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Effect of complete feed block on nutrient utilisation and rumen fermentation in Barbari goats

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Abstract

Fifteen Barbari goats (average BW 13 kg) were randomly divided into three groups of five animals each. All animals were fed complete diets consisting of natural grass hay and concentrate mixture in the ratio of 60:40 on the DM basis. In the concentrate mixture, 15% (T_2) or 30% (T_3) CP of mustard cake was replaced with *Leucaena* leaf meal (LLM). The diet of the control group (T_1) was offered as such, whereas T_2 and T_3 diets were offered in the form of blocks. The bulk density of the complete feed block was 550–600 kg/m^3. Densification of complete diets increased the bulk density 3.2–3.9 times. Total VFA concentration in the rumen was similar in the three groups. Ammonia N concentration was significantly ($P < 0.05$) higher in the mash-fed goats (T_1) than in the block-fed animals (T_2 and T_3). The rumen anaerobic fungal population was slightly higher in T_2 and T_3 than in T_1 as a result of the proportionate intake of roughage and concentrate from the block form of the diet. The total protozoa population ranged from 7.47×10^4 to 8.65×10^4 ml^{-1} of strained rumen liquor (SRL). Voluntary feed intake was similar in T_1 (431 g per day), T_2 (409 g per day) and T_3 (415 g per day). Digestibility coefficients (%) of DM, OM, CP, CF and NFE among treatment groups did not differ significantly. Inclusion of *Leucaena* leaf meal by replacing mustard cake did not affect the N balance in Barbari goats. DCP and TDN intake were sufficient for maintenance. Blood glucose, protein and urea-N were within normal physiological ranges in all groups. It was concluded that *Leucaena* leaf meal can be incorporated by replacing mustard cake safely and inexpensively without affecting nutrient utilisation in Barbari goats. Further, the process of block making from low bulk density roughage resources substantially reduces the storage space and transportation cost.

Keywords: Goat; Nutrient utilisation; Feed blocks; Rumen microbes; Complete feed

1. Introduction

Goats occupy a significant niche in the rural economy of India. With their inherent qualities of early maturity, ability to thrive even under harsh environment, low capital investment, etc. this small ruminant acts as an insurance against crop failure and provides alternative source of livelihood to the farmers all the year round (Selvam and Safiullah, 2002). These animals mostly thrive on grazing of natural grass as well as browsing on shrubs and tree leaves. These feed resources are characterised by low digestibility, low ME and low CP besides poor availability of minerals and vitamins. Moreover, the grazing lands are fast dwindling due to ever growing human population. Attempts were made to improve nutrient utilisation from these roughage resources by various means—complete feed block is one of them. No single feed

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in itself is complete in all respects of nutrients which when fed alone, leads to imbalance of nutrients in animals (Nagpal and Arora, 2002).

Complete feed is comprised of forage, concentrate and other supplementary nutrients in desired proportion capable to fulfil nutrient requirements of animals. The feeding of complete feed stabilises rumen fermentation, minimises fermentation loss and ensures better ammonia utilisation (Prasad et al., 2001). This pattern of rumen fermentation enhances utilisation of poor quality of roughages and improves the palatability of unconventional feeds. Because of seasonal availability and low bulk density, storage, handling and transportation of roughage materials are very difficult. Thus, complete feed in block form may overcome the above problems and will transport feed resources to deficit region or areas of natural calamities cost effectively. During the last decade, efforts were made to change from the traditional extensive animal farming to an intensive system. The extensive system provides abundant and constant availability of forages year round. A complete diet, used in cattle and buffalo (Verma et al., 1996; Singh et al., 2001) feeding, can be explored for small ruminants. This will in turn increase possibilities of providing animal requirements, facilitate management, allow full mechanisation and more flexibility for inclusion of a wide range of alternative feeds (Cavani et al., 1991). The preparation of a feed block offers scope for incorporation of tree leaves/shrubs in routine diets besides the potentiality to protect loss of feed ingredients during sneezing. In this endeavour, the roughage-based complete diets were densified and evaluated in Barbari goats to investigate effects on nutrient utilisation and rumen parameters.

2. Materials and methods

2.1. Preparation of complete feed block

Natural grass (predominated by *Sehima nervosum* and *Heteropogon contortus*) at mature stage and *Leucaena leucocephala* leaves were collected from the Experimental Farm of the Indian Grassland and Fodder Research Institute at Jhansi. In order to prepare complete feed blocks, the grass was mixed with the formulated concentrate mixture (Table 1) where 15 or 30% CP of mustard cake were replaced by *Leucaena* leaf meal (LLM). The complete diet containing natural grass and concentrate mixtures (B and C) at the ratio of 60:40 (on the DM basis) was subjected to the preparation of blocks at 4000 psi in an automatic feed blocking machine. The physical characteristics of the blocks were evaluated in terms of bulk density, keeping quality, texture, etc.

Table 1
Ingredients of concentrate mixtures used in different treatments

Ingredient	Proportion (kg/100 kg)		
	A	B	C
Mustard cake	35	30	25
Barley grain	15	15	10
Wheat bran	37	32	32
Leucaena leaf meal	00	10	20
Urea	1	1	1
Molasses	10	10	10
Mineral mixture	1	1	1
Common salt	1	1	1

A: concentrate mixture for mash diet; B: concentrate mixture for complete feed block B; C: concentrate mixture for complete feed block C.

2.2. Animals and feeding

Fifteen Barbari female goats, age 8–10 months, were randomly divided into three groups comprising of five goats each. The average body weights were 13.28 ± 1.15, 13.32 ± 1.23 and 13.24 ± 1.16 kg in T_1, T_2 and T_3, respectively. The animals of group T_1 served as controls and were maintained on the complete diet consisting of natural grass and concentrate mixture A in the ratio of 60:40 in mash form while the animals of group T_2 and T_3 were fed on the complete diet of natural grass and concentrate mixtures B or C, respectively at the same ratio in block form. All the goats were maintained on ad libitum feeding regime. Weighed quantities of feed were offered in separate troughs to individual goats once daily at 10:00 h for the entire experimental periods. The blocks were broken into two to three pieces in a trough and goats did not face any difficulty while eating. Left over was quantified daily and discarded. Clean drinking water was provided to all the animals twice daily (11:00 and 16:00 h). After 3 weeks of experimental feeding, animals were placed in cages having facilities for quantitative collection of faeces and urine separately, and a digestibility and metabolism trial of 7 days collection period was conducted to evaluate the nutritive value and balance of N from the various forms of the complete diets.

2.3. Analytical techniques

Dry matter in feed and faeces was determined by oven drying at 100 °C overnight. For chemical analysis, pooled samples of feed offered, refusals and faeces were dried at 60 °C and ground to pass through a 2 mm sieve. Wet faeces and urine samples, preserved in diluted and concentrated sulphuric acid, respectively, were analysed for N by the standard Micro Kjeldahl method. Feed and faecal samples were analysed for CP, EE and total ash contents (AOAC, 1990) and fibre fractions were analysed as per Van Soest et al. (1991).

Before the onset of the digestibility trial, rumen liquor was collected at 2 h of post-feeding through an oesophageal tube. Rumen liquor samples were analysed for total N (Micro Kjeldahl), ammonia N (Conway, 1957), total VFA (Barnett and Reid, 1957), TCA-precipitable N (Tagari et al., 1964). Rumen liquor samples were also used to monitor the population of anaerobic bacteria (Hungate, 1966), fungi (Samanta and Walli, 1999). Rumen ciliates were identified according to Hungate (1966). *Spirotrichs* not identified to generic level were classified into small *Spirotrichs* (mainly *Entodinia* with an average size 42 μm × 23 μm) and large *Spirotrichs* (mainly *Diplodinia* with an average size of 132 μm × 66 μm). The protozoa numbers were calculated according to Kamra et al. (1991).

Blood samples were collected in heparinised test tubes before the onset of the digestibility trial to study various blood metabolites, glucose (Somogyi, 1945), urea (Rahmatullah and Boyde, 1980) and protein (Reinhold, 1953).

2.4. Statistical analysis

The data were subjected to analysis of variance for a randomised block design (Snedecor and Cochran, 1967).

3. Results and discussion

3.1. Chemical composition

Chemical composition of the natural grass, mustard cake, *Leucaena* leaf meal, concentrate mixture A, complete feed blocks B and C are presented in Table 2. It is obvious that natural grass is poor in CP but rich in NDF. Similar levels of CP and higher values of NDF in natural grass have been reported by Singh and Samanta (1998). No significant difference was noticed in chemical composition of complete diet A (mash form), complete feed block B and C.

3.2. Physical characteristic of complete feed blocks

The complete feed blocks were made at 4000 psi in an automatic hydraulic block-making machine. The average dimension of the block was 10.16 cm × 20.32 cm × 20.32 cm with an average weight of 2.5 kg. The bulk density of natural grass, concentrate mixture A, B and C was 24.08, 470.00, 398.00 and 323.00 kg/m^3, respectively. In the present study, the bulk density of natural grass was low due to its bigger particle size (10–15 cm). Earlier reports suggested higher bulk density (100–130 kg/m^3) in fibrous feed like rice and wheat straw (Yadav et al., 1990) due to

Table 2
Chemical composition of different feed ingredients (% DM basis)

Feed	CP	CF	EE	NFE	Ash	NDF	ADF	OM
Mixed grass	3.10	32.06	1.12	53.39	10.33	68.19	38.64	89.67
Mustard cake	35.20	6.62	8.30	41.02	6.86	24.59	18.06	93.15
Leucaena leaf meal	16.76	12.65	2.98	58.39	9.22	34.52	14.04	90.81
Concentrate mixture A	19.50	6.92	4.78	61.29	7.51	23.36	10.12	92.49
Complete feed mash A (T_1)	9.60	23.12	2.73	55.30	9.27	50.30	28.02	90.73
Complete feed block B (T_2)	8.99	25.48	2.82	56.39	6.32	55.64	33.29	93.68
Complete feed block C (T_3)	9.16	25.56	2.61	53.87	8.80	54.06	33.30	91.20

smaller particle size (0.5–2.5 cm). The bulk density of the natural grass with different concentrate mixtures (A, B and C) at the ratio of 60:40 in mash form was 205.00, 170.00 and 140.00 kg/m^3, respectively. The thickness of the blocks was 8.89, 10.36, 10.36, 11.27 and 13.06 cm at 0, 15, 30, 60 and 120 min following block making. The expansion of the blocks ranged from 1.47 to 4.16 cm during the time frame of 15–120 min. The maximum expansion was noticed during the first 15 min after making the blocks, corroborating the findings of Singh (1986). The bulk density of the complete feed block was 550–600 kg/m^3. The increase in the bulk density of the complete feed blocks was 3.3–3.9 times. These findings were within the range given by Sihag et al. (1991) who also noticed 3.19–3.83 times higher bulk density during densification of roughage-based complete feed. There was no visible change in colour, texture, and no mould growth was noticed during 6 months of storage as reported earlier (Singh et al., 1998).

3.3. Rumen parameters

The pH of strained rumen liquor (Table 3) varied from 6.68 to 7.01, being lower in the mash-fed control group (T_1). Feeding of guinea or trispecific hybrid (TSH) grass to goats gave rumen pH around 7.30–7.40 (Misra et al., 1996). Natural grass-based diets are reported to ensure higher rumen pH in animals (Samanta et al., 1998). The lowest pH in T_1 was due to the rapid consumption of concentrate from the mash form of the complete diet (T_1). Rumen pH 6.83 and above in T_2 and T_3 was mainly due to the proportionate intake of grass and concentrate from the block form of the complete diet. Total VFA concentration in the rumen was almost identical (10.10–11.60 meq./dl SRL) in all three groups and did not differ significantly. Reports suggested that total VFA concentration ranged from 9.57 to 11.55 meq./100 ml SRL in Barbari goats maintained on concentrate, *Leucaena* leaves and oat hay (Senani and Joshi, 1995). Ammonia N was higher ($P < 0.05$) (30.23 ± 1.14 mg/dl SRL) in mash-fed goats (T_1) than in the block-fed goats (T_2 and T_3). This indicated that the feeding of the complete diet in the form of blocks can slow down the production of ammonia N in the rumen and thus prevent the body system from the burden of recycling of excess ammonia. Due to the faster consumption of the concentrate mixture from the mash form of complete diets (T_1), total N as well as NPN concentration were also significantly ($P < 0.05$) higher in T_1 than T_2 and T_3. This further strengthens the hypothesis that the block form of a complete diet can substantially protect valuable protein sources from degradation into NPN compounds inside the rumen ecosystem. In the rumen protein and other nitrogenous compounds are broken down into ammonia and peptides. The ammonia is used by the microbes for their protein synthesis. For normal microbial activity 5–7 mg NH_3 N/100 ml rumen liquor is required (Satter and Slyter, 1974) although latter experiments show that 15–20 mg/100 ml rumen liquor is required for maximum nutrient utilisation (Perdok and Leng, 1989). Thus, in the present experiment, the ammonia N in the rumen liquor in all three groups was sufficient to ensure optimum microbial growth and nutrient utilisation.

3.4. Microbial population

The total bacterial population did not differ significantly among the groups (Table 4). In berseem- or sorghum-fed Murrah buffalo, total bacterial count

Table 3
Effect of complete diets on various rumen parameters in Barbari goats

Parameters	Groups		
	T_1	T_2	T_3
pH	6.68 ± 1.17	7.01 ± 1.17	6.83 ± 1.15
TVFA (meq./dl)	10.40 ± 0.86	10.12 ± 0.38	11.60 ± 0.24
NH_3 N (mg/dl SRL)	30.23 ± 1.14^b	22.69 ± 0.16^a	22.02 ± 0.60^a
Total N (mg/dl SRL)	78.45 ± 2.31^b	67.50 ± 2.02^a	68.45 ± 2.80^a
TCA-precipitable N (mg/dl SRL)	35.10 ± 0.41	37.65 ± 0.63	38.82 ± 1.96
NPN (mg/dl SRL)	50.35 ± 2.66^b	29.85 ± 0.92^a	29.62 ± 0.85^a

Means with different superscripts in a row differ ($P < 0.05$).

Table 4
Effect of complete diets on rumen microbial populations in Barbari goats

Microbial population (number/ml)	Groups		
	T_1	T_2	T_3
Bacteria ($\times 10^9$)	4.70	4.70	4.60
Fungi ($\times 10^3$)	3.12	5.30	4.85
Protozoa ($\times 10^4$)	8.65	7.47	8.35
Spirotrichs			
Small ($\times 10^4$)	4.21	4.67	3.95
Large ($\times 10^4$)	2.34	1.37	1.55
Total ($\times 10^4$)	6.55	6.04	5.50
Holotricha			
Isotricha ($\times 10^4$)	1.75	1.10	2.20
Dasytricha ($\times 10^4$)	0.35	0.32	0.65
Total ($\times 10^4$)	2.10	1.42	2.85

varied from 1.02×10^9 to $3.62 \times 10^9\,ml^{-1}$ of rumen liquor (Sinha and Ranganathan, 1983). The rumen anaerobic fungal population was slightly higher (5.30×10^3 and $4.85 \times 10^3\,ml^{-1}$ in T_2 and T_3, respectively) in block-fed goats than in mash-fed (T_1) animals ($3.12 \times 10^3\,ml^{-1}$). This might be due to the faster consumption of concentrate in T_1, which in turn reduces the fungal population. Fibrous diets are reported to ensure higher fungal populations in cattle and buffaloes (Samanta and Walli, 1999; Samanta et al., 1999). Total protozoa population ranged from 7.47×10^4 to $8.65 \times 10^4\,ml^{-1}$ of SRL (Table 4). Under the stall feeding system, feeding of concentrate and ad libitum *Cenchrus ciliaris* grass ensures relatively higher ($36.0 \times 10^4\,ml^{-1}$ of rumen liquor) protozoal number at 2 h post-feeding in Kutchi goats (Santra and Karim, 2001). The *Spirotrichs* comprised 65–80% of total protozoa while *Holotricha* were 20–35% of total population which is in agreement with earlier observation of Kamra et al. (1991) and Santra and Karim (2001). Among *Spirotrichs*, the majority was small type while in the case of *Holotricha*, the majority was *Isotricha* spp. Misra et al. (1996) also noticed greater populations of *Entodinia* in goats while feeding guinea and TSH grass. The two ciliate groups, viz. *Holotricha* and *Entodionomorphid* occupy different metabolic niches (Williams, 1986). The former primarily utilises soluble carbohydrates whereas the latter ingests and ferments particulate material. Thus, roughage-based complete diet might be responsible for higher population of *Spirotrichs* than *Holotricha* in the present investigation.

3.5. Nutrient intake, digestibility and N balance

The complete diet either in mash or block form ensured acceptability by Barbari goats. Dry matter intake (DMI) was 431.53, 409.90 and 415.07 g per day in T_1, T_2 and T_3, respectively (Table 5). Dry matter intake in terms of kg/100 kg body weight ranged from 2.90 to 3.06. The calculated figures for DMI in terms of g/kg $W^{0.75}$ were 56.23–59.28. The block form of the diet had a mean bulk density 3.60 times greater than its mash form of diet and this higher bulk density will have resulted in a higher voluntary intake of DM as has been observed in buffaloes (Verma et al., 1996) and in crossbred calves (Singh et al., 2001). However, in the present experiment no difference ($P < 0.05$) was observed in DMI in Barbari goats which corroborates the findings of Yadav et al. (1990) and Sihag et al. (1991). Plane of nutrition was similar among treatment groups. The intake of TDN was sufficient for maintenance, whereas DCP intake was 24–36% higher than the maintenance requirement (ICAR, 1985).

Digestibility coefficients of the various nutrients (Table 5) also did not differ significantly among the treatment groups, corroborating the findings of Verma et al. (1996), who also did not notice significant differences in digestibility of various nutrients in Murrah buffaloes and in growing buffalo calves (Singh et al., 1998). All the animals were in positive N balance, which did not differ significantly among treatments. The retention of N as percentage of N intake and grams of absorbed N was similar among treatments. This indicated that dietary inclusion of LLM had no adverse effect on N utilisation as observed earlier (Virk et al., 1991; Garg and Kumar, 1994).

3.6. Blood profile

Dietary treatments did not influence the concentration of blood glucose, plasma urea-N and protein (Table 6). Plasma urea-N reflects the dietary CP intake, the ratio of dietary CP to ruminally fermentable OM and also serves as an indicator of ruminal protein supply. Thus, similar plasma urea-N and protein in the

Table 5
Effect of complete diets on feed intake and digestibility of nutrients in Barbari goats

Particulars	Groups		
	T_1	T_2	T_3
BW at the middle of trial (kg)	14.10 ± 1.01	14.13 ± 1.11	14.07 ± 1.12
Intake of DM and plane of nutrition			
DM intake (g per day)	431.53 ± 9.88	409.90 ± 8.57	415.07 ± 8.99
DMI (% BW)	3.06 ± 0.20	2.90 ± 0.18	2.95 ± 0.12
DMI (g/kg $W^{0.75}$)	59.28 ± 3.88	56.23 ± 4.56	57.17 ± 5.44
CP intake (g per day)	37.36 ± 2.47	34.71 ± 2.49	35.71 ± 2.87
DCP intake (g/kg $W^{0.75}$)	3.41 ± 0.45	3.14 ± 0.75	3.14 ± 0.65
TDN intake (g/kg $W^{0.75}$)	33.16 ± 4.05	34.33 ± 5.86	31.82 ± 6.42
Digestibility coefficient (%)			
DM	60.10 ± 2.07	64.10 ± 2.34	62.26 ± 1.90
OM	63.88 ± 1.88	66.94 ± 2.18	64.18 ± 1.26
CP	66.16 ± 2.28	65.30 ± 3.29	63.84 ± 1.57
CF	55.26 ± 3.43	60.85 ± 5.19	61.26 ± 2.91
EE	69.59 ± 3.73	73.57 ± 2.10	71.29 ± 4.90
NFE	61.43 ± 1.80	64.12 ± 2.26	59.67 ± 2.44
NDF	47.78 ± 1.83	49.87 ± 4.30	47.61 ± 3.46
ADF	43.63 ± 2.10	46.41 ± 6.04	44.05 ± 6.00
Nitrogen balance (g per day)			
Intake	5.98 ± 0.40	5.55 ± 0.36	5.71 ± 0.39
Faecal loss	3.49 ± 0.22	3.03 ± 0.20	3.25 ± 0.21
Urinary loss	1.40 ± 0.08	1.60 ± 0.10	1.59 ± 0.11
Balance	1.08 ± 0.11	0.92 ± 0.09	0.87 ± 0.11
Retention			
N intake (%)	18.06 ± 1.22	18.49 ± 1.06	15.35 ± 1.30
N absorbed (%)	43.42 ± 2.23	36.58 ± 1.98	35.42 ± 2.45

present study among treatment groups indicated that protein utilisation was not disturbed due to the replacement of mustard cake protein with LLM. Similarly, partial replacement of protein of concentrate mixture by *Leucaena* in growing buffalo calf diets did not alter the blood glucose or plasma protein contents (Akbar and Gupta, 1985).

Table 6
Effect of complete diets on blood metabolites in Barbari goats

Blood metabolites	T_1	T_2	T_3
Blood glucose (mg/dl)	53.59 ± 0.85	53.67 ± 1.05	53.80 ± 0.95
Blood urea (mg/dl)	21.55 ± 0.52	22.45 ± 0.35	22.71 ± 0.55
Total protein (g/dl)	6.64 ± 0.85	6.37 ± 0.94	6.74 ± 0.78

4. Conclusion

The making of block with natural grass and concentrate mixture increased bulk density 3.2–3.9 times. The colour and texture remained unchanged and no mould growth was observed during the storage period of 6 months. *Leucaena* leaves incorporation (20%) by replacing 30% CP of mustard cake in concentrate mixture and its subsequent usage during block making with natural grass does not interfere with nutrient utilisation in Barbari goats. The feeding of the blocks significantly reduced the rumen ammonia N concentration as compared to the mash form. Anaerobic bacteria and protozoa population was identical in both the block or mash-fed groups. However, block feeding sustained higher anaerobic fungal population in the rumen as compared to mash form. Thus, *Leucaena* leaves can be incorporated by replacing mustard cake safely and inexpensively without affecting nutrient utilisation in Barbari goats. Further, the process of block making from low bulk density roughage resources substantially reduces the storage space and transportation cost.

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