Effect of Protein Levels and Degradability in the Ration on Awassi Lambs Performance 1-Productive Parameters*

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ABSTRACT: Forty eight individually fed Awassi male lambs weighing 26.5 kg ± 1.1 and 5 months of old were used to investigate their responses to feeding concentrate diets containing three levels of dietary crude protein (CP, 11.5, 13.5 and 15.5%). Each level was formulated with high and low rumen degradable N (RDN) to undegradable dietary N (UDN) ratios. Concentrates were offered once a day at rate of 3% of live body weight with free choice of barley straw. Results revealed that neither straw nutrient intakes, nor the total intake were significantly affected by increasing levels of dietary CP or RDN: UDN ratios, However, total nitrogen (N) intake was increased significantly ($P<0.01$). Better intakes of digestible dry matter (DDM) and organic matter (OM) were achieved ($P<0.05$) by lambs fed the medium level of dietary CP. Body weight gain was not significantly affected by RDN:UDN ratio, However, lambs fed medium and high levels gained higher ($P<0.05$) than those fed the low level of dietary CP. Feed conversion ratio (FCR) based on DM and OM intakes was not significantly affected by level of dietary CP or RDN:UDN ratio, Even though, less amount of N required per unit of gain was achieved with low and medium as compared to high levels. Higher DM, nitrogen free extract (NFE) and hemicelluloses ($P<0.05$), OM, CP, crude fiber (CF) and cellulose ($P<0.01$) digestibility's were achieved by lambs fed the medium level of CP, whereas, no significant effect was observed on ether extract (EE), neutral detergent fiber (NDF) and acid detergent fiber (ADF) digestibility's. Lambs fed diets formulated with low RDN: UDN ratio digested its dietary nutrients at higher rate than those fed diets formulated with the high ratio .In conclusion, effect of interaction between levels of dietary CP and RDN: UDN ratio revealed that productive parameters of lambs fed diets containing medium level of CP and formulated with low RDN: UDN ratio was somewhat tended be better.
Keywords: Protein, degradability, digestibility, growth, sheep.

INTRODUCTION

Today, the characterization of feeds according to their chemical composition, and the constitution of their different fractions, is one of the principal objectives of nutritionists when balancing diets that provide nutrients for the growth and development of the microorganisms in the rumen and, consequently, of the animal (Muniz, et. al., 2008).There is a real gap between the dietary requirements of ruminants and their available feeds. Protein is one of the limiting nutrients in the diet of ruminant animals (Sarwar et al., 2002). Ali, et. al., (2009) reported that CP requirements are twofold; to support the anaerobic condition in the rumen and to meet the animal needs. However, because of ruminal anaerobic fermentation, a portion of dietary CP is degraded in the rumen and the rest escape from ruminal degradation. Hassan (2009) reported that RDN should be optimized to provide N required by rumen microbes and maintain moderate rumen pH through avoiding accumulation of ruminal ammonia (NH_3-N), and thus, preventing N waste. Poor efficiency of converting dietary protein into body muscles results partly from the extensive degradation of protein in the rumen with high rates of ammonia absorption and significant excretion of N in the urine (Oba et al., 2004; Sarwar et al., 2004). Feeding too much high protein diets became undesirable due to quick ruminal degradation associated with wasteful consequences. The alternate is to include little above the exact required quantity, taking in account the degradability rate in rumen. The objective of this study is to investigate the effect of three levels of dietary crude protein, each level was formulated with high and low rumen degradable N (RDN) to undegradable dietary N (UDN) ratios on productive parameters of Awassi lambs.

MATERIAL and METHODS

Forty eight Awassi male lambs weighing 26.5 kg ± 1.1 and 5 months of age were used to study responses to feeding three levels of dietary CP (11.5, 13.5 and 15.5%), and two RDN:UDN ratios within each level high (70:30), achieved by incorporating intact soybean meal (SBM), and low (60:40) achieved by substituting the SBM with formaldehyde-treated SBM (FTSBM). Concentrate diets were formulated including all these variables, and were offered to lambs once daily at rate of 3% of live body weight in addition to free choice of barley straw. FTSBM was prepared by spraying 4% formaldehyde (HCHO) solution into the meal at a rate of 10 ml /100 g SBM DM, (Hassan, et. al., 1990). The treated SBM was then mixed well and packed into tightly closed polyethylene bags and left at room temperature (25C°) for 3 days and were shaken occasionally, then all bags were opened and the treated SBM was exposed to air. Formulation and chemical composition of concentrate diets and chemical analysis of the ingredients are presented in Tables 1and 2 respectively.

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Table 1. Chemical composition of concentrate ingredients and barley straw and effective degradability of their CP content

Ingredients % of DM	DM %	% of DM										Effective degradability
		OM	CP	CF	EE	NFE	NDF	ADF	Cellulo	Hemicellulo	ADL	
Barley	92.31	90.32	8.40	6.24	3.20	72.48	25.22	5.78	1.02	4.76	19.44	80*
Yellow corn	91.21	92.60	8.55	3.89	4.63	75.53	13.72	6.25	1.76	4.49	7.47	60*
SBM	90.78	91.23	43.09	5.31	2.65	40.18	45.46	10.85	2.13	8.72	34.61	70**
FTSBM	90.78	91.23	43.09	5.31	2.65	40.18	45.46	10.85	2.13	8.72	34.61	30**
Wheat bran	90.15	92.00	13.82	9.60	4.96	63.62	50.50	13.23	3.01	10.22	37.27	67***
Barley straw	95.72	90.19	2.43	40.17	2.09	45.50	72.94	51.96	38.93	20.98	13.60	-

*(Humady, 1988) ** (Abdullah, 1988) *** (Paya, et al., 2008)

Table 2. The formulation and chemical composition of experimental concentrate diets (%)

Level of CP %	11.50		13.50		15.50	
RDN:UDN ratio	70:30	60:40	70:30	60:40	70:30	60:40
Treatments no.	1	2	3	4	5	6
Ingredients %						
Barley	40	40	40	40	40	40
Wheat bran	35	35	35	35	35	35
Yellow corn	18	18	13	13	8	8
SBM	5	0	10	0	15	0
FTSBM	0	5	0	10	0	15
Mineral and vitamin mixture	2	2	2	2	2	2
Chemical composition %						
DM	93.7	93.9	93.8	93.7	94.1	93.9
OM	93.4	94.0	93.9	93.2	93.6	93.9
CP	11.3	11.4	13.3	13.2	15.3	15.2
CF	7.0	6.6	7.0	7.1	6.8	6.7
EE	2.8	2.4	3.0	2.0	3.1	2.5
NFE	72.2	73.4	70.6	70.8	68.2	69.3
NDF	36.0	37.1	34.4	41.4	35.2	39.7
ADF	8.5	7.6	7.3	8.3	8.3	9.5
Cellulose	6.3	5.5	15.	6.4	5.8	7.3
Hemicellulose	27.4	29.4	27.0	33.0	26.8	30.2
ADL	2.2	2.1	2.2	1.8	2.5	2.1
RDN (g/MJ of ME)	1.2	1.1	1.5	1.2	1.7	1.4
UDN	0.54	0.73	0.64	0.8	0.73	0.97
ME (MJ/kg DM)	12.1	12.1	12.1	11.9	12.0	11.9

* Metabolizable energy (ME) values are estimated according to following equation: ME (MJ/kg DM) = [- 0.45 + (0.04453×% TDN)] × 4.184

TDN is estimated according to equations of Kearl (1982) as follows: TDN for energy feeds (% of DM) = 40.3227+0.5398 % CP+0.4448 % NFE+1.4218% EE–0.7007 %CF

Lambs were individually housed and weighed weekly before morning feeding to the nearest 0.5 kg. Feed intake was daily recorded and feed conversion ratio was estimated accordingly. Feeding trial was lasted for 9 weeks including preliminary period for 2 weeks.

Digestibility trail was conducted to determine the digestibility of total diets using the quantitative collection of feces for 6 days during which the quantities of diets offered and remained were accurately recorded. Feces excreted by each lambs were collected using special hand made digestion sacs and were weighed precisely and about 10% were sub sampled and stored at -20 C^{o}. At the end of the collection period, samples of diets and feces were thoroughly mixed and one sample of each was obtained and stored in deep freezing for the subsequent chemical analysis. Samples of ingredients used in the formulation of concentrate diets, the offered and refused concentrate diets and straw that sampled during feeding and digestibility trials were dried in electric oven at 100 C^{o} until constant weight, while feces were dried at 60 C^{o} (Yuangklang, et. al., 2010). Dry matter (DM), organic matter (OM), crude protein (CP), ether extract (EE) and crude fiber (CF) were determined according to AOAC (1990), where, OM was determined by burning dry samples in furnace at 550 C^{o} for 4 hrs, CP was determined by Kjeldahl method, EE was determined by extraction with hexane according to Soxhlet method, CF was determined by hot extraction HCI and NaOH subsequently, Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined by extraction with NDF, ADF and 72% H_2SO_4 solutions respectively according to the method of Goering and Van Soest (1970).

Data obtained was statistically analyzed using 3×2 factorial experiment design using completely randomized design model (CRD) procedure by (SAS, 2001). Duncan's multiple range test was used to determine the significance of differences between treatments means (Duncan, 1955). Analysis of variance was carried out on all data. The treatments were partitioned into main effects and their interactions.

RESULTS and DISCUSSION

Concentrate has been offered in quantities calculated to support maintenance and gain in addition to free choice of straw. Lambs would consume the majority, if not all, of their daily concentrate allowances, therefore, it seems more benefit to exhibit the nutrients intake values of straw in addition to the total intake values expressed as g/day.

Main effect of level of dietary protein (A) on feed intake:

Daily nutrients intake of straw and total intake values (g/day) as affected by level of dietary CP are presented in Table 3.

Table 3. Main effect of level of dietary protein on straw and total intake g/day

Items	Level of dietary protein			Significance of effects
	Low	Medium	High	n = 48
Straw dry matter intake g/d	358 ± 10.1	364 ± 4.8	366 ± 4.6	NS
Total dry matter DM intake g/d	1185± 33	1176 ± 27	1169 ± 27	NS
Total digestible DM intake g/d	783^{b} ± 37	844^{a} ± 17.6	788^{b} ± 23	*
Straw organic matter intake g/d	323 ± 9.1	328 ± 4.3	331 ± 4.2	NS
Total OM intake g/d	1098± 30.7	1089 ± 25	1083 ± 25	NS
Total digestible OM intake g/d	727^{b} ± 34.5	786^{a} ± 17	730^{b} ± 22	*
Straw nitrogen (N) intake g/d	1.35 ± 0.03	1.37± 0.01	1.38 ± 0.01	NS
Total N intake g/d	16.6^{c} ± 0.57	18.8^{b} ± 0.5	21.2^{a} ± 0.6	**
Total digestible N intake g/d	11.0^{b} ± 0.64	13.8^{a} ± 0.5	14.1^{a} ± 0.5	**
Straw NDF intake g/d	261± 7.4	266 ± 3.5	267 ± 3.4	NS
Total NDF intake g/d	572± 15.3	568 ± 12.2	577± 11	NS
Straw ADF intake g/d	186± 5.3	189 ± 2.5	190 ± 2.4	NS
Total ADF intake g/d	257± 6.7	256 ± 4.4	261 ± 3.7	NS
Straw cellulose intake g/d	140± 3.9	141± 1.8	143 ± 1.8	NS
Total cellulose intake g/d	191 ± 5.0	191 ± 3.3	196± 2.9	NS
Straw hemicellulose intake g/d	75 ±2.1	76 ± 1.0	77 ± 1.0	NS
Total Hemicellulose intake g/d	316 ± 10.1	312 ± 8.9	316 ± 8.4	NS
Total RDN intake g/d	13.4^{c} ± 0.4	14.8^{b} ± 0.4	16.4^{a} ± 0.5	**
Total UDN intake g/d	10.5^{b} ± 0.3	11.0^{b} ± 0.3	12.2^{a} ± 0.3	**
Total ME intake MJ/d	12.5 ± 0.4	12.2 ± 0.3	12.1 ± 0.3	NS
RDN:ME intake g/MJ of ME	1.06^{c} ± 0.01	1.2^{b} ± 0.01	1.34^{a} ± 0.02	**

Means in the same row with different superscripts are significantly different
* (P<0.05) ** (P<0.01) NS= Non significant.

Statistical analysis revealed that neither straw dry matter intake (DMI), organic matter intake (OMI), and other straw nutrient intakes, nor the total intake were significantly affected by level of dietary CP. This may attributed to higher intake of concentrate according to the layout of the experiment, where it was offered at 3% of body weight. Similar results were obtained by Hassan, et. al., (2010), the diets in their study were offered in quantities calculated to support maintenance and daily gain of 200 g/day as in a current study.

Lascano, et. al., (2009) reported that the use of high concentrate diets permits a reduction of the DMI needed to satisfy the nutrients requirement of the animal. As expected the consumption of total N intake was increased significantly (P<0.01) with the increasing level of dietary CP, this is because of the trend to increase (P<0.01) concentrate N intake with the increasing level of dietary CP. Similar findings were observed by Broderick, et. al., (2008). The total rumen degradable nitrogen (RDN) and undegradable dietary nitrogen (UDN) ‘intakes, were adopted similar trend as total N. Regarding the intake of digestible nutrients, Statistical analysis illustrated that better intake of digestible dry matter (DDMI) and digestible organic matter (DOM) were achieved (P<0.05) by group of lambs fed the medium level of dietary CP, This increase may attributed to the higher digestibility of DM (P<0.05) and OM (P<0.01) recorded in this group of lambs (Table 6). In a review of research on CP supplementation, Owens, et. al., (1991) reported that improved animal performance as a result of CP supplementation was mediated through either an increased DOMI and/or an enhanced efficiency of ME utilization.

Main effect of level of dietary protein on gain and feed conversion ratio (FCR) parameters:

Body weight gain and feed conversion parameters as affected by level of dietary CP are presented in Table 4. As shown, lambs fed medium and high levels of CP gained higher (P<0.05) total gain (kg) and daily gain (ADG) (g/day) than those fed the low level of dietary CP. The positive effect of level of CP in general has been reported by many researchers (Hoffman, et. al., 2001; Bohnert, et. al., 2002; Champawadee, et. al., 2006 and Ali, et. al., 2009). The additional CP consumed by group of lambs fed the medium and high levels of CP may have met amino acid deficiency that perhaps existed in the low level of CP, Rusche, et. al., (1993) reported the same attribution. FCR was not significantly affected by level of dietary CP when it was estimated according to total DM and OM intakes. Absence of significant response to increasing level of CP on FCR was observed by Gleghorn (2003) in growing and finishing beef calves and AL-Mallah (2007) in growing Awassi lambs, However, a quadratic response on ADG/DMI was reported by Huntington, et. al., (2001), The authors claimed that some factor other than CP supply, such as ME supply or coordination of carbohydrate and protein fermentation in the rumen, was affecting efficiency of CP use to support ADG. Even though, less amount of N required per unit of gain was achieved with low and medium levels as compared to high level. The priority towards low and medium levels of dietary CP may attributed to lower N intake by lambs fed these levels (16.62 and 18.81 g/day) as compared to those fed high level (21.23 g/day, Table 4).

Main effect of level of dietary protein (A) on nutrients digestibility (%):

Nutrients digestibility of diets used in the study as affected by level of dietary CP are presented in Table 5. As shown, nutrients digestibility were significantly affected by level of CP. Higher DM, NFE and hemicellulose (P<0.05), OM, CP, CF and cellulose (P<0.01) digestibilities were achieved by group of lambs fed the medium level of CP, whereas, no significant effect was observed on EE, NDF and ADF digestibilities.

The general trend for increasing nutrients digestibility due to increasing level of CP was observed by many workers (Haddad, et. al., 2001; Hristov, et. al., 2004; Chumpawadee, et. al., 2006 and Shamoon, et. al., 2009). This is most likely a result of improved N availability for the ruminal microflora (Petersen, 1987). Higher content of starchy substances or non structural carbohydrates accompanied with low level of CP according to higher level of ground corn (Table 2) may be another probable reason for the tendency of decreased digestibility of low CP level-diets and increased digestibility towards the medium level. Similar attribution was derived by Moreira and Ribeiro (2000). Al-Mallah (2007) reported 3.11, 2.95 and 4.71 units increases in DM, OM and CP digestibilities by lambs due to increase CP levels from 13 to 14.5%, no responses detected with higher levels. Higher (P<0.01) CF digestibility (CFD) was achieved by group of lambs fed medium level of CP as compared to low and high levels, the improvement were 2.8 and 3.56 units, respectively. Broderick, et. al., (2008**)** observed that increasing level of dietary CP led to improve DMD and CFD significantly. The trend towards enhancing CFD in a current study has expanded to improve cell wall constituents, where, Results exhibited significant (P<0.01) improvement in cellulose (P<0.01) and in hemicellulose (P<0.05) digestibilities by lambs fed the medium level of CP. The preference of medium levels of CP (12-14%) has been mentioned by Costas, et. al., (1998) and Soto Navarro, et. al., (2006).

Table 4. Effect of level of dietary protein on body gain and feed conversion ratio (FCR) parameters

Items	Level of dietary protein (%)			Significance of effect
	Low	Medium	High	n = 48
Total gain (TG) kg	10.60^{b}±0.11	11.10^{a} ± 0.14	11.16^{a} ± 0.14	*
Average daily gain (ADG) g/d	168.25^{b}±1.80	176.19^{a}±2.31	177.14^{a}±2.37	*
g dry matter intake/g gain	7.03± 0.16	6.67 ± 0.12	6.58 ± 0.11	NS
g organic matter intake/ g gain	6.50± 0.15	6.18 ± 0.11	6.11 ± 0.10	NS
g nitrogen intake/g gain	0.097^{b}±0.002	0.106^{b}±0.002	0.119^{a}±0.002	**

Means in the same row with different superscripts are significantly different
* (P<0.05) ** (P<0.01) NS= Non significant.

Main effect of RDN: UDN ratio on feed intake:

Daily nutrients intake of straw and total intake values (g/day) as affected by RDN: UDN ratios are presented in Table 6. Straw nutrients intake were not significantly altered by ratio of RDN: UDN. This result is in agreement with other studies (Christensen, et. al., 1993; Devant, et. al., 2000; Braud, 2005 and Hassan and Arif , 2010) and it seems reasonable since daily RDN and UDN requirements of lambs in all treatments were almost completely met through their allowances of concentrate, hence, there was no need to straw which is very poor roughage in both nitrogenous fractions to participate with more of these nutrients. Kellaway and Leibholz (1983) reported that when RDN is non-limiting, dietary CP supplements, feeding at moderate levels have negligible effects on roughage intake. However, other study observed that high UDN-low RDN diet stimulated higher DMI as compared to low UDN-high RDN diet (Nisa, et. al., 2008).The inconsistency with our results may attributed to RDN: UDN ratios. Three ratios were used in later study (50:50, 66:34 and 82:18) or may be attributed to level of feeding, in a current study, offering concentrate at level of 3 % of body weight may prevented the effect of high RDN: UDN ratio from being appear.

Table 5. Main effect of level of dietary protein (A) on nutrients digestibility (%)

Items	Level of dietary protein			Significance of effect
	Low	Medium	High	n = 24
Dry matter digestibility	67.15^{b}±1.12	70.17^{a}± 0.95	67.07^{b}±0.68	*
Organic matter digestibility	67.26^{b}±1.08	70.46^{a}± 0.92	67.06^{b}±0.62	**
Crude protein digestibility	67.10^{b}±1.05	70.77^{a}± 0.80	65.49^{b}±0.82	**
Crude fiber digestibility	65.71^{b}±1.13	68.51^{a}± 1.11	64.95^{b}±0.60	**
Ether extract digestibility	75.84± 0.67	76.22± 0.50	75.81± 0.54	NS
Nitrogen free extract digestibility	67.37^{b}±1.27	70.66^{a}± 1.00	67.39^{b}±0.80	*
Neutral detergent fiber digestibility	63.29± 1.64	65.72± 0.84	63.89± 1.00	NS
Acid detergent fiber digestibility	62.43± 2.21	63.05 ± 1.35	63.47± 1.28	NS
Cellulose digestibility	63.40^{b}±1.44	67.18^{a}± 1.25	61.34^{b}±0.73	**
Hemicellulose digestibility	63.75^{ab}±2.08	66.81^{a}± 1.07	61.64^{b}±1.02	*

Means in the same row with different superscripts are significantly different
* (P<0.05) ** (P<0.01) NS= Non significant

Table 6. Main effect of RDN:UDN ratio on straw and total intake g/day

Items	RDN:UDN ratio		Significance of effects
	High	Low	n = 48
Straw dry matter intake (DM) g/d	364.90 ± 5.74	361.04 ± 5.62	NS
Total DM intake g/d	1177.18 ±24.77	1176.19± 22.19	NS
Total digestible DM intake g/d	810.93± 23.15	799.15± 23.01	NS
Straw organic matter (OM) intake g/d	329.10 ± 5.17	325.62 ± 5.07	NS
Total OM intake g/d	1091.86 ± 23.08	1088.92 ± 20.75	NS
Total digestible OM intake g/d	752.26 ± 21.73	743.07 ± 21.84	NS
Straw nitrogen (N) intake g/d	1.38 ± 0.02	1.36 ± 0.02	NS
Total N intake g/d	18.86 ± 0.62	18.92 ± 0.60	NS
Total digestible N intake g/d	13.09 ± 0.60	12.88 ± 0.59	NS
Straw neutral detergent fiber intake g/d	266.15 ± 4.18	263.34 ± 4.10	NS
Total neutral detergent fiber intake g/d	566.49 ± 11.57	578.02 ± 9.28	NS
Straw acid detergent fiber (ADF) intake g/d	189.60 ± 2.98	187.59 ± 2.92	NS
Total ADF intake g/d	257.21± 4.41	258.75± 3.84	NS
Straw cellulose intake g/d	142.05± 2.23	140.55± 2.19	NS
Total cellulose intake g/d	190.95± 3.28	193.85± 2.96	NS
Straw hemicellulose intake g/d	76.56± 1.20	75.74± 1.18	NS
Total Hemicellulose intake g/d	309.28± 7.70	319.26± 6.93	NS
Total RDN intake g/d	15.73^{a} ± 0.45	13.99^{b} ± 0.37	**
Total UDN intake g/d	10.46^{b} ± 0.22	11.99^{a} ± 0.28	**
Total ME intake MJ/d	12.28 ± 0.28	12.22 ± 0.26	NS
RDN:ME intake g/MJ of ME	1.27^{a} ± 0.02	1.14^{b} ± 0.02	**

Means in the same row with different superscripts are significantly different
* (P<0.05) ** (P<0.01) NS= Non significant

Main effect of RDN: UDN ratio on gain and feed conversion ratio (FCR) parameters:

Body gain and feed conversion ratio parameters as affected by RDN: UDN ratio are presented in Table 7. As shown, there were no significant differences in final body weight and ADG of lambs due to RDN: UDN ratio. Similar findings were observed by many other reports (Zerbini and Polan, 1985; Firkins, et. al., 1986; Braud, 2005). Khampa, et. al., (2003) observed that 1.92% of RDN: DOMI was beneficial in maximizing performance, In a current study this ratio were 2.09 and 1.88% for high and low RDN:UDN ratios respectively. Generally, the positive response to provide supplements with adequate amounts of RDN are commonly noticed when ruminants consume low-quality forage by promoting increased flow of nutrients to the SI (Lintzenich, et. al., 1995). In a current study, concentrate constitutes about 70% of total diets.

Table 7. Effect of RDN: UDN ratio on gain and feed conversion ratio (FCR) parameters

Items	RDN:UDN ratios		Significance of effect
	High	Low	n = 48
Total gain (TG) kg	10.82 ± 0.11	11.08 ± 0.12	NS
Average daily gain (ADG) g/d	171.74 ± 1.77	175.87 ± 2.00	NS
g dry matter intake/g Gain	6.85 ± 0.12	6.68 ± 0.10	NS
g organic matter intake/g Gain	6.35 ± 0.11	6.17 ± 0.09	NS
g nitrogen intake/g Gain	0.109 ± 0.002	0.106 ± 0.002	NS

* ($P<0.05$) ** ($P<0.01$) NS= Non significant

Ammonia is probably the most important source of N for growth of ruminal bacteria (Allison, 1969). However, infrequent supplementation with RDN can supply ammonia in excess of the immediate demands of the rumen microbial population. Therefore, Hassan (2009) demonstrated that LWG was not significantly affected by increasing level of RDN. UDN may be better suited to less frequent supplementation because of its delayed degradation (Bohnert, et. al., 1998) compared with RDN. This could result in increased N recycling to the gut (due to lower ruminal ammonia levels) and decreased urinary N excretion.

FCR values were not significantly affected by this ratio. This result agrees with findings of Hassan (2009), Where, neither increased levels of RDN (1.0, 1.3 and 1.6 g RDN / MJ of ME) nor UDN (7 and 10 g UDN / kg DM) affected FCR, but our result disagrees with findings of Khan, et. al., (2000) and Abdullah and Awawdeh (2004) who reported that formaldehyde HCHO) treatment of CP sources led to improve FCR. This improvement was attributed to increase bypass protein to small intestine (SI), where utilization of protein and glucose absorbed via SI instead of its extensive ruminal fermentation is more efficient process (Meissner, et. al., 1996). Therefore, it was expected that feeding low RDN: UDN ratio may increase the efficiency of utilization of diet. The response in a current study may disappear due to high level of concentrate feeding and a combination of dietary protein and energy.

Main effect of RDN: UDN ratio on nutrients digestibility (%)

Nutrients digestibility of the diets used in this study as affected by RDN: UDN ratio are presented in Table 8. OM, CP, CF, NFE and NDF digestibilities were significantly affected by RDN: UDN ratio, while, DM, EE, ADF, cellulose and hemicellulose digestibilities were not. Many investigations observed positive responses to increase level of UDN sources (Broudiscou and Jouany, 1995; Bohnert, et. al., 2002a; Haddad, et. al., 2005a and Polan, 2010) or protection of CP supplements in order to decrease its degradabilities (Liu, et. al., 1993; Khan, et. al., 2000 and Al-Mallah, 2007). Results showed that lambs fed diets formulated with low RDN:UDN ratio digested its dietary nutrients at higher rate than those fed diets formulated with the high ratio, where, DM, ADF, cellulose and hemicellulose digestibilities were increased by 1.81, 3.22, 2.25 and 1.97 units, However, these increases were statistically insignificant. Whereas, semi equal but significant increases ($P<0.05$) were observed in OM, CF, NFE, NDF and in CP ($P<0.01$) digestibilities, these increases reached 2.14, 2.25, 2.44, 3.07 and 2.5 units respectively. Similar increase ($P<0.05$) in CPD (3.51 units) was obtained by Shamoon, et. al.,(2009) due to decreasing degradability of dietary CP by HCHO treatment. Hassan, et. al., (2001) concluded that sun flower meal could be protected from ruminal degradation effectively by treatment with blood or roasting without any inverse effect on N digestion and absorbability in abomasum and SI. The expected decrease in digestibility of CP ruminally due to protection treatment may be compensated postruminally, In this regard, Noftsger and St-Pierre (2003) noted that post ruminal digestibility of UDN and AA balance can be more important than total UDN supplementation. Bohnert, et. al., (2002a) reported that DM and OM digestibilities decreased with RDN and increased with UDN supplementations, they consider this response as a consequence of the large amount of RDN supplement provided which may have altered ruminal fermentation and decreased ruminal digestibility.

Table 8. Main effect of RDN: UDN ratio on nutrients digestibility (%)

Items	RDN:UDN ratio		Significance of effect
	High	Low	n = 24
Dry matter digestibility	67.23 ±0.81	69.04 ± 0.82	NS
Organic matter digestibility	67.19[b] ±0.75	69.33[a] ± 0.83	*
Crude protein digestibility	66.54[b] ±0.91	69.04[a] ± 0.89	**
Crude fiber digestibility	65.27[b]±0.76	67.52[a] ± 0.91	*
Ether extract digestibility	75.10 ±0.43	75.81 ± 0.48	NS
Nitrogen free extract digestibility	67.25[b] ±0.82	69.69[a] ± 0.93	*
Neutral detergent fiber digestibility	62.77[b] ±0.93	65.84[a] ± 0.87	*
Acid detergent fiber digestibility	61.38±1.08	64.59 ± 1.39	NS
Cellulose digestibility	62.85±1.16	65.10 ± 1.12	NS
Hemicellulose digestibility	63.08±1.45	65.05 ± 1.13	NS

Means in the same row with different superscripts are significantly different
* ($P<0.05$) ** ($P<0.01$) NS= Non significant

Effect the interaction between levels of dietary protein × RDN: UDN ratios on feed intake

Daily nutrients intake of straw and total intake values (g/day) as affected by interaction between levels of dietary CP and RDN: UDN ratios are presented in Table 9. It is clear that there were significant ($P<0.05$) effects on total N and digestible N intakes. Similar results were obtained by Nisa, et. al., (2008).These are expected in a current study since both were significantly ($P<0.01$) affected by level of dietary CP (Table 4), however, there was no effect for RDN: UDN ratio as interacted with level of dietary CP, but low level of CP-low RDN: UDN ratio stimulated higher (though insignificant) digestible intake leading to believe that this level was insufficient to meet lambs requirement of N. The increase in total N intake is due to the increase ($P<0.05$) in concentrate N intake.

The results also revealed that total RDN and total UDN intakes were significantly ($P<0.05$) affected by the above interaction. Higher total RDN intake was achieved by lambs fed high level of CP formulated with high RDN: UDN ratio, While, higher total UDN intake was achieved by lambs fed high level of CP formulated with low RDN: UDN ratio. Such like this trend was noticed by Santos, et. al., (1998). Weiss (2002) demonstrated that high RDN ratio is not preferable as compared to high UDN ratio, because RDN dose not compensate the deficiency of UDN, Whereas, UDN can make up for that deficiency of RDN, but when it is not deficient, high UDN will lead to same waste, such concepts should be taken in a mined in diet formulation.

Effect of the interaction between levels of dietary protein × RDN: UDN ratio on gain and feed conversion ratio (FCR) parameters

Gain and feed conversion ratio (FCR) parameters as affected by interactions between level of dietary CP and RDN: UDN ratio are presented in Table 10. As shown TG and ADG achieved by lambs fed medium and high levels of CP, regardless to RDN: UDN ratio, were higher ($P<0.05$) than those achieved by lambs fed low level of CP with high and low RDN: UDN ratio. This may attributed to the main effect of level of CP, where, higher ($P<0.05$) gain was accompanied with those levels of protein (table 8). In each level, greater gain was observed due to low RDN: UDN ratio. Rusche, et. al., (1993) demonstrated that feeding a high level of CP with high escape potential seemed to support higher gain. Devant, et. al., (2000) attributed such like this trend to a reduction in degradability which resulted in a slight increase in N retention by growing heifers fed low-CP diets and a decrease by those fed high-CP diets. FCR values were not significantly affected by this interaction; this is expected since FCR values were not significantly affected by both level of level of protein × RDN: UDN ratio. In contrast a significant ($P<0.05$) effect of interaction between level and degradability of dietary CP was detected, because a reduction in degradability resulted in a slight increase in N retention in low-CP treatments and a decrease in high-CP treatments (Devant, et. al., 2000). In a current study lower FCR value within each level were noticed due to feeding low RDN: UDN ratio. Similar trend were observed for UDN sources as compared to RDN sources introduced at the same level of dietary CP (Tomlinson, et. al., (1997).

Effect of the interaction between levels of dietary protein × RDN: UDN ratio on nutrients digestibility (%)

Nutrients digestibility of diets as affected by interaction between level of dietary CP and RDN:UDN ratio are presented in Table 11. As shown from the table all nutrients digestibilities were significantly ($P<0.05$) affected by this interaction except that of EE and ADF. Erasmus, et. al., (1994) observed significant differences ($P<0.05$) for DM and OM digestibilities due to the interaction between level of protein × protection. Results also revealed that higher digestibilities were accompanied with feeding high UDN containing diets. The tendency to improve digestibility due formulating diets with UDN (Haddad, et. al., 2005a and Polan, 2010) or protected CP sources have been previously mentioned (Khan, et. al., 2000 and Al-Mallah, 2007)

Table 9. Effect of the interaction between level of dietary protein × RDN:UDN ratio (A×B) on straw and total intake g/d

Items	Interactions						Significance of Effect
	A_1B_1	A_1B_2	A_2B_1	A_2B_2	A_3B_1	A_3B_2	
							n = 48
Straw dry matter intake (DM) g/d	366.52 ± 14.76	350.21 ±14.19	360.06 ± 7.79	368.22± 5.79	368.14± 6.40	364.71± 7.13	NS
Total DM intake g/d	1191.66 ±53.63	1178.97 ±41.70	1171.20 ±34.89	1180.68±43.13	1168.69±43.70	1168.93±35.30	NS
Total digestible dry matter intake g/d	757.40 ± 55.45	808.91 ± 52.11	850.30 ± 16.87	838.27± 33.77	825.08± 31.61	750.28± 25.10	NS
Straw organic matter (OM) intake g/d	330.56 ± 13.31	315.85 ± 12.80	324.74 ± 7.03	332.10± 5.22	332.02± 5.77	328.92± 6.43	NS
Total OM intake g/d	1102.86 ±49.93	1093.17 ±39.10	1089.06 ±32.56	1090.45±40.24	1083.69±40.86	1083.16±33.01	NS
Total digestible organic matter intake g/d	708.49 ± 54.56	745.31 ± 48.50	791.09 ± 13.88	780.61± 32.82	757.21± 29.59	703.30± 28.60	NS
Straw nitrogen (N) intake g/d	1.38 ± 0.05	1.32 ± 0.05	1.36 ± 0.02	1.39 ± 0.02	1.39 ± 0.02	1.38 ± 0.02	NS
Total N intake g/d	16.56^{b} ± 0.87	16.68^{b} ± 0.80	18.79^{ab} ± 0.63	18.85^{ab} ± 0.92	21.24^{a} ± 1.05	21.23^{a} ± 0.80	*
Total digestible nitrogen intake g/d	10.77^{c} ± 0.96	11.34^{bc} ± 0.97	13.82^{a} ± 0.16	13.79^{a} ± 1.03	14.68^{a} ± 0.53	13.52^{ab} ± 0.79	*
Straw NDF intake g/d	267.33 ± 10.76	255.44 ± 10.35	262.62 ± 5.68	268.58 ± 4.22	268.52 ± 4.67	266.01 ± 5.20	NS
Total NDF intake g/d	584.21 ± 26.64	560.34 ± 15.75	547.44 ± 14.81	587.60 ± 17.34	567.85 ± 17.17	586.12 ± 15.28	NS
Straw ADF intake g/d	190.43 ± 7.67	181.96 ± 7.37	187.08 ± 4.05	191.32 ± 3.00	191.28 ± 3.32	189.49 ± 3.70	NS
Total ADF intake g/d	265.06 ± 10.62	248.29± 7.62	249.18± 5.94	262.69 ± 5.87	257.38 ± 5.08	265.24 ± 5.40	NS
Straw cellulose intake g/d	142.67 ± 5.74	136.33± 5.52	140.16± 3.03	143.34 ± 2.25	143.31 ± 2.49	141.97 ± 2.77	NS
Total cellulose intake g/d	197.23^{ab} ± 7.85	185.24^{ab} ± 6.07	184.69^{b} ± 4.52	196.30^{ab} ± 4.04	190.92^{ab} ± 3.62	199.99^{a} ± 4.07	*
Straw hemicellulose intake g/d	76.88 ± 3.09	73.47 ± 2.97	75.53 ± 1.63	77.24 ± 1.21	77.25 ± 1.35	76.51 ± 1.49	NS
Total Hemicellulose intake g/d	319.11 ± 16.90	312.03 ± 12.25	298.24 ± 9.14	324.88 ± 14.24	310.48 ± 13.58	320.86 ± 10.39	NS
Total RDN intake g/d	14.14^{bc} ± 0.66	12.57^{c} ± 0.47	15.64^{b} ± 0.48	13.99^{bc} ± 0.56	17.40^{a} ± 0.74	15.42^{b} ± 0.50	*
Total UDN intake g/d	9.80^{d} ± 0.39	11.15^{bc} ± 0.33	10.39^{cd} ± 0.27	11.62^{b} ± 0.50	11.20^{bc} ± 0.33	13.19^{a} ± 0.36	*
Total ME intake MJ/d	12.51 ± 0.58	12.40 ± 0.51	12.26 ± 0.38	12.20 ± 0.50	12.09 ± 0.52	12.11 ± 0.40	NS
RDN:ME intake g/MJ of ME	1.12^{d} ± 0.005	1.00^{e} ± 0.01	1.27^{b} ± 0.003	1.14^{c} ± 0.006	1.43^{a} ± 0.003	1.26^{b} ±0.005	**

Means in the same row with different superscripts are significantly different

* (P<0.05) ** (P<0.01) NS= Non significant

Table 10. Effect of the interaction between levels of dietary protein × RDN: UDN ratio on gain and feed conversion ratio (FCR) parameters.

Items	Interactions						Significance of effect
	A_1B_1	A_1B_2	A_2B_1	A_2B_2	A_3B_1	A_3B_2	
							n = 48
Total gain (TG) kg	10.43^{c} ±0.14	10.75^{bc}± 0.16	11.00^{ab}± 0.18	11.19^{ab}± 0.23	11.00^{ab}± 0.18	11.31^{a}± 0.23	*
Average daily gain (ADG) g/d	165.55^{c}± 2.34	170.63^{bc}± 2.59	174.60^{ab}± 2.99	177.61^{ab}± 3.65	174.60^{ab}± 2.99	179.52^{a}± 3.65	*
g dry matter intake /g Gain	7.17± 0.25	6.90 ± 0.20	6.70 ± 0.18	6.63 ± 0.16	6.66 ± 0.17	6.50± 0.14	NS
g organic matter intake /g Gain	6.64 ± 0.24	6.37 ± 0.19	6.23 ± 0.17	6.12 ± 0.15	6.19 ± 0.15	6.02± 0.13	NS
g nitrogen intake /g Gain	0.099 ± 0.004	0.096 ± 0.003	0.107 ± 0.003	0.105 ± 0.003	0.120 ± 0.004	0.117± 0.003	NS

Means in the same row with different superscripts are significantly different
* (P<0.05) , NS= Non significant

Table 11. Effect of the interaction between levels of dietary protein × RDN: UDN ratio (A×B) on nutrients digestibility (%)

Items (%)	Interactions						Significance of effect
	A_1B_1	A_1B_2	A_2B_1	A_2B_2	A_3B_1	A_3B_2	
							n = 24
Dry matter digestibility	65.00^{c} ± 1.09	69.31^{ab} ± 1.28	69.57^{ab} ± 1.35	70.78^{a} ± 1.48	67.12^{bc} ± 0.92	67.03^{bc} ± 1.15	*
Organic matter digestibility	65.64^{c} ± 1.22	68.89^{abc}± 1.49	69.57^{ab} ± 1.01	71.35^{a}± 1.55	66.37^{bc}± 0.86	67.76^{bc} ± 0.87	*
Crude protein digestibility	65.79^{cd}± 1.43	68.41^{bc} ± 1.40	69.60^{ab} ± 0.96	71.94^{a} ± 1.10	64.21^{d} ± 1.06	66.71^{bcd}± 0.97	*
Crude fiber digestibility	64.19^{b}± 1.23	67.24^{ab} ± 1.71	67.02^{ab} ± 1.62	70.01^{a} ± 1.27	64.59^{b} ± 0.85	65.31^{b} ± 0.94	*
Ether extract digestibility	75.52 ± 1.14	76.15 ± 0.84	76.33 ± 0.29	76.11 ± 1.04	76.46 ± 0.69	75.15± 0.77	NS
Nitrogen free extract digestibility	65.60^{c} ± 1.27	69.14^{abc} ± 1.95	69.86^{ab} ± 0.95	71.46^{a} ± 1.83	66.31^{bc} ± 1.18	68.48^{abc}± 0.91	*
Neutral detergent fiber digestibility	61.39^{b} ± 2.00	65.19^{ab} ± 2.49	64.81^{ab} ± 1.19	66.64^{a} ± 1.17	62.10^{ab} ± 1.42	65.68^{ab} ± 0.70	*
Acid detergent fiber digestibility	59.63^{a} ± 1.74	65.23^{a} ± 3.83	63.23^{a} ± 2.27	62.86^{a} ± 1.82	61.27^{a} ± 1.58	65.68^{a} ± 1.39	NS
Cellulose digestibility	61.96^{bc} ± 2.08	64.85^{abc} ± 2.00	66.17^{ab} ± 1.97	68.20^{a} ± 1.65	60.43^{c} ± 0.85	62.25^{bc} ± 1.10	*
Hemicellulose digestibility	62.60^{ab} ± 3.76	64.91^{ab} ± 2.27	65.95^{ab} ± 1.29	67.67^{a} ± 1.80	60.70^{b} ± 1.66	62.59^{ab} ± 1.23	*

Means in the same row with different superscripts are significantly different
* (P<0.05) , NS= Non significant.

In a current study, this trend was observed with low and medium levels of CP. Soto Navarro, et. al., (2006) demonstrated that the moderate level of CP (12-15%) supplied by the slow degraded source seemed to justify ruminal requirements, while the higher may exceeded this requirement leading to wasted amounts of supplemented CP. Results also showed that higher digestibilities were obtained when lambs fed medium level of CP with high UDN diet (low RDN:UDN ratio), where, DM, OM, CF, NFE, NDF and ADF digestibilities were 5.78, 5.71, 5.82, 5.86, 5.25 and 3.23 units respectively, greater (P<0.05), than those obtained when lambs fed diets containing the low level of CP formulated with high RDN diet (high RDN:UDN ratio), While, CP, cellulose and hemicellulose were 7.73, 7.77 and 6.97 units respectively, greater (P<0.05) for lambs fed the medium level of CP with high UDN diet than those fed diets containing the high level of CP formulated with high RDN diet. Increasing dietary CP diluted the ruminally fermentable carbohydrates, Lana, et. al., (1997) suggested that feeding an excess of CP would place an additional demand on energy or arginine to run the urea cycle, diverting them away from growth. Higher amounts of SBM accompanied with increasing CP level in a current study may be not achieved good synchronization between energy released and protein degradation in the rumen; this led to lower nutrients utilization and then probably exceeded microbial requirements.

CONCLUSION

Effect of interaction between levels of dietary CP and RDN: UDN ratio revealed that productive parameters of lambs fed diets containing medium level of CP and formulated with low RDN:UDN ratio was somewhat tended be better.

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