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Influence of Different Dietary Rumen Degradable Protein Concentrations on Nutrient Intake, Nutrient Digestibility, Nitrogen Balance, Blood Urea Nitrogen and Milk Yield of Lactating Beetal Goats

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MUA and AS presented the concept. MUA, IM and AQ performed experimental analysis. AS, MUA and SWAS wrote the manuscript. SC and HJ reviewed and edited the article.

Key words
Beetal goats, RDP, Nutrients digestibility, Nitrogen balance, BUN, Milk yield

ABSTRACT

In this study, we investigated the effect of different dietary RDP concentrations on nutrient intake, nutrient digestibility, nitrogen balance, blood urea nitrogen (BUN) and milk yield of lactating Beetal goats. Thirty five lactating Beetal goats were randomly divided into five groups (seven goats per group) in a randomized complete block design. Five isocaloric and isonitrogenous diets were formulated to contain 30, 40, 50, 60 and 70% RDP of dietary protein represented as 30RDP, 40RDP, 50RDP, 60RDP and 70RDP, respectively. Feed intake was recorded, nutrient digestibilities (DM, CP, ADF and NDF) were determined and blood samples were taken at 3, 6, 9 and 12 h post feeding, and examined for BUN. In addition, milk produced by each goat was recorded. The results showed that increasing RDP level in the diet has a linear effect (dose-dependently) on nutrient digestibilites, nutrient intake and milk yield. Dry matter (DM), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) intake were higher ($P < 0.05$) in goats fed 70RDP diet than those fed 30RDP diet. Nutrients digestibilities (DM, CP, NDF and ADF) were significantly higher ($P < 0.05$) in goats fed 60RDP diet than those fed 30RDP. Goats fed 70RDP diet produced higher milk yield/d than those fed 30RDP diet. These results revealed that Beetal goats fed 70RDP showed increased nutrient intake and digestibility and proved to be the best in terms of economics as compared to 60RDP, 50RDP, 40RDP and 30RDP diets.

INTRODUCTION

Recently, reports demonstrated that goats with more than 64.9 million heads are contributing 801 thousand tons of milk to serve ever growing human population of Pakistan (GOP, 2012). Despite large population, goat share to total milk production is quite meager which is generally attributed to poor or imbalanced nutrition because of high fiber and low nutrient profile of herbage where they are grazed and the current forage production is not dealing with the feeding requirements of livestock in Pakistan (Naseer *et al*., 2017). However, indoor feeding of goats not only enhances goat productivity by ensuring adequate supply of nutrients but also increases profitability, contrary to grazing goats where it is seriously compromised. Studies reported that sufficient supply of nutrients for increased productivity of indoor goats is considered a main nutritional principle to be practiced in order to harvest real benefits associated with dairy goat enterprise. In this regard, ensuring sufficient concentrations and respective forms of dietary protein is of vital significance.

In ruminants, ruminal undegradable protein (RUP)

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and ruminal degradable protein (RDP) are considered important fractions of dietary protein which determines protein quality for ruminants. Protein which differs in rumen degradable protein concentrations have direct association with nutrient intake, digestibility and rumen microbial enzyme production and thus can make or mar animal productivity (Tamminga, 2006). Ruminal ammonia is formed by the hydrolyzation of RDP under the action of ruminal microbes, which is the main source of nitrogen for rumen microbes for microbial protein synthesis. Rumen microbial protein composes about 75% protein or amino acids which serve as a valuable protein and amino acid source for ruminants (Tamminga, 2006). As dietary RDP increases, it enhances organic matter, dry matter and hemicellulose digestibility because of enhanced microbial enzymes and VFA's production (Griswold *et al.,* 2003). However, significance of adequate balance between RDP and RUDP concentrations can't be neglected. Similarly, lack or less RDP level will tend to reduce nutrient intake and their digestiblities which results in significant reduction in milk of dairy animals (Reynal and Broderick, 2005). On the other hand, high RUDP production may significantly reduce microbial growth, utilization of feed nutrients, supply of microbial protein to small intestine leading to compromise animal productivity (Nousiainen *et al*., 2004). In early lactating cows, increased feed intake has been reported when RDP level increased from 53 to 73 % of dietary CP (Erdman and Vandersall, 1983). Likewise, dry matter intake increased with gradual increase in dietary RDP concentration (20, 30, 40 and 50% RDP of dietary CP) and was found to be optimum in animals fed 50% RDP (Scott and Hibberd, 1990). Similarly, significant influence on fiber fractions digestiblities have been reported in lactating cows with alteration in rumen undegradable protein concentrations (Wright *et al*., 1998).

Adequate dietary RDP can enhance animal productivity, this aspect becomes more important in high producing or rapidly growing ruminants and the same has been supported by different scientific studies on large dairy animals (Hannon and Trenkle, 1990). However, information regarding adequate level of RDP for lactating Beetal goats in tropical environment is scanty. Therefore, the present study was designed to investigate the response of altering concentrations of RDP on nutrient intake, nutrients digestibility, N-balance, blood urea nitrogen and milk production in lactating Beetal goats.

MATERIALS AND METHODS

Experimental animals

Thirty five early lactating Beetal goats were randomly divided into five groups and each group assigned with seven goats in a randomized complete block design to determine the effect of altering rumen degradable protein concentrations on nutrients intake, nutrients digestibility, nitrogen balance, blood urea nitrogen (BUN) and milk yield. Blocking was done on the basis of different milk yield of early lactating goats. The goats of each group were tagged for their identification. All the experimental protocols were approved by the ethics committee of University of Agriculture, Faisalabad, Pakistan.

Experimental ration

Five isocaloric and isonitrogenous diets were formulated having 30, 40, 50, 60 and 70% of ruminal degradable protein (RDP) concentration and were represented as 30RDP, 40RDP, 50RDP, 60RDP and 70RDP diets, respectively. The composition of five formulated rations shown in Table I.

Feeding and management

Feeding was done twice a day (6:00 am, 6:00 pm) including 10% weigh back during collection period. The experimental animals were fed ad libitum and clean fresh drinking water was provided. Goats were allowed to acclimate to housing conditions for a month prior before the trial. The goats were housed on concrete floor in different pens. Before the beginning of the trial (90 days), all goats were dewormed (Vermicide gold; 1 ml/ kg body weight) and deworming was repeated after every 20 days. The goats were vaccinated against enterotoxaemia and Peste des petits ruminants (PPR). Last five days of each month were taken as collection period. During each collection period, ration offered, refused and feces were recorded to determine the feed intake and digestibility. These samples were dried at 55^{o}C, bulked, mixed and sampled at the end of each collection period.

Collection of blood samples

Duplicate blood samples were collected from jugular vein of each goat in vaccutainer tubes containing ethylene diaminetetracetic acid (EDTA) as anticoagulant. Blood samples were taken in each collection period at 3, 6, 9 and 12 h post feeding for the determination of blood urea nitrogen (BUN) level.

Data collection

The experimental goats were provided with weighed amount of feed. Offered and refused feed were weighed and recorded daily during the whole experimental period. Refused feed was collected after every 24 h. Nutrient digestibilities (DM, CP, ADF and NDF) were determined by total collection method as described previously (Williams *et al.,* 1984). In

brief, goats were housed in separate metabolic pens for complete collection of urine and feces to determine nutrient digestibilities and nitrogen balance (NRC, 2001). The urine and feces of each goat were stored in their respective collection bags. Fecal bags were weighed and mixed properly, and 20% of each bag was sampled and dried at 60°C. The dried fecal samples were composted and 10% of composted sample was taken for laboratory analysis. Urine samples were collected by using the method as described previously (Williams *et al.,* 1984). Milk produced by each goat was recorded.

Chemical analysis

Samples of feed offered and the collected fecal sampleswere analyzed for DM (Method 930. 15; AOAC 1990). Crude protein (CP) (Kjeidahl method 955. 04; AOAC 1990), Acid detergent fiber (ADF; Goering and Van-Soest, 1970) and Neutral detergent fiber (NDF; Van-Soest*et al.,* 1991) was determined in the samples. Preserved urine sample, after thawing, were composted and 10% of the composted sample was used to determine nitrogen balance using the equation described by NRC (1985). Blood urea concentration was examined by using semi-automated clinical chemistry analyserMicrolab 300 (Merck^{R}country).

Statistical analysis

The data was analyzed by the analysis of variance technique under randomized complete block design (Steel *et al.,* 1996) using general linear model option of SPSS 17.0. Duncan's new Multiple Range Test was applied to separate the means. The experiments were performed in triplicates and statistical significance was determined at $P<0.05$.

RESULTS

Nutrients intake

Nutrients intake were different ($P<0.05$) in goat fed

Table I.- Ingredients composition of experimental rations.

Item	Diets[1]				
	30RDP	40RDP	50RDP	60RDP	70RDP
Wheat straw	20.00	20.00	20.00	20.00	20.00
Corn grain	30.00	30.00	30.00	30.00	30.00
Sun flower meal	0.00	8.00	8.00	15.00	12.00
Canola meal	6.50	15.50	20.50	14.80	8.50
Urea	0.00	0.00	0.00	0.70	1.50
Cotton seed meal	20.50	10.50	5.50	0.00	0.00
Rice polish	5.00	1.00	1.00	2.50	6.50
Wheat bran	1.00	1.00	1.00	2.00	7.50
Corn gluten	10.00	6.00	6.00	7.00	5.00
Molasses	5.00	6.00	6.00	6.00	7.00
DCP	1.00	1.00	1.00	1.00	1.00
Na-bicarbonate	0.50	0.50	0.50	0.50	0.50
Mineral mixture	0.50	0.50	0.50	0.50	0.50
Total	100	100	100	100	100
Chemical composition					
Crude protein, %	16.22	16.23	16.22	16.25	16.31
RDP, % of dietary CP	30.25	40.91	50.72	60.79	70.76
NDF, %	23.41	26.24	27.73	29.39	28.42
ADF, %	14.32	17.03	18.05	19.22	17.72
Lignin, %	3.12	4.34	4.81	4.98	4.23
ME, Mcal/kg DM	2.19	2.25	2.23	2.21	2.25

[1] 30RDP, 40RDP, 50RDP, 60RDP and 70RDP diets contain 30, 40, 50, 60 and 70% RDP of dietary protein, respectively.

Table II.- Effect of feeding different dietary rumen degradable protein concentrations on Nutrient intake and Nutrient digestibilities in Beetal goat.

Item (g/d)	Diets[1]					SE
	30RDP	40RDP	50RDP	60RDP	70RDP	
DM	1517^{e}	1570^{c}	1539^{d}	1830^{b}	1870^{a}	± 34.97
CP	246.2^{e}	254.8^{c}	249.8^{d}	297.5^{b}	305.0^{a}	± 05.70
NDF	357.2^{c}	411.7^{b}	425.7^{b}	541.2^{a}	534.8^{a}	± 16.60
Nutrients digestibilities (%)						
DM	63.68^{d}	67.16^{c}	67.87^{c}	70.66^{a}	69.67^{b}	± 5.67
CP	72.41^{d}	74.81^{c}	76.22	82.20^{a}	82.73^{a}	± 9.52
NDF	56.18^{d}	63.60^{c}	65.53^{b}	66.53^{ab}	67.01^{a}	± 9.25

Means in the same rows with different superscript letters were significantly different (P<0.05). 130% RDP, 40% RDP, 50% RDP, 60% RDP and 70% RDP diets represent 30, 40, 50, 60 and 70% rumen degradable protein of dietary protein, respectively.

diets having different levels of RDP (**Table** II). Higher DM and CP intake were noticed in goats fed 70RDP diet than those fed 60RDP, 50RDP, 40RDP and 30RDP diets. Goats fed 70RDP diet had 2.14, 17.70, 16.04 and 18.87% more DM intake than those fed 60RDP, 50RDP, 40RDP and 30RDP diets, respectively. Crude protein intake in goats fed 70RDP diet had 2.62, 18.62, 16.72 and 19.34% more CP intake than those fed 60RDP, 50RDP, 40RDP and 30RDP diet, respectively. In contrast, higher NDF intake was observed in goats fed 60RDP diet than those fed 50RDP, 40RDP and 30 RDP diets. Goats fed 60RDP diet had 34.01% more NDF intake than those fed 30RDP diet. There was no observed difference (P>0.05) in NDF intake in goats fed 70RDP and 60RDP while similar trend was observed in 50RDP and 40RDP diets. Acid detergent fiber in goats fed 60RDP had 1.8, 18.47, 21.40 and 36.36% more ADF intake than those fed 70RDP, 50RDP, 40RDP and 30RDP diets, respectively. However, ADF intake was unaltered in goats fed 50RDP and 40RDP diets.

Nutrients digestibility

Nutrients digestibility was different (P < 0.05) in lactating goats fed different levels of RDP diets (Table II). Higher DM digestibility was noticed in goats fed 60RDP diet than those fed 70RDP, 50RDP, 40RDP and 30RDP diets. Goats fed 60RDP diet had 9.88% more dry matter digestibility than those fed 30RDP diet. However, non-significant difference (P > 0.05) in DM digestibility was observed in goats fed 50RDP and 40RDP diet. Crude protein digestibility in goats, fed 70RDP diet had 7.92, 9.57 and 12.47% more CP digestibility than those fed 50RDP, 40RDP and 30RDP diet, respectively. While, goats fed 70RDP and 60RDP diets remain unchanged. On the other hand, neutral detergent fiber digestibility was highest in goat fed 70RDP diet. Goats fed 70RDP diet had 16.16% more NDF digestibility than those fed 30RDP diet. NDF digestibility did not differ (P>0.05) in goats fed diet 70RDP and 60RDP. Similar trend was also observed in goats fed diet 60RDP and 50RDP. In case of acid detergent fiber, higher ADF digestibility was observed in goats fed 50RDP diet than those fed 40RDP and 30RDP diets. Goats fed 50RDP diet had 11.17% more ADF intake than those fed 30RDP. Interestingly, there was no difference (P>0.05) in ADF digestibility among 70RDP, 60RDP and 50RDP diets fed to the lactating goats.

Nitrogen balance

Nitrogen balance was different in goats fed diets containing different (P < 0.05) levels of RDP (Table III). Higher nitrogen intake was noticed in goats fed 70RDP diet than those fed 60RDP, 50RDP, 40RDP and 30RDP diets. Goats fed 70RDP diet had 20.41% more nitrogen intake than those fed 30RDP diet. Goats fed 30RDP diet showed higher losses of fecal nitrogen than those fed 70RDP, 60RDP, 50RDP and 40RDP diets. Goats fed 30RDP diet had 25.92% more fecal nitrogen losses than those fed 70RDP diet. Notably, non-significant difference (P > 0.05) in fecal nitrogen was observed in goats fed 70RDP and 60RDP and similar trend was also observed in 50RDP and 40RDP diets. Higher urinary nitrogen was noticed in goats fed 30RDP than those fed 70RDP, 60RDP, 50RDP and 40RDP diet. Goats fed 30RDP diet had 46.93% more urinary nitrogen than those fed 70RDP. However, there was no difference (P > 0.05) in urinary nitrogen observed in goats fed 70RDP and 50RDP. Similar trend was also observed in 60RDP and 40RDP diets. Higher milk nitrogen was noticed in goats fed 70RDP than those fed 60RDP, 50RDP, 40RDP and 30RDP diets. Goats fed 70RDP diet had 71.43% more milk nitrogen than those fed

30RDP. Furthermore, regarding Nitrogen balance, higher N retention was noticed in goats fed 70RDP diet than those fed 50RDP, 40RDP and 30RDP diets. Goats fed 70RDP diet had 33.02% more nitrogen retention than those fed 30RDP diet. Interestingly, non-significant ($P > 0.05$) Nitrogen retention had observed in goats fed 70RDP and 60RDP diets as well as 50RDP and 40RDP diets.

Blood urea nitrogen

Blood urea nitrogen was different ($P < 0.05$) in goats fed diets having different levels of RDP (Table IV). At 3 h of post feeding, higher BUN level was noticed in goats fed 70% RDP than those fed 60RDP, 50RDP, 40RDP and 30RDP. Goats fed 70RDP diet had 19.14, 17.46, 24.59 and 17.56% more BUN level than those fed 60RDP, 50RDP, 40RDP and 30RDP. Likewise, non-significant differences ($P>0.05$) had noticed in 3 h of post feeding in goats fed 50RDP and 60RDP diets. At 6 h of post feeding, higher BUN level was observed in goats fed 70RDP than those fed 60RDP, 50RDP, 40RDP and 30RDP. Goats fed 70RDP diet had 15.91% more BUN level than goats fed 30RDP. At 9 h of post feeding, higher BUN level was observed in goats fed 70RDP than those fed 60RDP, 40RDP and 30RDP. Goat fed 70RDP diet had 14.32% more BUN level than those fed 30RDP. However, there was no significant difference ($P > 0.05$) in BUN at 9 h of post feeding in goat fed 70RDP and 50RDP diet. At 12 h of post feeding, higher BUN level was noticed in goats fed 70RDP than those fed 60RDP, 50RDP, 40RDP and 30RDP. Goat fed 70RDP diet had 14.21% more BUN level than goats fed 30RDP. However, non-significant ($P > 0.05$) BUN at 12 h of post feeding had noticed in goat fed 50RDP and 40RDP diet.

Milk yield

Significant milk yield (kg) ($P < 0.05$) was observed in goats fed diets containing different levels of RDP (Table IV). Milk yield in goat fed 70RDP was 2.51 kg/day, and 0.762 kg/day milk production was observed in goats fed 30RDP. Goats fed 70RDP diet had shown higher milk yield/day than those fed 60RDP, 50RDP, 40RDP and 30RDP. Goats fed 70RDP diet had 11.16, 28.69, 57.17 and 69.64% more milk yield/day than those fed 60RDP, 50RDP, 40RDP and 30RDP diet.

Table III.- Effect of different dietary rumen degradable protein concentrations on nitrogen balance in Beetal goat.

Item	Diets[1]					
	30%RDP	40%RDP	50%RDP	60%RDP	70%RDP	SE
Nitrogen intake, g/d	0.0390^{e}	0.0400^{d}	0.0410^{c}	0.0480^{b}	0.0490^{a}	0.00097
Faecal nitrogen, g/d	$.0108^{a}$	$.0100^{b}$	$.0100^{b}$	$.0085^{c}$	$.0080^{c}$	0.00018
Urinary nitrogen, g/d	$.0098^{a}$	$.0074^{b}$	$.0042^{c}$	$.0065^{b}$	$.0052^{c}$	0.00040
Milk nitrogen, g/d	0.0040^{e}	0.006^{d}	0.0100^{c}	$.0120^{b}$	0.014^{a}	0.00085
Nitrogen balance, g/d	$.0142^{c}$	$.0162^{b}$	$.0175^{b}$	$.0200^{a}$	$.0212^{a}$	0.00054

Note: Means in the same rows with different superscript letters were significantly different ($P<0.05$). 130% RDP, 40% RDP, 50% RDP, 60% RDP and 70% RDP diets represent 30, 40, 50, 60 and 70% rumen degradable protein of dietary protein, respectively.

Table IV.- Effect of feeding different dietary rumen degradable protein concentrations on blood urea nitrogen and milk yield in Beetal goat.

Item (g/d)	Diets[1]					
	30%RDP	40%RDP	50%RDP	60%RDP	70%RDP	SE
BUN 3hr	23.47^{b}	21.47^{a}	23.50^{b}	23.02^{c}	28.47^{a}	± 0.54
BUN 6hr	24.03^{b}	20.03^{e}	21.47^{c}	21.03^{d}	25.01^{a}	± 0.43
BUN 9hr	21.47^{b}	19.12^{d}	23.02^{a}	19.75^{c}	23.05^{a}	± 0.37
BUN 12hr	19.75^{d}	21.47^{c}	21.37^{c}	22.12^{b}	23.02^{a}	± 0.25
Milk yield (Kg/day)	0.762^{e}	1.075^{d}	1.79^{c}	2.23^{b}	2.51^{a}	± 0.153

Means in the same rows with different superscript letters were significantly different ($P<0.05$). [1]30% RDP, 40% RDP, 50% RDP, 60% RDP and 70% RDP diets represent 30, 40, 50, 60 and 70% rumen degradable protein of dietary protein, respectively.

DISCUSSION

Previous studies demonstrated that rumen degradable part of dietary protein is of vital significance for ruminal microbial activity and proliferation which can alter the nutrient digestion along with nutrient intake so that might be attributed to the adequate RDP supply of those diets (Thornton and Ferreira, 2000; Nolte *et al*, 2003: Kalscheur *et al*., 2006; Nisa *et al*., 2008; Javaid *et al*., 2008). This might have optimized rumen microbial proliferation by ensuring the optimal ruminal ammonia nitrogen. Optimum rumen ammonia nitrogen has also been reported to increase feed intake in ruminant animals (Westwood *et al.,* 2000; Chumpawadee *et al*., 2006). Increased nutrient digestibility might be attributed to increased ruminal microbial activity in ruminants with increased in level of RDP (Perdock *et al.,* 1988). Similar findings have been noticed by other researchers (Keery and Amous, 1993; Lallo *et al*., 1996: Chaturvedi and Walli, 2000; Griswold *et al.,* 2003; Fu *et al*., 2005). This not only increased rumen ammonia concentration but also facilitated the proliferation of ruminal bacterial population. However, unaltered nutrient digestibility by increasing level of RDP had been reported by other workers (Mishra and Rai, 1996; Castillo *et at.,* 2001; Paengkoum *et al.,* 2004). The probable explanation of unaltered nutrient digestibility with increased RDP level might be endorsed to several RDP sources and slight range of RDP concentration. Our data showed that nitrogen intake increased linearly as the level of RDP contents increased in diets due to DMI of diet increased with increasing level of RDP. Gradually increased nitrogen intake with increasing level of RDP might be attributed to adequate supply of RDP contents for ruminal microbes, and it leads towards more production of microbial protein and ultimately increase N intake. These findings are in agreement with previous studies (Valkeners *et al.,* 2007; Javaid *et al*., 2008; Nisa *et al*., 2008). However, increased tendency of fecal and urinary N losses had noticed as the level of RDP contents reduced in diets (Pattanaik *et al*., 2003; Peangkoum *et al*., 2004). Furthermore, positive N-balance was noticed among all the diets but significantly higher positive nitrogen balance had observed in goats fed 60% RDP diet due to better provision of RDP as reported in some other studies (Mishra and Rai, 1996: Wright *et al*., 1998; Javaid *et al*., 2008; Nisa *et al*., 2008).Our data showed that increasing trend was noticed in BUN concentration as the level of RDP contents increased in the diets. Chumpawadee *et al*. (2006) reported that an increase in ruminal NH3-N concentrations increased BUN concentration by supplying more quality of amino acids that might be used as energy and ammonia from deamination of these amino acids lead to higher BUN. Increased plasma urea nitrogen with increased dietary RDP level has also been reported by Roseler *et al*. (1993). However, non-significant results were also reported by Rivas and Serrato-Corona (2005).Interestingly, an increase in milk yield was noticed with increase in the level of RDP contents in diets. The possible reason might be attributed with the provision of carbohydrates that were not limiting, bacterial N and bacterial efficiency continued to increase as RDP increased in the diets lending support to the theory that greater RDP will support greater microbial protein synthesis and consequently, greater milk production (Mishra and Rai, 1996; Kalscheur *et al*., 2006; Tufarelli *et al*., 2008). The lower milk production was related to inadequate amino acid profile reaching the small intestine (Liamadis and Milis, 2006). Laudadi and Tufarelli (2010) reported that a decrease of rumen degradable protein (RDP) level does not negatively influence milk production. Fascinatingly, Triplett *et al*. (1995) reported that milk production in mature cows was not influenced by diet. Nevertheless, further studies needed to investigate BUN toxicity with increase in RDP level in diet.

CONCLUSION

In conclusion, findings of the present study imply that Beetal goats fed 70RDP increased nutrient intake and digestibility in goats and proved to be the best as compared to 60RDP, 50RDP, 40RDP and 30RDP diets.

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Statement of conflict of interest

Authors have declares that there is no conflict.

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