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Full Length Article

Effect of Varying Levels of Dietary Ruminal Undegradable Protein on Feed Consumption and Growth Performance of Growing Kajli Lambs

Muhammad Akhtar[1], M. Ali[1], Z. Hayat[2], M. Yaqoob[1] and M. Sarwar[1*]
[1]*Institute of Animal Sciences, University of Agriculture, Faisalabad-38040, Pakistan*
[2]*Department of Animal Sciences, University College of Agriculture, University of Sargodha, Pakistan*
[*]For correspondence to: drms01@gmail.com

Abstract

The present experiment was conducted to evaluate the effect of different levels of ruminal undegradable protein (RUP) on feed consumption, digestibility and growth performance of growing *Kajli* lambs. In this 70 days trial, 36 growing *Kajli* male lambs (average weight of 20±2 kg) were used. Lambs were randomly divided into 4 groups (9 lambs per group). Four *iso-caloric* and *iso-nitrogenous* diets but varying in RUP were formulated. The control diet had 25% bypass protein and was termed as RUP25 diet. The RUP35, RUP45 and RUP55 diets contained 35, 45 and 55% RUP, respectively. The dry matter (DM), CP, neutral detergent fiber (NDF) and acid detergent fiber (ADF) intakes were higher ($P< 0.05$) in lambs fed RUP55 diet than those fed RUP45 diet, however, remained unchanged ($P>0.05$) in animals fed RUP35 and RUP25 diets. The DM and CP digestibility by lambs fed RUP25 (63.61 and 76.03%) and RUP35 (63.96 and 78.30%) diets were higher ($P<0.05$) than those fed RUP45 (60.11 and 73.60%) and RUP55 (59.80 and 72.80%) diets. However, NDF and ADF digestibility remained unaltered ($P>0.05$) across all treatments. The nitrogen balance in lambs fed RUP55 diet was 8.05 gram (g) and was higher ($P<0.05$) than those fed RUP45 (5.14 g) diet but it remained unchanged ($P>0.05$) in animals fed RUP35 (3.58 g) and RUP25 (3.63 g) diets. The blood urea nitrogen (BUN) and creatinine were higher ($P<0.05$) in lambs fed RUP25 and RUP35 diets than those fed RUP45 and RUP55 diets. The daily live weight gain was 170, 201, 222 and 245 g in lambs fed RUP25, RUP35, RUP45 and RUP55 diets, respectively. The feed conversion ratios in lambs fed RUP25, RUP35, RUP45 and RUP55 diets were 4.94, 4.22, 4.05 and 4.08, respectively. The best feed conversion values ($P<0.05$) were noticed in lambs fed RUP45 and RUP55 diets compared to those fed RUP25 and RUP35 diets. In conclusion, increasing dietary RUP concentration not only increased *Kajli* lamb's growth but it also improved feed efficiency.

Keywords: Ruminal undegradable protein; Growing kajli lambs; Feed consumption; Digestibility; Nitrogen balance; Growth performance

Introduction

In South Asian region, the growth performance of post weaned lambs is low which renders sheep husbandry business less cost effective. The lamb and mutton meat demand is increasing because of ever increasing human population and their improved socio-economic conditions in this region. There are many ways and means (Nasir *et al.*, 2010) to meet this ever increasing mutton demand but one of the most promising is to improve growth performance of sheep weaners through nutritional manipulation. The dietary protein is one of the most limiting nutrients in small ruminant, grazing poor quality pastures which are often low in protein concentration. Thus, dietary protein supplementation can help achieve their optimum production. A positive relationship exists between dietary ruminal degradable protein (RDP) level and forage utilization (Bohnert *et al.*, 2002). Decreasing dietary RDP supplementation frequency to ruminants consuming low quality forages not only lowered feed consumption and digestibility (Ludden *et al.*, 2002a) but also reduced nutrient's net flux (Krehbiel *et al.*, 1998) and animal performance (Bohnert *et al.*, 2002; Ludden *et al.*, 2002b). However, enhanced RDP consumption may result into excessive ruminal NH_3 production, exceeding the immediate ruminal microbial population demand. This excessive ruminal ammonia gets absorbed into blood and undergoes urea genesis in the liver. This urea synthesis is not only energy consuming process but it also minimizes the propensity for nitrogen (N) recycling, resulting into ruminant's poor performance.

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The ruminal undegradable protein (RUP) is dietary protein's fraction which bypasses ruminal degradation and is digested in the small intestine. Since this RUP is not ruminally degraded and its dietary addition can increase amino acids (AAs) flow to duodenum. However, intestinal absorption of these AAs is dependent on their post-ruminal digestibility which differs among varying protein sources. Stern *et al*. (1997) evaluated various animal feed products and reported that intestinal absorption of RUP sources ranged from 22 to 67%. Santos *et al*. (1998) reported that while RUP supplementation increased the flow of essential AAs to the small intestine, the flow of the first limiting AA did not consistently increase. Therefore, both source and its protein quality need to be considered, while evaluating results from trials involving RUP supplementation. This approach may explain RUP's inconsistent effects on ruminant's productive performance. Thus, partially replacing dietary RDP with supplemented RUP may spare energy used to excrete urea, enhancing N usage efficiency and animal growth. However, scientific evidence about the dietary RUP requirement of growing lambs is very limited. Therefore, the present study was planned to examine the influence of varying levels of dietary RUP on feed intake (FI), nutrient digestibility, N balance, blood chemistry and daily body weight gain (BWG) of growing *Kajli* lambs.

Materials and Methods

In this trial, 36 growing *Kajli* male lambs with an average weight of 20±2 kg were used. The lambs were randomly divided into 4 groups (9 lambs per group). Four *iso-caloric* and *iso-nitrogenous* diets were formulated. The RUP25, RUP35, RUP45 and RUP55 diets contained 25, 35, 45 and 55% RUP, respectively (Table 1). The lambs were randomly allotted to these 4 diets and were fed twice daily *ad-libitum.* The animals were given first10 days as an adaptation period followed by 60 days as a collection period. The feed offered and orts were recorded daily to calculate FI. The lambs were weighed weekly. The dry matter (DM), crude protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF) intakes were calculated. The lambs were placed into metabolic cages to determine digestibility by total collection method. The urine after collection in plastic bowls was acidified with 50% H_2SO_4 to prevent N losses (Nisa *et al*., 2004). The weight of feces and urine from each individual animal was recorded daily and composited by animal and were frozen. After collection period, samples were thawed, dried at 55ºC and ground to pass through 1 mm sieve. The trial lasted for 70 days.

Chemical Analysis

The NDF and ADF content of feed and fecal samples were determined as described by Van Soest *et al*. (1991) and DM and N content were determined (AOAC, 2000). The N balance was calculated by equation described in NRC (2001). The blood samples from jugular vein were collected 6 h post prandial. The 2 mL blood from each animal was collected into the vaccutainers containing anticoagulant solution and 8 mL in test tube to harvest serum. Blood samples were analyzed for blood glucose and blood urea N (BUN) according to methods described by Bull *et al*. (1991) and blood creatinine was determined according to methods described by Davies *et al*. (2007).

Statistical Analysis

Data regarding various parameters were analysed using PROC GLM procedure of SAS 9.2 (SAS, 2009) and treatment means were compared by Duncan Multiple Range Test (Duncan, 1955).

Results

The DM, CP, NDF and ADF intakes were higher ($P< 0.05$) in lambs fed RUP55 diet than those fed RUP45 diet and remained unchanged ($P>0.05$) in animals fed RUP35 and RUP25 diets (Table 2). The DM and CP digestibility were higher ($P<0.05$) in lambs fed RUP25 (63.61 and 76.03%) and RUP35 (63.96 and 78.30%) diets than those fed RUP45 (60.11 and 73.60%) and RUP55 (59.80 and 72.80%) diets. However, NDF and ADF digestibility remained unaltered ($P>0.05$) across all treatments (Table 2). The N balance was higher ($P<0.05$) in lambs fed RUP55 (8.05 g) diet than those fed RUP45 (5.14 g) diet but remained unchanged ($P>0.05$) in animals fed RUP35 (3.58 g) and RUP25 (3.63 g) diets (Table 3). The BUN and creatinine were higher ($P<0.05$) in lambs fed RUP25 and RUP35 diets than those fed RUP45 and RUP55 diets (Table 4). However, blood glucose and blood pH remained unaltered ($P>0.05$) across all treatments. Similarly blood chemistry parameters (Table 5) remained unchanged ($P>0.05$). The daily BWG was 170, 201, 222 and 245 g in lambs fed RUP25, RUP35, RUP45 and RUP55 diets, respectively (Table 6). The feed conversion ratio (FCR) in lambs fed RUP25, RUP35, RUP45 and RUP55 diets was 4.94, 4.22, 4.05 and 4.08, respectively. The best FCR ($P<0.05$) was observed in lambs fed RUP45 and RUP55 diets compared to those fed RUP25 and RUP35 diets. In conclusion, increasing dietary RUP concentration increased the growth performance of *Kajli* lambs and improved their feed efficiency.

Discussion

The DM intake (DMI) by *Kajli* lambs increased linearly with increasing dietary RUP concentration and this increased DMI might be due to better essential AAs balance of RUP diets than those of RDP. Kumar *et al*. (2005) reported increased DMI by animals fed diets containing increasing dietary RUP from 41 to 48% of dietary CP.

Table 1: Ingredients and chemical composition of experimental diets having different level of rumen undegradable protein (RUP) used for Kajli lambs

Ingredients (%)	Diets[1] RUP25	RUP35	RUP45	RUP55
Barseem fodder	15.00	15.00	15.00	15.00
Oat fodder	15.00	15.00	15.00	15.00
Maize Broken	13.50	13.00	14.00	3.00
Wheat Straw	1.00	5.00	14.00	28.00
Wheat bran	30.00	14.00	0.50	0.50
Maize gluten Meal 30%	1.00	1.00	2.50	0.50
Maize gluten Meal 60%	0.00	1.00	3.00	0.50
Canola meal	3.00	6.00	1.00	0.50
Soybean Meal	1.00	6.00	9.00	14.00
AmiPro	0.00	6.00	9.00	14.00
Vegetable Oil	1.00	0.00	0.00	0.00
Cane Molasses	15.00	15.00	15.00	8.00
Mineral Mix[2]	1.00	1.00	0.75	0.50
DCP pliner	1.00	1.00	0.75	0.50
Urea	2.50	1.00	0.50	0.00
Chemical composition (%)				
Dry matter	66.05	65.92	66.13	67.42
Crude protein	18.06	18.04	18.01	18.04
RUP	25.45	35.20	45.00	55.10
RUP % of crude protein	4.75	6.53	8.21	10.14
RDP % of crude protein	13.91	12.02	10.03	8.27
Neutral detergent fiber	22.22	22.02	23.93	33.71
Acid detergent fiber	11.10	13.00	15.59	23.14
Acid detergent lignin	2.40	2.99	3.31	4.74
Ash	9.07	9.29	8.87	8.11
Metabolizable energy (Mcal/kg)	2.18	2.20	2.19	2.17

[1]RUP25, RUP35, RUP45 and RUP55 contain 25, 35, 45 and 55% rumen undegradable protein, respectively
[2]Mineral mixture contains 22, 9.0, 0.2, 0.02, 0.6, 0.5. 0.02, 0.20 and 0.02% Ca, P, Mn, I, Fe, Cu, Co, Zn and Se, respectively

Table 2: Nutrient intake and digestibility in growing Kajli lambs fed different dietary rumen undegradable protein (RUP) levels

Parameter	Diets[1] RUP25	RUP35	RUP45	RUP55	SEM[2]	Significance
Nutrient Intake, (g/d)						
Dry matter	840[c]	850[c]	900[b]	1000[a]	36.60	*
Crude protein	156.74[c]	157.76[c]	164.16[b]	184.10[a]	6.35	*
Neutral detergent fiber	186.65[c]	187.17[c]	215.37[b]	337.1[a]	35.81	*
Acid detergent fiber	92.40[d]	110.5[c]	140.31[b]	231.4[a]	30.87	*
Digestibility, %						
Dry matter	63.61[a]	63.96[a]	60.11[b]	59.80[b]	1.11	*
Crude protein	76.03[a]	78.30[a]	73.60[b]	72.80[b]	1.25	*
Neutral detergent fiber	64.56	65.03	61.75	61.00	1.00	NS
Acid detergent fiber	49.72	51.24	52.50	51.22	0.57	NS

[1]RUP25, RUP35, RUP45 and RUP55 contain 25, 35, 45 and 55% rumen undegradable protein, respectively
[2]Standard error mean. NS stand for non-significant (P>0.05) and * stand for significant (P<0.05)
[a,b,c,d]Means in a row with different superscripts differ significantly (P<0.05)

Similarly, Haddad *et al*. (2005) reported increased DMI by Awassi ewes fed increasing dietary RUP levels (18, 27 and 34% dietary RUP of dietary CP). Kridli *et al*. (2001) also reported increased DMI by Awassi ewes fed diet containing 35% RUP than those fed diet containing 20% RUP. Paengkoum *et al*. (2004) examined the effect of different levels of RUP (0, 2, 4 and 6% of CP) in goats and reported linear increase in DMI (729, 791, 818 and 829 g/d) with increased dietary RUP level.

In our study, the higher nutrients digestibility in lambs fed RUP25 and RUP35 diets supported findings of Matras *et al*. (2000) who reported increased nutrients digestibility by animals fed diets containing high RDP. However, Christensen *et al*. (1993) reported no difference (P>0.05) in protein digestibility in animals fed diets containing low (55%) and high degradable (70%) protein. Similarly, Tiwari *et al*. (2000) also reported unaltered protein digestibility by calves fed diets containing varying RUP and RDP concentrations. Similarly, Atkinson *et al*. (2007) noticed no effect on DM and organic matter digestibility because of increasing dietary RUP. Unless optimal ratio between RUP and RDP is ensured, the optimal rumen ecosystem activity cannot be obtained. In our study, decreasing DM, CP, NDF and ADF digestibilities trend was noticed with increasing

Table 3: Nitrogen intake, fecal nitrogen, urinary nitrogen and nitrogen balance in growing Kajli lambs fed different dietary rumen undegradable protein (RUP) levels

Parameter	Diets[1]				SEM[2]	
(g)	RUP25	RUP35	RUP45	RUP55		Significance
Nitrogen intake	25.07[b]	25.24[b]	26.27[b]	29.45[a]	1.02	*
Fecal nitrogen	6.15[c]	5.55[c]	7.01[b]	8.19[a]	0.57	*
Urinary nitrogen	15.29[a]	16.11[a]	14.12[ab]	13.21[b]	0.64	*
Nitrogen balance	3.63[c]	3.58[c]	5.14[b]	8.05[a]	1.05	*

[1]RUP25, RUP35, RUP45 and RUP55 contain 25, 35, 45 and 55% rumen undegradable protein, respectively
[2]SEM stand for Standard error mean. * stand for significant (P<0.05)
[a,b,c]Means in a row with different superscripts differ significantly (P<0.05)

Table 4: Blood urea nitrogen, blood glucose and blood creatinine in Kajli lambs fed different dietary rumen undegradable protein (RUP) levels

Parameter	Diets[1]				SEM[2]	
(mg/dL)	RUP25	RUP35	RUP45	RUP55		Significance
Blood pH	7.79	7.81	7.80	7.81	0.01	NS
Blood Urea Nitrogen	19.74[a]	18.92[a]	16.14[b]	16.12[b]	0.94	*
Blood glucose	73.09	73.60	72.85	73.57	0.18	NS
Creatinine	2.72[a]	2.69[a]	1.78[b]	1.67[b]	0.28	*

[1]RUP25, RUP35, RUP45 and RUP55 contain 25, 35, 45 and 55% rumen undegradable protein, respectively
[2]Standard error mean. NS stand for non-significant (P>0.05) and * stand for significant (P<0.05)
[a,b]Means in a row with different superscripts differ significantly (P<0.05)

Table 5: Blood chemistry in growing Kajli lambs fed different dietary rumen undegradable protein (RUP) levels

Parameters	Diets[1]				SEM[2]	
(%)	RUP25	RUP35	RUP45	RUP55		Significance
Haemoglobin (g/dL)	13.62	13.93	13.97	13.81	0.08	NS
Neutrophils	44.41	44.18	44.48	44.49	0.07	NS
Lymphocytes	45.43	46.83	44.97	45.89	0.40	NS
Monocytes	3.36	3.12	3.39	3.36	0.06	NS
Eosinophils	5.33	5.60	5.85	5.88	0.13	NS
Basophils	1.47	1.37	1.31	1.39	0.03	NS
Platelets (k/µL)	571.76	578.19	574.38	578.44	1.61	NS

[1]RUP25, RUP35, RUP45 and RUP55 contain 25, 35, 45 and 55% rumen undegradable protein, respectively
[2]Standard error mean. NS stand for non-significant (P>0.05)

Table 6: Growth performance of growing Kajli lambs fed different dietary rumen undegradable protein (RUP) levels

Parameters	Diets[1]				SEM[2]	
	RUP25	RUP35	RUP45	RUP55		Significance
Dry matter intake (g/d)	840[c]	850[c]	900[b]	1000[a]	36.60	*
Daily weight gain (g/d)	170[d]	201[c]	222[b]	245[a]	15.94	*
Feed conversion ratio	4.94[c]	4.22[b]	4.05[a]	4.08[a]	0.21	*

[1]RUP25, RUP35, RUP45 and RUP55 contain 25, 35, 45 and 55% rumen undegradable protein, respectively
[2]SEM stand for Standard error mean. * stands for Significant (P<0.05)
[a,b,c]means in a row with different superscripts differ significantly (P<0.05)

dietary RUP beyond 35% which is concordant to findings of Hussein *et al*. (1991) who reported reduced fiber digestion by ruminants fed diets containing higher RUP. This reduced nutrients digestibility by animals fed high dietary RUP might have impacted ruminal fermentation because of limited ruminal ammonia concentration.

Findings of the current study indicated that higher dietary RUP resulted in decreased N excretion and were concordant with findings of other workers (Pattanaik *et al*., 2003; Paengkoum *et al*., 2004) who reported an increase in N balance and reduction in N excretion when high dietary RUP was fed to ruminants. In the present study, RUP55 diet excreted less urinary N (P<0.05) than RUP25, RUP35 and RUP45 diets. The fecal N excretion increased with increasing dietary RUP indicating that excessive RUP could result in decreased protein digestibility. The N retention was highest in animals fed diets containing highest RUP concentration. The N retention increased with increasing dietary RUP. The excessive RUP can impact ruminal fermentation adversely which resultantly decreased microbial yield and reduced OM and fiber digestion. Santos *et al*. (1984) reported 40% higher ruminal NH_3-N in animals fed diet containing high RDP and similar results were reported by Keery *et al*. (1993). The ruminal bacteria use

NH_3 generated as product of protein degradation, in the presence of adequate amounts of soluble carbohydrates, to synthesize AA necessary for MP synthesis but excess ruminal ammonia gets absorbed in the blood which resultantly increases BUN. Thus, higher the dietary RUP, lesser it will ruminally be degraded, resulting into both reduced blood NH_3 and BUN concentration. In current study, BUN concentration was the highest in lambs fed RUP25 diet. This RUP25 diet had the highest amount of RDP that might have produced excessive ruminal ammonia (Ali *et al.*, 2009), which after absorption into blood was converted into urea and excreted in the urine. The BUN has been used as an indicator of both dietary protein and dietary degradable protein overfeeding. The lower BUN levels noticed in lambs fed RUP55 diet might have had less physiological wasting of ammonia N as urea. The urea can be recycled into the rumen and becomes again available for conversion into microbial protein. Diets having an increased RUP concentration resulted in improved N balance and decreased N excretion relative to intake (Pattanaik *et al*., 2003; Reynal and Broderick, 2005). An appropriate balance between ruminally degradable and undergradable protein fractions can assure sufficient amount of required AAs balance for intestinal absorption to match animal's requirement.

Results of this study showed that the daily BWG and FCR improved with increasing dietary RUP concentration. The increasing dietary RUP levels increased body tissue deposition through increasing average daily gain (ADG). Chalupa (1975) also suggested that RUP was important to improve ADG when protein from microbial supply was insufficient to meet AA requirement for maintenance and rapid growth of growing ruminants. The increased ADG of lambs fed increased dietary RUP in current study suggests that microbial protein supply from RUP25 and RUP35 diets was insufficient to meet AAs requirement of rapidly growing lambs. However, Can *et al*. (2004) reported that feed efficiency remained unaffected in Awassi lambs fed diets containing high RUP concentration. Tufarelli *et al*. (2009) also reported no effect of different ratios of RDP and RUP on the BWG of Comissana ewe lambs.

Diets containing improper proportion of RDP and RUP not only affect animal's productive performance but also aggravate some metabolic changes which ultimately deteriorate animal health (NRC, 2007). The increasing dietary RUP has been practiced to balance protein requirement instead of increasing dietary protein content (Eastridge, 2006). The precision or accuracy of RUP prediction in ruminant's diet to get optimum production performance may depend upon RUP concentration variation and the basic knowledge about the ruminal protein degradation (Pacheco *et al*., 2012).

Conclusion

The increased dietary RUP concentration not only improved DMI but also improved ADG and feed efficiency of *Kajli* lambs. The high N balance and less urinary N in lambs fed high RUP diets indicate high protein bioavailability. The results of present study may help small ruminant farming community get optimum growth performance from lambs by feeding high dietary RUP concentration.

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