Effect of Undegradable Dietary Protein Level and Plane of Nutrition on Lactation Performance in Crossbred Cattle

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ABSTRACT : An experiment was conducted in order to assess the effect of level of RDP:UDP ratio and level of feeding concentrate on milk yield, milk composition and nutrient utilization in lactating crossbred cattle. Twenty four medium producing (~10 kg/d, 45 to 135 days postpartum) lactating crossbred cows were divided into four groups of six animals each in a 2×2 factorial completely randomized design. The cows in group 1 were fed concentrate mixture I containing 59:41 RDP:UDP ratio (low UDP) at normal plane (LUDP+NP), in group 2 were fed low UDP ration at 115% of NRC (1989) requirements (LUDP+HP), whereas cows in group 3 were fed concentrate mixture II containing 52:48 RDP:UDP ratio (high UDP) at normal plane (HUDP+NP) and in group 4 were fed high UDP ration at 115% of NRC (1989) requirements (HUDP+HP). Green jowar was fed *ad libitum* as the sole roughage to all the animals. The experimental feeding trial lasted for 105 days. The total dry matter intake (DMI), DMI/100 kg body weight, DMI/kg $W^{0.75}$, digestibilities of DM, OM, CP, CF, EE and NFE and intakes of TDN and DCP did not differ significantly among the different groups and also due to both UDP level and plane of nutrition and also due to their interaction. The total dry matter intake varied from 145 g in group 1 (LUDP +NP) to 152.57 g/kg $W^{0.75}$ in group 2 (LUDP+HP) diet. However, increase in milk yield with increased UDP level and also with increased plane of nutrition was observed consistently throughout the experimental period. The average milk yield was 7.66, 8.15, 8.64 and 9.35 kg in groups 1, 2, 3 and 4, respectively and there was no significant difference in milk yield among different groups of cows. The overall daily average milk yields in cows fed with low and high UDP diets were 7.91 and 8.99 kg, respectively and at normal and higher plane of feeding the milk yields were 8.15 and 8.75 kg/day, respectively. Thus, there was 13.65% increase in milk yield due to high UDP level and 7.36% due to higher plane of feeding. The daily 4% FCM yields were 9.20 kg for low UDP diet and 10.28 kg for high UDP diet, whereas it was 9.11 kg at normal plane of feeding and 10.37 kg at higher plane of feeding. Fat yields for the corresponding treatment groups were 0.37, 0.43, 0.41 and 0.48 kg, respectively. The 4% FCM yield and also fat yield did not differ significantly among different dietary treatments and also due to UDP level and plane of nutrition, however, 4% FCM yield was increased by 11.74% with high UDP level and 13.83% with higher plane of feeding. The values for total solids, fat, lactose, solids-not-fat and gross energy contents in milk differed significantly ($p<0.05$) among the different groups and were significantly ($p<0.05$) higher in milk of cows fed LUDP+HP diet followed by HUDP+HP diet. Total solids (14.65 and 13.83%), lactose (5.44 and 4.92%), solids-not-fat (9.44 and 8.83%) and gross energy (887 and 838 kcal/kg) of milk decreased significantly ($p<0.05$) with increased UDP level while total solids (13.84 and 14.64), fat (4.84 and 5.36%) and gross energy (832 and 894 kcal/kg) increased significantly ($p<0.05$) with increase in plane of feeding. Gross and net energetic efficiencies and also gross and net efficiencies of nitrogen utilization for milk production were not significantly different among different groups and also were not affected significantly due to either UDP levels or plane of feeding. Results of the present study suggest that, increasing UDP level from 41% to 48% of CP in concentrate mixture and also increasing plane of feeding from normal (100%) to 115% of NRC requirements maintain a consistently higher milk production. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 10 : 1407-1413)***

Key Words : Undegradable Dietary Protein, Rumen Degradable Protein, Plane of Nutrition, Milk Yield, Crossbred Cows

INTRODUCTION

Crude protein (CP) and digestible crude protein (DCP) have been the conventional measures of expressing protein requirements of ruminants and also nutritive value of feeds. However, more recently the use of rumen degradable protein (RDP) and undegradable dietary protein (UDP, also called bypass protein) has gained acceptance and ARC (1980) and NRC (1989) have replaced the traditional CP and DCP system with RDP and UDP system for ruminants. Many studies have been conducted in India and elsewhere to investigate the effects of feeding different UDP levels on performance of ruminants. In developed countries the UDP sources were commonly animal protein sources like blood meal (Rodriguez et al., 1997), meat meal (Dean et al., 1999) and fishmeal (Lopez et al., 1999). Since Indian consumer preferences do not allow feeding of dairy animals with animal products, such results have little practical significance in India. The vegetable UDP sources used in western countries include maize gluten meal (Newbold and Rust, 1990) and roasted soybean meal (Stallings, 1999), which are not commonly available ingredients for ruminant feeding in India. Most of the Indian studies employed formaldehyde-treated oilseed cakes as sources of UDP (Tiwari and Yadava, 1994; Srivastava and Mani, 1995). In

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Table 1. Ingredient composition and chemical composition of experimental concentrate mixtures and green *jowar*

Particulars	Concentrate mixture I	Concentrate mixture II	Green *jowar*
Ingredient composition			
Cottonseed cake	-	18	-
Mustard cake	26	-	-
Linseed cake	-	14	-
Wheat grain	31	-	-
Maize grain	-	17	-
Rice Polish	40	48	-
Mineral mixture*	2	2	-
Common salt	1	1	-
Chemical composition (% DM basis)			
Dry matter	91.64	90.08	25.5
Organic matter	91.47	90.98	90.83
Crude protein	19.58	20.37	5.98
Ether extract	7.41	8.51	3.27
Crude fiber	7.62	5.00	29.46
Nitrogen-free extract	56.86	57.10	52.12
Total ash	8.53	9.02	9.17
RDP:UDP ratio (calculated)	59:41	52:48	-

* Mineral mixture AGRIMIN (Manufactured by Brinavan Phosphates Ltd. and marketed by Glaxo India) contained copper 312 mg, cobalt 45 mg, magnesium 2.114 g, iron 979 mg, zinc 2.13 g, iodine 156 mg, DL-methionine 1.92 g, L-lysine monohydrochloride 4.4 g, per kg and 24% calcium and 12% phosphorus.

the present study, attempt was made to use naturally occurring bypass proteins of vegetable sources to formulate concentrate mixtures containing the required content of UDP. These products are agro-industrial byproducts and available in sufficient amounts for ruminant feeding throughout the country. Effects of feeding such concentrate mixtures on intake and utilization of nutrients, milk yield and composition, efficiency of utilization of energy and nitrogen for milk production were investigated and presented in this communication.

MATERIALS AND METHODS

Experimental animals and rations

Twenty-four crossbred (Jersey×Sahiwal) cows (45 to135 days postpartum, average milk production 10 kg/day) were selected from the milch cattle herd of Livestock Research Center, G. B. Pant University of Agriculture and Technology, Pantnagar and maintained on concentrate mixture as per NRC (1989) and green jowar *ad libitum* for 15 days, which was observed as an adaptation period. Thereafter, the cows were divided into four groups of six animals each in such a way that the average milk yield and body weight of all the groups were similar. The four groups of cows were allotted randomly to four dietary treatments as follows:

Group 1 (LUDP+NP) : The cows were offered concentrate mixture I, containing 59:41 RDP:UDP ratio (low UDP) at normal plane (100%) of feeding as per NRC (1989) nutrient requirements.

Group 2 (LUDP+HP) : The cows were offered concentrate mixture I, containing 59:41 RDP:UDP ratio (low UDP) but at 115% of NRC (1989) nutrient requirements (higher plane of feeding).

Group 3 (HUDP+NP) : The cows were offered concentrate mixture II, containing 52:48 RDP:UDP ratio (high UDP) at normal plane (100%) of feeding as per NRC (1989) nutrient requirements.

Group 4 (HUDP+HP) : The cows were offered concentrate mixture II, containing 52:48 RDP:UDP ratio (high UDP) but at 115% of NRC (1989) nutrient requirements (higher plane of feeding).

The experimental feeding trial lasted for 105 days. All the animals were weighed for three consecutive days at the start and at the end of the experimental feeding period. The concentrate mixtures were formulated using cottonseed cake, mustard cake, linseed cake, wheat grain, maize grain, rice polish, mineral mixture and common salt so as to contain either low UDP i.e. 59:41 RDP:UDP ratio (concentrate mixture I) or high UDP i.e. 52:48 RDP:UDP ratio (concentrate mixture II) based on the values reported by Kumar and Tiwari (2003) in this laboratory. The UDP level as 41% of total protein in the concentrate mixture was used which is normally present in the practical concentrate mixture, whereas it was elevated to 48% by manipulating the dietary ingredients as shown in Table 1. Both the concentrate mixtures were nearly iso-nitrogenous and iso-caloric. The ingredient composition of concentrate mixtures is presented in Table 1. The allowance of concentrate mixture was calculated for each cow and given for a month and thereafter adjusted according to changes in milk production. Green *jowar* was fed *ad libitum* as the sole roughage. The samples of both concentrate mixtures and also green *jowar* were analyzed for chemical composition as per the methods of AOAC (1990) and presented in Table 1.

Digestion trial

A five-day digestibility trial was conducted between 86th and 90th day of feeding trial to determine nutrient utilization in each treatment group. During this period feed and fodder offered, residue left and faeces voided were accurately weighed and recorded and representative samples were analyzed for proximate principles as per AOAC (1990).

Milk recording, sampling and analysis

Daily milk records of each animal were maintained

Table 2. Effect on dry matter intakes (DMI) in experimental crossbred cows fed different UDP levels and planes of nutrition during entire experimental feeding period

Particulars	Treatment groups				SEM
	1	2	3	4	
	LUDP+NP	LUDP+HP	HUDP+NP	HUDP+HP	
Roughage DMI (kg)	9.01	9.10	9.05	8.83	0.20
Concentrate DMI (kg)	3.88	4.06	4.15	4.71	0.61
Concentrate:roughage ratio	2.49	2.74	2.62	1.99	0.41
Total DMI (kg)	12.89	13.16	13.20	13.54	0.72
DMI/100 kg body weight (kg)	3.26	3.45	3.39	3.34	0.15
DMI/W^{075} kg (g)	145.18	152.57	150.62	149.77	6.73

UDP = Undegradable dietary protein, LUDP = Low undegradable dietary protein.
HUDP = High undegradable dietary protein, NP = Normal plane, HP = High plane.

throughout the experimental feeding period of 105 days. Milk samples of each animal were collected at fortnightly intervals. Total solids, fat, protein (N×6.38) and ash contents of the milk were estimated as described by Gupta et al. (1992). Solids-not-fat (SNF) content was calculated by subtracting fat content from total solids content, and lactose content was calculated by subtracting the sum of protein and ash content from SNF content. Gross energy of milk was calculated by the following formula given by Tyrell and Reid (1965):

$$\text{Gross energy of milk (kcal/kg)} = 92.25F+49.15S-56.40$$

where; 'F' is fat % in milk and 'S' is SNF % in milk.

Energetic efficiency and efficiency of nitrogen utilization

The gross energetic efficiency for milk production was calculated by dividing the total gross energy (kcal) of daily milk yield of each animal from that of daily TDN intake (kg) of respective animal multiplied by 4400, presuming that each kg of TDN contained 4400 kcal of digestible energy as per the following formula:

Gross energetic efficiency (%)

$$= \frac{\text{Gross energy of total milk/day (kcal)}}{4{,}400\times\text{TDN intake (kg/day)}} \times 100$$

The net energetic efficiency of milk production was calculated by subtracting the TDN required for maintenance (35.2 g/kg$W^{0.75}$) as per NRC (1978) from the total TDN intake as given below:

Net energetic efficiency (%)

$$= \frac{\text{Gross energy of milk produced/day (kcal)}}{4{,}400\times[\text{TDN intake (kg/day) - TDN required for maintenance as 35.2 g/kg } W^{0.75}]} \times 100$$

The gross and net efficiencies of nitrogen utilization for milk production were calculated using the following formulae:

Gross efficiency of N utilization (%)

$$= \frac{\text{Milk N secreted}}{\text{Feed N intake}} \times 100$$

Net efficiency of N utilization (%)

$$= \frac{\text{Milk N secreted}}{\text{Digestible N intake}} \times 100$$

Statistical analysis

The data were subjected to 2×2 factorial completely randomized design and analysed by ANOVA (Snedecor and Cochran, 1980) to compare differences between treatments by Duncan multiple range test using General Linear Model procedures of SAS (1989).

RESULTS AND DISCUSSION

Nutrient intake and utilization

The total DM intake, roughage DM intake, concentrate DM intake, roughage: concentrate ratio, DM intake/100 kg body weight and DM intake/kg $W^{0.75}$ did not differ significantly among the different treatments groups and also due to either UDP level, plane of feeding or their interaction (Table 2). These results corroborate those of Bedi and Vijjan (1978), Bharadwaj et al. (2000) and Christenson et al. (1993) who reported that protected protein did not influence DM intake for different physiological functions. On the contrary Chaturvedi and Walli (2000, 2001) concluded that increasing UDP level from 29 to 43% of dietary protein increased the total dry matter intake. The total DM intake in the present study ranged from 12.89 to 13.54 kg/day, and dry matter intake per 100 kg body weight ranged from 3.26 to 3.45 kg. These values were slightly more than those reported by Chaturvedi and Walli (2001) who reported 10.66 to 11.54 kg dry matter intake per day, or 2.37 to 2.82 kg per 100 kg body weight in lactating crossbred cows yielding about 10 kg milk/day. The lower dry matter intake as reported by Chaturvedi and Walli (2001) in lactating

Table 3. Effect on nutrient intake and digestibilities (%) in experimental crossbred cows fed different UDP levels and planes of nutrition

Particulars	Treatment groups				SEM
	1 LUDP+NP	2 LUDP+HP	3 HUDP+NP	4 HUDP+HP	
Nutrient intake					
TDN intake (kg)	6.77	7.12	7.05	7.74	0.60
TDN intake/100 kg body weight (kg)	1.68	1.84	1.74	1.83	0.13
TDN intake/$W^{0.75}$ kg (g)	75.18	81.74	78.03	82.77	6.07
DCP intake (kg)	0.68	0.75	0.74	0.88	0.10
DCP intake/100 kg body weight (g)	170.20	194.50	183.2	205.20	23.66
DCP intake/$W^{0.75}$ kg (g)	7.50	8.53	8.13	9.23	1.08
Nutrients digestibility (%)					
Dry matter	57.29	57.06	59.08	61.92	2.16
Organic matter	59.50	59.21	61.12	63.67	2.06
Crude protein	57.34	58.71	58.23	62.15	3.05
Crude fiber	42.81	43.44	41.61	41.17	2.37
Ether extract	86.37	86.48	87.14	89.08	1.09
Nitrogen-free extract	63.97	63.73	65.20	66.02	1.92

UDP = Undegradable dietary protein, LUDP = Low undegradable dietary protein.
HUDP = High undegradable dietary protein, NP = Normal plane, HP = High plane.

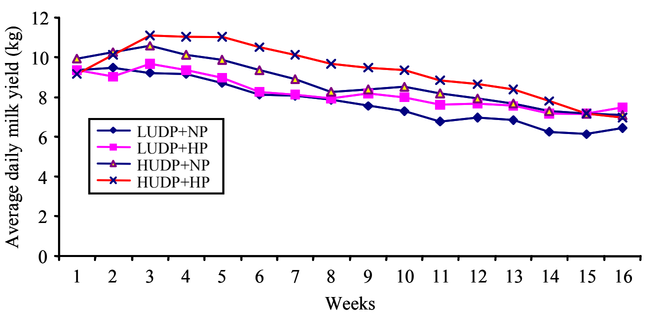

Figure 1. Average weekly milk yield in crossbred cows fed ration with different UDP levels and planes of nutrition.

cows as compared to the present study might be due to fact that they were fed green maize fodder and wheat straw as roughages in calculated quantity, whereas in the present study green jowar fodder was fed *ad libitum* as sole source of roughage. Ramachandran and Sampath (1995) also reported a lower DM intake (2.90 to 2.94 kg/100 kg body weight) than recorded in the present study. The daily dry matter intake ranged from 145.18 g in group 1 (LUDP+NP) to 152.57 g/kg $W^{0.75}$ in group 2 (LUDP+HP) in the present study. The variation in dry matter intake might be due to type and quality of roughage, time and frequency of feeding and watering and also climatic conditions.

The TDN and DCP intakes also did not differ significantly among different dietary treatments (Table 3). The TDN consumption ranged from 6.77 to 7.74 kg/day which was similar to that reported by Chaturvedi and Walli (2001) in crossbred cows (6.67 to 7.49 kg/day) but in another study the TDN intake was significantly ($p<0.01$) higher in cows fed ration containing low UDP (70:30 RDP: UDP ratio) than in cows fed ration containing high UDP (58:42 RDP:UDP ratio) (Chaturvedi and Walli, 2001). The data on digestibility coefficients are presented in Table 3. The digestibility coefficients for DM, organic matter (OM), crude protein (CP), crude fibre (CF), ether extract (EE) and nitrogen-free extract (NFE) also did not differ significantly among different dietary treatments. However, Bedi and Vijjan (1978) reported significantly ($p<0.05$) better digestibility of EE in calves fed ration containing formaldehyde-treated mustard cake, whereas Chaturvedi and Walli (2000) reported significant reduction in crude fiber digestibility due to increase in UDP level which might be due to decreased intake of maize fodder and wheat straw and less rumen microbial protein synthesis in lactating crossbred cows with increase in UDP level. Kridi *et al* (2001) reported significant improvement in digestibilities of DM, OM and CP in Awassi ewes. Similarly, Wankhede and Kalbande (2001) found significant improvement in DM, OM, CP, EE CF and NFE digestibilities due to protein protection in Red Kandhari calves. Similar to the present studies Ramachandran and Sampath (1995) also did not find any significant differences in digestibilities of DM, OM, CP, NDF and ADF due to change in UDP level (35 or 55% of dietary CP) in lactating crossbred cows. Similar observations were also reported by Srivastava and Mani (1995) in crossbred cows and Tiwari and Yadava (1994) in male buffalo calves fed rations containing formaldehyde-treated protected proteins.

Milk yield, milk composition and gross energy value of milk

The values for weekly milk yields of different treatment groups are presented in Figure 1. There was a consistently higher milk production in cows of group 4 (HUDP+HP) fed concentrate mixture containing high UDP and at higher plane of feeding. The higher milk yield due to HUDP and

Table 4. Effect on average daily milk yield, 4% FCM yield, fat yield and milk composition and gross energy content in experimental crossbred cows fed different UDP levels and planes of nutrition during experimental feeding trail of 105 days

Particulars	Treatment groups				SEM	UDP levels		Plane of nutrition	
	1	2	3	4		LUDP	HUDP	NP	HP
	LUDP+NP	LUDP+HP	HUDP+NP	HUDP+HP		(UDP:RDP; 41:59)	(UDP:RDP; 48:52)	(100 % of NRC)	(115 % of NRC)
Milk yield (kg)	7.66	8.15	8.64	9.35	1.24	7.91	8.99	8.15	8.75
4% FCM yield (kg)	8.63	9.77	9.59	10.96	1.32	9.20	10.28	9.11	10.37
Fat yield (kg)	0.37	0.43	0.41	0.48	0.05	0.41	0.44	0.39	0.46
Total solids %*	14.11[b]	15.19[a]	13.57[b]	14.09[b]	0.32	14.65[a]	13.83[b]	13.84[b]	14.64[a]
Fat %*	4.93[b]	5.49[a]	4.76[c]	5.23[ab]	0.19	5.21	4.99	4.84[b]	5.36[a]
Protein %	3.23	3.31	3.17	3.21	0.05	3.27	3.19	3.20	3.26
Lactose %*	5.21[b]	5.67[a]	4.91[b]	4.92[b]	0.21	5.44[a]	4.92[b]	5.06	5.29
Ash %	0.74	0.73	0.73	0.73	0.01	0.73	0.73	0.74	0.73
Solids-not-fat %*	9.18[b]	9.71[a]	8.81[b]	8.86[b]	0.22	9.44[a]	8.83[b]	9.00	9.28
Gross energy* (kcal/kg)	849[b]	926[a]	816[b]	862[b]	22.60	887[a]	839[b]	832[b]	894[a]

UDP = Undegradable dietary protein, LUDP = Low undegradable dietary protein.
HUDP = High undegradable dietary protein, NP = Normal plane, HP = High plane.
[a, b, c] values bearing different superscripts in a row differ significantly from each other; * $p<0.05$.

HP diet could be due to higher energy and other nutrients intake through concentrate mixture. The data on milk yield and milk composition are presented in Table 4. The average milk yield was 7.66, 8.15, 8.64 and 9.35 kg in groups 1 (LUDP+NP), 2 (LUDP+HP), 3 (HUDP+NP) and 4 (HUDP+HP), respectively. There was no significant difference in milk yield, 4% fat-corrected milk yield, fat yield and protein and ash contents of milk among different treatment groups. Whereas total solids, fat, lactose, solid-not-fat and gross energy contents of milk differed significantly ($p<0.05$) among the different treatment groups. The total solids, fat, solid-not-fat, lactose and gross energy content of milk were significantly ($p<0.05$) higher in cows fed rations containing low UDP at higher plane of feeding (LUDP+HP) and significantly ($p<0.05$) lowest value for corresponding parameters was observed in cows fed ration containing high UDP at normal plane of feeding (HUDP+NP). Though the differences were statistically non-significant ($p<0.05$), a consistent improvement in daily milk yield, 4% FCM yield and fat yield were observed due to increase in UDP level and also due to increase in plane of feeding. The overall daily average milk yield was 13.65% more in cows fed ration containing high UDP (8.99 kg/d) than in cows fed the ration containing low UDP (7.91 kg/day). There was also increase in milk yield by 7.36% in animals fed at higher plane of feeding (8.75 kg/day) compared with those fed at normal plane of feeding (8.15 kg/day). The 4% FCM yield was 12% more in high UDP fed group (10.28 kg/day) than in low UDP fed group (9.20 kg/day). The cows given higher plane of feeding (10.37 kg/day) produced 14% more milk than in cows given normal plane of feeding (9.11 kg/day). The increase in 4% FCM yield is also due to increase in fat content of milk due to feeding of ration with high UDP content and also due to higher plane of feeding. The average daily milk fat yield was 7.5% more in high UDP fed animals (0.44 kg) than in the low UDP fed animals (0.41 kg). Similarly, the milk fat yield was 18% more in cows fed at higher plane (0.46 kg) than in cows fed at normal plane (0.39 kg). However, the differences in milk yield, 4% FCM yield and fat yield were statistically non-significant among different treatment groups (Table 4). Chaturvedi and Walli (2000, 2001) also reported significant increase in 4% FCM yield in lactating crossbred cows due to increase in UDP content from 42 to 56% of dietary CP, which is due to the fact that fat content in milk was increased due to increase in UDP level in the ration but milk yield was not affected due to change in UDP level as also observed in the present study. Chowdhury et al. (2002) also found a significant ($p<0.01$) increase in 4% FCM yield due to protein protection but increased level of feeding had no effect on 4% FCM yield in lactating German Fawn goats. Kanjanpruthipong and Buatong (2002) also reported significant ($p<0.01$) improvement in milk and FCM yields in dairy cows due to protein protection. However, contradictory results were also reported by Hartwell et al. (2000) in which there was a significant ($p<0.05$) decrease in milk production in transition dairy cows due to increase in rumen undegradabe protein (UDP) content from 4.0 to 6.2% of DM.

Protein and ash contents of overall composition of the milk in the present study were not affected due to UDP levels and also due to increased level of feeding. The total solids, SNF, lactose and gross energy contents of high UDP diet fed group (13.83%, 8.83%, 4.92% and 839 kcal/kg, respectively) were significantly ($p<0.05$) lower than those of low UDP fed animals (14.65%, 9.44%, 5.44% and 887 kcal/kg, respectively). The total solids, fat and gross energy contents in milk were significantly higher in cows fed at higher plane of feeding (14.64%, 5.36% and 894 kcal/kg, respectively) than in cows fed at normal plane of feeding

Table 5. Effect on energetic efficiencies and efficiencies of nitrogen utilization for milk production in experimental crossbred cows fed different UDP levels and planes of nutrition

Particulars	Treatment groups				SEM
	1	2	3	4	
	LUDP+NP	LUDP+HP	HUDP+NP	HUDP+HP	
Gross energetic efficiency (%)	19.15	22.21	19.77	21.34	1.72
Net energetic efficiency (%)	37.81	40.02	37.53	37.09	3.25
Gross efficiency of nitrogen utilization (%)	17.50	19.26	18.43	17.88	1.24
Net efficiency of nitrogen utilization (%)	30.96	33.21	31.97	28.61	3.82

UDP = Undegradable dietary protein, LUDP = Low undegradable dietary protein.
HUDP = High undegradable dietary protein, NP = Normal plane, HP = High plane.

(13.84%, 4.84% and 832 kcal/kg). A decrease in milk fat content due to increase in UDP content had also been reported by Christensen et al. (1993), which is contradictory to the present findings, but they attributed the change to the source of UDP, fish-meal, which was not used in the current study. Maiga and Schingoethe (1997) observed no effect of rumen undegradable protein (UDP) content on milk composition, while decrease in milk protein content due to increase in UDP content was reported by Hartwell et al. (2000). Chaturvedi and Walli (2000; 2001) reported significant positive effects of UDP level on milk fat, protein and total solids content. Positive effects of UDP and negative effects of increased level of feeding on milk composition (exactly opposite to the findings of the present study) were reported by Chowdhury et al. (2002) in German Fawn goats where an increase in the level of feeding reduced the fat, protein and net energy content of milk significantly, and dietary protein protection increased fat, lactose and net energy content of milk. In the present study the increase in milk yield, fat yield due to increase in UDP level in the diet might be due to better utilization of nutrients with decrease in the blood urea nitrogen and increase in blood alpha amino nitrogen concentration (Chaturvedi and Walli, 2000) required for tissue protein synthesis. Lee et al. (2001) reported increase in blood urea nitrogen in goats fed low UDP diets (32% of dietary protein) which resulted in a high aspartate amino transferase level causing increase in liver load and also increase in milk urea nitrogen, whereas lowered blood urea nitrogen and milk urea nitrogen were recorded with medium UDP (35% of dietary protein) and high UDP ration (38% of dietary protein).

Efficiency of energy and nitrogen utilization

The data on efficiency of energy and nitrogen utilization for milk production are presented in Table 5. There was no significant difference in the gross and net energetic efficiencies and gross and net efficiencies of nitrogen utilization for milk production in cows among different dietary treatment groups. Gross energetic efficiency for milk production in the present study ranged from 19.2 to 22.2%, which was well above the values reported by Tiwari and Patle (1983) in buffaloes but comparable to the values (18.6 to 20.2%) reported by Kawalkar and Patle (1978) in crossbred cows. The net energetic efficiency for milk production in the present study ranged from 37.1 to 40.0%, which is higher than those reported by Kawalkar and Patle (1978) in crossbred cows and Tiwari and Patle (1983) in Murrah buffaloes. The level of UDP, plane of feeding and also their interaction had no significant effect on energetic efficiencies for milk production. The gross and net efficiencies of nitrogen utilization for milk production in the present study varied from 17.5 to 19.3% and 28.6 to 33.2%, respectively. The gross and net efficiencies of nitrogen utilization were also not affected significantly due to UDP level, plane of feeding or their interaction. Chowdhury et al. (2002) reported significant ($p<0.05$) improvement in efficiency of utilization of metabolizable energy (ME) for milk production in goats due to protein protection, whereas similar to the present study efficiency of utilization of metabolizable protein (MP) for milk production was not affected and level of feeding also did not have any significant effect on efficiency of utilization of ME or MP for milk production. Lee et al. (2001) concluded that level of dietary UDP did not significantly influence the milk production efficiency but they recorded better milk production efficiency per unit of feed protein and energy intake in the high UDP group.

From the present studies, it was concluded that, though the differences in milk production due to UDP level and level of feeding concentrate were statistically non-significant, the consistently higher milk production and fat yield due to increase in UDP level in the ration and increase in level of feeding indicated that increasing UDP level from 41 to 48% of the CP of concentrate mixture and increasing plane of feeding from normal to 115% of NRC recommendations under Indian conditions is beneficial in lactating crossbred cows in improving the milk production as well as milk constituents.

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