib.* before each milking. Dry matter intake (DMI) and milk yield for individual animals was recorded daily throughout the experimental period. Live weight change and the milk composition was recorded for all the animals at fortnightly intervals.

Table 1. Proportion of concentrate ingredients and chemical composition of concentrate mixtures and roughages (% DM basis)

Component (%)	Concentrate mixtures			Maize fodder	Wheat straw
	T1	T2	T3		
Ingredients for concentrates (% DM basis)					
Barley	45.0	45.0	45.0	-	-
Groundnut cake	30.0	15.0	-	-	-
SECSC	5.0	10.0	15.0	-	-
Maize gluten meal	-	10.0	20.0	-	-
Wheat bran	17.0	17.0	17.0	-	-
Mineral Mixture	2.0	2.0	2.0	-	-
Common salt	1.0	1.0	1.0	-	-
Chemical composition (% DM basis)					
DM	92.20	92.10	92.60	19.40	92.80
OM	91.86	91.70	91.50	89.12	87.45
EE	5.75	5.23	4.82	1.32	1.12
CF	9.18	9.32	9.88	33.62	38.34
NFE	55.93	56.15	54.05	46.30	44.49
Ash	8.14	8.30	8.50	10.88	12.55
CP	22.17	22.02	21.87	7.88	3.50
RDP	15.77	12.68	9.60	4.62	0.92
UDP	6.40	9.34	12.27	3.26	2.58
RDP/UDP ratio	71.13:28.87	57.58:42.42	43.90:56.10	58.62:41.38	26.20:73.80
TDN	71.19	72.74	74.29	65	45

Analysis of samples and data

Dry matter (DM), organic matter (OM), ether extract (EE), crude fibre (CF) and nitrogen free extract in feed and fodder were analyzed according to AOAC (1990). Milk samples were analyzed for per cent protein, fat, solid not fat (SNF) and total solids following ISI (1982) procedures. Four per cent fat corrected milk (FCM) was calculated by using the equation given by Gaines (1928). Yield of solid corrected milk (SCM) and milk energy (Mcal/d) were determined by formula established by Tyrrell and Reid (1965) and feed efficiency for milk production was calculated using the milk energy and digestible energy (DE) consumed by adopting the following formula:

Feed efficiency (FE %)=Milk energy (Mcal/d)/DE consumed (Mcal/d)

The data obtained during the course of investigation were analyzed in accordance to Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

Nutrient intake and body weight

The DM intake (kg/d) differed significantly ($p<0.01$) among the treatments as well as among the fortnights over a period of 120 days (table 2). DMI (kg/d) progressively increased form first to eighth fortnight in all the treatments (figure 1). The daily DMI (% BW) also differed significantly ($p<0.01$) among the treatments and it was lower in T1 than that of T2 and T3. The RDP and UDP intake differed significantly ($p<0.1$) among the treatments, while the RDP intake decreased from T1 to T3, the UDP intake increased (table 2). The CP intake i.e. a sum of RDP and UDP intake (g/d) did not differ among the three treatments, however, TDN intake (kg/d) differed ($p<0.01$) among the treatments as well as among the fortnights. The TDN intake was higher in T1 than that of T2. The increase in DM intake with the advance in the stage of lactation is corroborated with the reasons given by NRC (1988). During early lactation cows do not consume as much as feed as they do during later lactation. The significant ($p<0.01$) variation in DM and TDN consumption (kg/d) might be attributed to significant ($p<0.05$) variation in live weight of the animals under various treatments (table 2). This variation in body weights among the treatments remained more or less unchanged throughout the experimental period, whereas the body weights did not differ significantly among the fortnights (table 2). The size, age, sex and physiological status of the animals, nature of the diet and in case of lactating animals, the lactation number, stage of lactation and level of production are the most important factors in determining

Table 2. Effect of graded levels of UDP feeding on intakes and weight changes of cows

Attributes	Experimental diets			SEM	Significance		
	T1	T2	T3		Treatment (T)	Period (P)	T×P
DM intake							
Maize fodder, kg/d	4.83[b]	4.57[a]	4.78[ab]	0.06	**	**	NS
Wheat straw, kg/d	2.41[b]	2.29[a]	2.38[ab]	0.03	**	**	NS
Concentrate, kg/d	4.30[b]	3.80[a]	4.02[a]	0.07	**	**	NS
Total, kg/d	11.54[c]	10.66[a]	11.18[b]	0.06	**	**	NS
% BW	2.37[a]	2.82[b]	2.67[b]	0.05	**	NS	NS
RDP intake, g/d	923[c]	714[b]	628[a]	15.28	**	ND	ND
UDP intake, g/d	494[a]	563[b]	711[c]	13.32	**	ND	ND
RDP + UDP intake, g/d	1417	1277	1339	40.28	NS	ND	ND
RDP/UDP ratio of the diets	65.14: 34.86	55.91: 44.09	46.90: 53.10	ND	ND	ND	ND
TDN intake, kg/d	7.49[b]	6.67[a]	6.98[ab]	0.21	**	**	NS
DE (TDNx4.4) intake, Mcal/d	32.96[b]	29.35[a]	30.71[ab]	0.78	**	**	NS
Body weight, kg	486.76[c]	377.33[a]	419.33[b]	7.54	**	NS	NS
Initial, kg	501.20[b]	376.00[a]	423.60[ab]	30.51	*	ND	ND
Final, kg	490.60[b]	399.00[a]	436.20[ab]	23.381	*	ND	ND
Gain (+)/loss (-), kg/120 d	-10.60	+23.00	+12.60	ND	ND	ND	ND
Gain (+)/loss (-), kg/d	-0.088	+0.192	+0.105	ND	ND	ND	ND

* $p<0.05$; ** $p<0.01$; NS=non significant; ND=not detected.

Except the initial and final body weight (n=5), the n value for each attribute is 45.

the nutritional demands of the animals which are to be met through DMI. In the present study, besides the difference in live weight and age of the animals in the three groups, the diets also differed with respect to RDP and UDP ratio. However, the difference in nutrient intake (DM and TDN) could not be strictly explained due to difference in the diet. Many workers (Santos et al., 1984; Cody et al., 1990; McGuffey et al., 1990; Robinson et al., 1991; Winsryg et al., 1991) also could not find a significant effect on DM intake when isonitrogenous diets varying in RDP/UDP ratio were fed to lactating cows from early to mid lactation.

The body weights of cows decreased up to 4th fortnight in case of T1 and up to 3rd fortnight in cases of T2 and T3, then it showed an increasing trend till the end of the experiment in all treatments (figure 2). The mean body weight during whole period of the study differed significantly ($p<0.01$) among the treatments just because of the significant ($p<0.01$) difference in the initial body weight (table 2). The present relationship between milk production, DMI and liveweight change during lactation is largely corroborated with the reports of NRC (1988). The lag of maximum DMI behind peak milk yield causes a negative energy balance in early lactation. Consequently, the cow mobilizes body tissues, particularly fat deposits, to overcome the energy deficit, which results in body weight loss. As DMI increases and milk production plateaus or begins to decline, body weight stabilizes and subsequently increases in mid and late lactation. The cow's body weight continues to increase during the dry period. During experimental period of 120 days, cows in T1 lost 10 kg body weight but cows in T2 and T3 gained 23 and 12 kg body weight, respectively. Solan et al. (1988) and Broderick (1990) recorded higher body weight gain in early lactating cows fed diets supplying more UDP as compared to less UDP diets. In the present investigation, the cows were of medium producing potential and had passed a good part of the early lactation stage. The cows were in the stage at which body weight stabilizes, and subsequently increases as lactation advances. Feeding of high UDP diets generally improves the nitrogen utilization by reducing the dietary protein degradation in the rumen and also by discouraging the catabolism of amino acids at tissue level, which results gain in body weight. Lower liveweight gain in T3 (12 kg) despite a higher UDP supply in comparison to T2 (23 kg) during the experimental period of 120 days could be attributed to the variation in source of dietary UDP (MGM, a comparatively lower biological value protein source). Further, the observed difference in body weights between T2 and T3 was not significant.

Milk production and feed efficiency

Both the milk and FCM yield differ significantly ($p<0.01$) among the fortnights (table 3) and exhibited a close parallelism with each other. The FCM yield increased up to 2nd fortnight (about 80 d after parturition) in all treatments and thereafter, the FCM yield declined gradually as the lactation advanced (figure 3). The pattern of milk production from 1st to 8th fortnight as observed in present investigation was also reported by Moe (1985) and Srinivas (1991). They observed that milk production usually peaks between 4 to 8 weeks postpartum and a negative relationship exists between milk production and the number of days in lactation due to change in the physiological status of the cows. While the daily milk yield did not differ significantly among the treatments, daily FCM yield (kg/d) was significantly ($p<0.05$) higher in T3 than in T1 and T2, which were at par with each other. FCM yield also showed an increasing trend from T1 to T3 suggesting that increased level of UDP in the diet exerted a positive effect on milk production. Obviously, such a trend in FCM yield can be explained due to the increase in milk fat percent as a result of feeding higher UDP diets (McGuffey et al., 1990; Robinson et al., 1991; Winsryg et al., 1991). Despite a slight reduction in milk yield (kg/d), Robinson et al. (1991)

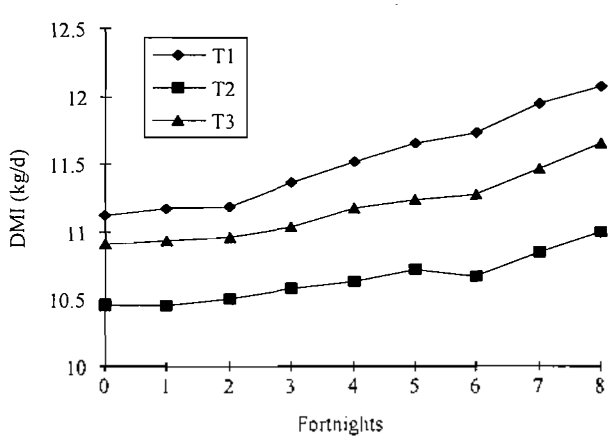

Figure 1. Fortnightly DMI of cows fed graded levels of UDP in diet

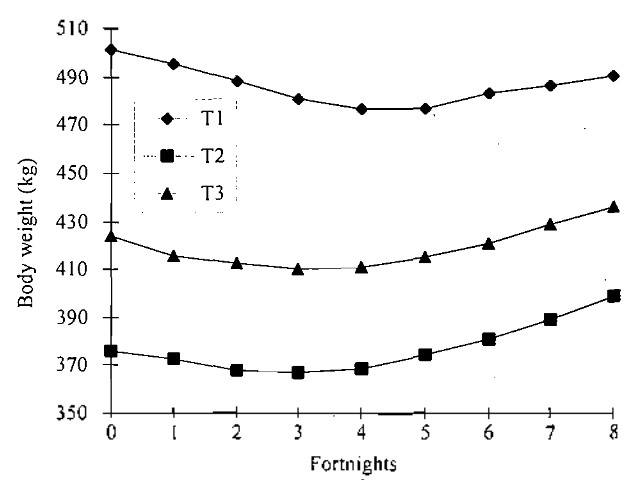

Figure 2. Fortnightly body weight of cows fed graded levels of UDP in diet

Table 3. Effect of graded levels of UDP feeding on milk yield and compositions

Attributes	Experimental diets			SEM	Significance		
	T1	T2	T3		Treatment (T)	Period (P)	T×P
Milk yield, kg/d	9.81	9.87	10.09	0.22	NS	**	NS
4% FCM yield, kg/d	9.68[a]	9.81[a]	10.47[b]	0.20	*	**	NS
SCM yield, kg/d	9.74	9.93	10.49	0.28	NS	NS	NS
Milk energy yield, Mcal/d	7.30	7.45	7.87	0.24	NS	NS	NS
Fat, %	3.93[a]	4.01[a]	4.27[b]	0.02	**	**	NS
Protein, %	3.48[a]	3.50[ab]	3.57[b]	0.02	**	**	NS
SNF, %	8.91	8.96	8.99	0.03	NS	*	NS
Total solids, %	12.83[a]	12.96[ab]	13.19[b]	0.05	**	**	NS
Feed efficiency	22.15	25.38	25.63	1.28	NS	NS	NS

* $p<0.05$; ** $p<0.01$; NS=non significant.
The n value for each attribute is 45.

found an increase in FCM yield up to 1.12 kg/d in lactating cows fed diets containing corn gluten meal (CGM) in place of soybean meal (SBM), with the overall protein degradability of about 71 and 83% for the two diets, respectively. These authors assigned the reason for the improvement in FCM yield as a result of increase in milk fat % on CGM based on high UDP diet. In present study also, the FCM yield followed just a similar pattern as that of milk fat % (table 3). Fat % in milk increased progressively from 1st to 8th fortnight i.e. with the passage of lactation period in all treatments (figure 4). Similarly, the milk protein % also increased from 3rd fortnight onwards in case of T1 and T3 and from 2nd fortnight in case of T2 till the 8th fortnight (figure 5). However, fortnightly SNF % in milk showed an irregular trend (figure 6). The % fat, protein, SNF and total solids in milk differed significantly ($p<0.01$) among the fortnights (table 3). The effect of stage of lactation on contents of milk components corroborates the earlier reports (Elhami et al., 1981; Wohlt et al., 1991). They reported that the contents of milk fat, SNF and total solids was lowest in the 7th week of lactation whereas, the milk protein contents reached minimum in the 9th week of lactation. However, the contents of these constituents reached the highest level at the end of lactation. Except SNF content in milk, the other milk components (%), viz. fat, protein and total solids (TS) differed significantly ($p<0.01$) among the treatments, increasing from T1 to T3 (table 3). The % milk protein and milk total solids were higher ($p<0.01$) in T3 than T1 (T2 being at par with T1 and T3), whereas the % milk fat was higher ($p<0.01$) in T3 than those of T1 and T2. The improvement on milk fat as well as milk protein from T1 to T3 closely agreed with those reported by earlier workers, in which cows were given isonitrogenous diets containing different RDP/UDP ratios, in which mostly CGM used as the slowly degradable protein source, either during early lactation (Robinson et al., 1991; Winsryg et al., 1991) or during mid lactation (King et

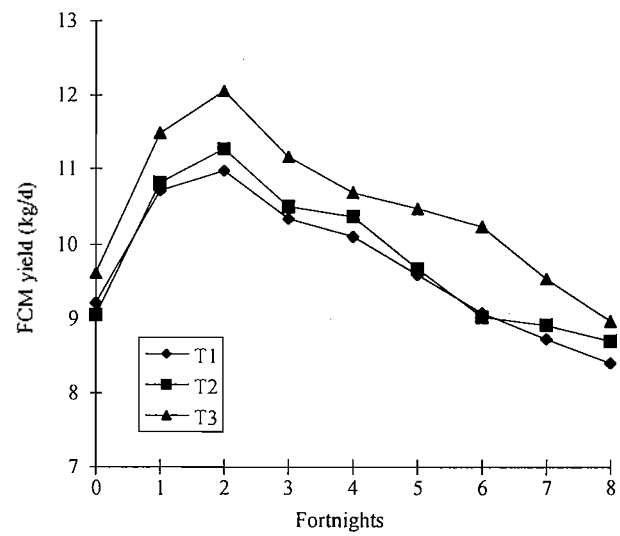

Figure 3. Fortnightly FCM yield of cows fed graded levels of UDP in diet

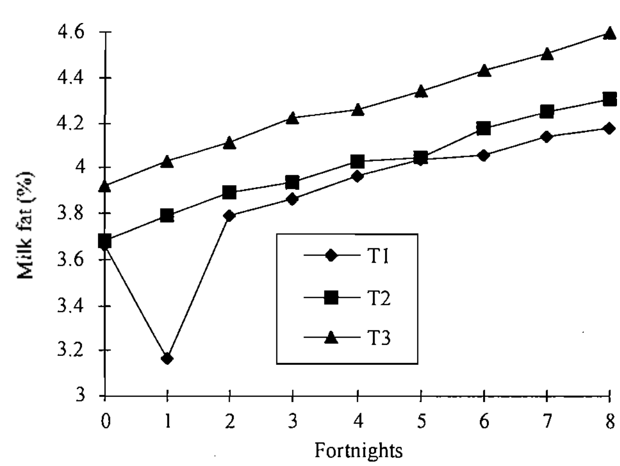

Figure 4. Fortnightly milk fat of cows fed graded levels of UDP in diet

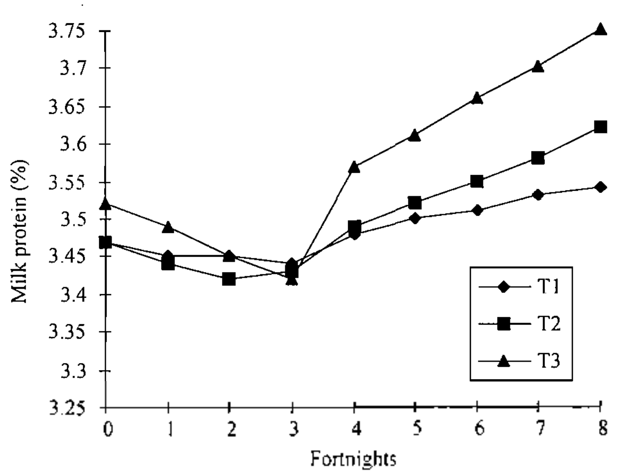

Figure 5. Fortnightly milk protein of cows fed graded levels of UDP in diet

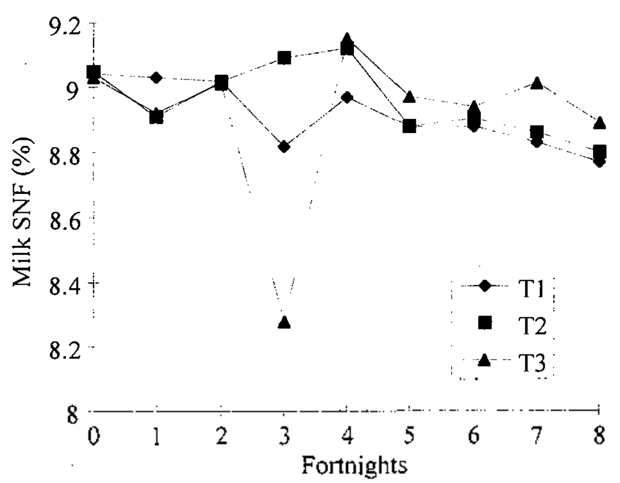

Figure 6. Fortnightly milk SNF of cows fed graded levels of UDP in diet

al., 1990). Feeding the isonitrogenous diets of lower protein degradability improved milk protein content but without causing any change in milk fat content in cows in early lactation as compared to the diets of higher protein degradability (Cody et al., 1990; Murphy et al., 1990). Dietary fish meal (FM) has been frequently associated with milk fat depression in lactating dairy cows and reduced milk fat content was related to a reduction in the ruminal ratio of acetate to propionate and the high level of polyunsaturated fatty acids in FM (Windschitl, 1991; Wohlt et al., 1991). While testing the isonitrogenous diets of similar undegradable intake protein (UIP) from FM or CGM in early lactating cows, Blauwiekel et al., (1990) concluded that FM supplementation resulted in decreased milk fat and SNF percentage in place of CGM. These results corroborate with the present findings and the higher ($p<0.01$) milk fat per cent in T3 than in T1 and T2 could also be attributed to the higher proportion of MGM in T3. A slight increase in milk SNF content from T1 to T3 was obviously due to increase in milk protein content, while total solids content was influenced by both protein as well as fat content and thus its value increased from T1 to T3. The daily milk yield, SCM yield and also energy outgo in milk (Mcal/d) did not vary significantly among the three treatments, although there was a steady increase in these parameters as the dietary RDP/UDP ratio progressively decreased from T1 to T3 (table 3). These observations get support from the data recorded by Blauwiekel et al. (1990), King et al. (1990) and Winsryg et al. (1991) in which the lactating cows were fed isonitrogenous diets varying in RDP/UDP ratio. Although the feed efficiency for milk production showed an increasing trend from T1 to T3, yet the difference was non-significant among the treatments as well as among the fortnights (table 3). These observations get support from the results obtained by earlier investigators (Kung and Huber, 1983; Winsryg et al., 1991; Windschitl, 1991), who found that the milk production efficiency did not vary when isonitrogenous diets varying in CP degradability were fed to lactating cattle.

Economics of feeding

Encouraging results on economics of feed cost in T2 and T3 over the T1 are attributed to the manipulations of concentrate ingredients from higher UDP intake and the cost of ingredients (table 4). Cheaper ingredients viz. CSC and MGM which contain higher UDP replaced costlier ingredient GNC to the tune of 50 and 100 % in T2 and T3, respectively. Thus concentrate mixtures of T2 and T3 were more profitable than that of T1, because of higher milk production and more economical ration formulation for lactating cows. Feed cost per kg milk production was Rs. 3.84, 3.21 and 3.04 for T1, T2 and T3, respectively, which

Table 4. Economic analysis of graded levels of UDP feeding on feed utilization in cows

Attributes	T1	T2	T3
Feed cost, Rs.			
Maize fodder	6.22	5.89	6.16
Wheat straw	3.25	3.09	3.20
Concentrate	28.19	22.66	21.31
Total	37.66	31.64	30.67
Feed cost per kg milk yield	3.84	3.21	3.04
Feed cost per kg FCM yield	3.89	3.23	2.93
Milk sale, Rs/hd/d	88.29	88.83	90.81
Profit, Rs/hd/d	50.63	57.19	60.14
Rs/hd/mo	1518.90	1715.70	1804.2

Cost of feed and fodder as per the financial year 1999-2000 (Rs. Per 100 kg): Barley, 580; Groundnut cake, 850; SECSC, 430; Maize gluten meal, 490; Wheat bran, 280; Mineral mixture, 980; Common salt, 70; Maize fodder, 25; Wheat straw, 125. Milk, Rs. 9 Per Kg; 1 US \$=Rs. 42.

in turn provided 13 and 19 % higher profit daily in T2 and T3, respectively in comparison to T1.

It is concluded from the study that by increasing the UDP level from 29 to 56 per cent of the total CP in the concentrate mixture of crossbred lactating cows, fat and protein content in milk and consequently FCM yield (kg/d) increases, while the cost of milk decreases.

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