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Effect of Level of Protein on Digestibility and Nitrogen Balance in Sudan Desert Sheep Fed Molasses-Based Fattening Rations

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Abstract: Three yearling intact males of Sudan desert sheep (Hamari ecotype) ranging in weight between 26 and 30 kg were used in a 3x3 latin square design with the objective of studying the effect of feeding three crude protein (CP) levels (14.5%, 16.7% and 18.7%) in complete iso-caloric molasses-based diets on nitrogen-balance, digestibility of nutrients, rectal temperature and respiration rate. Nitrogen (N) level had no significant effect on the digestibility coefficients of the different nutrients, total digestible nutrients (TDN) and N-balance. Urine volume, rectal temperature and respiration rate were not affected by N level.

Key words: Sheep; protein level; digestibility coefficients; N-balance

INTRODUCTION

Sudan is a vast country with tremendous agricultural and livestock resources. Its ruminant livestock population currently comprises about 39.5 million cattle, 50.7 million sheep, 42.9 million goat and 4.2 million camel (AOAD 2008).

Available feed resources in the Sudan are not sufficient for optimal production because of the recurrent drought, overgrazing, misguided polices and imbalance of demographic set.
Use of traditional rations must very soon discontinue because of the escalating prices of the ingredients (the cost is prohibitive to production relative to the potential benefit) and competition with human food requirements.

The shortage of animal feed resources and increasing cost of traditional feeds have stimulated the utilization of agricultural (e.g. groundnut hulls) and agro-industrial (e.g. molasses) by-products as feeds for ruminants.

Protein is one of the most limiting nutrients in sheep fattening rations formulated from these by-products, leading to low intake and poor utilization by livestock resulting from inefficient rumen ecosystem and an imbalance in the products of rumen fermentation (Bird 1999). Protein and non-protein N supplements may be used to correct this deficiency (Galyean 1996). Protein supplements are the most expensive.

The dietary CP level affects digestibility of nutrients. Dry matter (DM) digestibility tends to decrease with increasing CP in lambs (Cole 1999). Haddad *et al*. (2001) reported that organic matter (OM) and CP digestibility were lowest in lambs fed the 10% CP diet compared with 12%, 14%, 16%, and 18% CP diets. Similar results were obtained by Bunting *et al*. (1987), Sultan and Loerch (1992) and Manso *et al*. (1998). In a recent study, Girdhar and Balaraman (2005) reported no significant difference in the digestibility coefficients of DM, OM, ether extract (EE), neutral detergent fibre (NDF) and acid detergent fibre (ADF) in Karan Fries crossbred cows fed increasing amounts of dietary CP (10%,12% and 14%). CP digestibility was significantly higher with high protein level (14%). The digestibility of crude fibre (CF) was significantly higher at 10% or 14% CP compared to 12% CP. However, protein level failed to induce a significant effect on TDN.

The level of protein also affects N-balance. Davenport *et al*.(1995) reported an increase in N retention when dietary N increased in Suffolk wether lambs fed increasing amounts of dietary N (9%,12% or 15% CP). Bunting *et al*. (1989) reported an increase in N retention in Angus heifer calves with high CP intake (18.8%) compared to calves with low CP intake (10.2%). An increase in CP concentration results in higher N digestibility (Davenport *et al*. 1995).

The objective of this experiment was to evaluate the effects of CP content of molasses-based diets on digestibility coefficients, N-balance, rectal temperature and respiration rate.

MATERIALS AND METHODS

Digestibility trial Three yearling intact males of desert sheep (Hamari ecotype) ranging in weight between 26 and 30 kg, were used in this study which was conducted in early summer. The animals were purchased from the local market. On arrival at the experimental farm, they were treated with Levafas against endoparasites, sprayed with Gamatox for control of ectoparasites and given a prophylactic dose of Alamycine. The animals were left to acclimatize for 14 days and allotted at random to each of the experimental rations under investigation. The rations, containing three N levels (14.5%, 16.7% and 18.7% CP) through increasing percentage of urea (1.7%, 2.5% and 3%), were calculated to be isocaloric. The detailed composition of the rations is given in Table 1. The three treatments will be referred to as treatment T_1, T_2, T_3, respectively.

The digestibility trial was carried out in a 3x3 latin square design. The experimental period lasted for 7 days, preceded by a 14 days preliminary period. The following parameters were recorded daily: feed intake, faecal output, urine volume, respiration rate and rectal temperature. During the collection period, feed samples were taken weekly and composited sub-samples of the weekly composites were dried at 60˚C for 24 hours and ground through a 1-mm mesh screen for analysis.

Faeces and urine were collected every 24 hours during each collection period. Urine was acidified with concentrated sulphuric acid and measured volumetrically. Ten percent of collected urine and faeces were taken as samples. Aliquot of each sheep's urine and faecal outputs were refrigerated, bulked at the end of the period and sub-sampled. Faecal samples were processed as for feeds.

Samples from the weekly composites of rations and faeces were analyzed for their proximate chemical components as described by AOAC (1980), and urine-N as determined by El-Shazly (1958). Daily respiration rate was recorded by counting flank movements for one minute, and daily rectal temperature was taken by inserting a clinical thermometer inside the sheep rectum for one minute (Ahmed 1989). Digestion coefficients were calculated according to standard procedures (Schneider and Flatt 1975).

Table 1. Percentage of ingredients and chemical composition of the experimental rations

Ingredients (%)[*1]	T_1	T_2	T_3
Molasses	40	40	40
Wheat bran	29.3	28.5	28
Groundnut hulls	20	20	20
Groundnut cake	8	8	8
Urea	1.7	2.5	3
Salt	0.95	0.95	0.95
Vitamin/Minerals supplement*[2]	0.05	0.05	0.05
Total	100	100	100
Dry matter (%)			
Ash	8.34	10.55	9.47
Organic matter	91.66	89.45	90.53
Ether extract	2.10	1.95	4.10
Crude protein	10.50	10.75	10.65
Crude protein	14.53	16.71	18.73
Nitrogen free extract	64.53	60.04	57.06
ME(MJ/Kg DM) *[3]	11.95	11.56	12.04

*1 On as fed basis

*2 Avico Products, Jordan

T_1: 14.5% CP; T_2: 16.7% CP; T_3: 18.7% CP

Each 1 g of vitamin supplement contains:

Vitamin A	8000 IU		
Vitamin D3	1400 IU	Nicotinamide(B3)	15 mg
Vitamin E	2 mg	Choline choloride	100 mg
Vitamin K3	2 mg	Folic acid	0.5 mg
Vitamin B2	4 mg	Iron	22 mg
Vitamin B1	2 mg	Manganese	33 mg
Vitamin B12	5 mg	Copper	2.2 mg
Ca-d pantothenate	5 mg	Cobalt	0.5 mg
Zinc	25 mg	Iodine	1.1 mg

*3 Calculated after MAFF (1975) using the following equation:

ME(MJ/Kg DM)= 0.012 CP+0.031 EE+0.005 CF+0.014 NFE

Statistical Analysis

Data from the digestibility trial were analyzed as 3x3 latin square design, with sum of squares partitioned into animal, period and treatment effects. Data were analyzed by analysis of variance according to general linear models procedure of SAS (1990). Duncan multiple range test was used for mean separation at $P \leq 0.05$.

RESULTS AND DISCUSSION

Effects of N level on the digestibility coefficients of the proximate components and TDN

N level had no significant effect on the digestibility coefficients of the different nutrients (Table 2). This finding agrees with those reported by Varma *et al*. (1975) and Pathak and Sharma (1991) who found no significant differences in the digestibility coefficients of various nutrients, except that the digestibility of CP increased significantly ($P<0.05$) with increasing CP content of diets. With the exception of the digestibility coefficient of nitrogen free extract (NFE) the digestibility coefficients of the other nutrients tended to increase with the increase of N concentration in the diet. Girdhar and Balaraman (2005) reported an increase in the digestibility coefficients of nutrients, with the exception of CF, which showed inconsistent trend when dietary CP increased. NFE digestibility (NFED) decreased with the increase of N content of the diet. This confirms the finding of Putnam *et al*. (1966) that the NFED decreased with protein levels when energy was offered at the medium or high level. A similar decreasing trend was also reported by Varma *et al*. (1975).

The N level in the diet had no significant effect on the TDN values. Similar results were obtained by Pathak and Sharma (1991) and Girdhar and Balaraman (2005). The TDN of T_1 and T_2 were similar. T_3 showed the highest TDN value. Girdhar and Balaraman (2005) reported that the highest TDN value is associated with the high level of protein.

The depression in CF digestibility (CFD) in this study may be due not only to reduced pH when the diet contained >25% non-structural carbohydrates, such as starch or soluble sugars (Allen and Mertens 1988), but also due to substrate substitution by fibre digesting bacteria (Wiedmeier *et al*. 1992).

Table 2. Effect of nitrogen level on the apparent digestibility coefficients of the proximate components and total digestible nutrients in desert sheep

Component	T_1	T_2	T_3
Dry matter	59.55± 2.26	62.21± 1.30	63.43± 5.56
Organic matter	63.24± 3.25	64.89± 1.63	67.04± 5.47
Crude protein	74.26± 7.76	81.68± 5.58	83.20± 5.51
Ether extract	74.89± 6.42	78.92± 9.13	87.06± 5.09
Crude fibre	17.87± 3.92	27.35± 6.32	32.72± 11.36
Nitrogen free extract	67.61± 5.70	66.38± 4.36	66.81± 7.07
Total digestible nutrient	59.70± 2.75	59.90± 1.30	65.21± 4.89

T_1: 14.5% CP; T_2: 16.7% CP; T_3: 18.7% CP
Values are means± SD of 3 animals
Means in the same row without superscripts are not significantly different (P>0.05).

Effect of N level on N-balance

The level of N had no significant effect on N retention (Table 3). This result is in line with those obtained by Varma *et al*. (1975) and Cheema *et al*. (1987). Laughern and Young (1979) reported similar N retention by lambs fed diets based on corn cobs at 1.2 times maintenance containing 8% to 17% CP. Contrasting findings were reported by several research workers (Bunting *et al*. 1987; Bunting *et al*. 1989; Pathak and Sharma 1991; Cole, 1999) who obtained higher N retention values in animals kept on high level of CP.

In the experiments conducted by Willms *et al*. (1991), the N balance found at 14% CP level was higher than that at 16% CP level, even though the intestinal supply of amino acids continues to increase with increasing CP level. This confirms the results obtained in this study. The difference in N retention due to dietary CP level may be explained by differences in dietary energy concentration and/or intake (Willms *et al.* 1991) or variation in N intake (Sharma *et al.* 1975). T_3 showed the highest TDN (and subsequently high energy intake) and N intake value than the other two treatments. Therefore, the difference in N retention may be due to the difference in energy and/or N intake.

Table 3. Nitrogen balance of sheep fed different nitrogen levels

Item	T_1	T_2	T_3
Nitrogen intake (g/day	20.53± 2.00	22.93± 0.94	26.24± 4.33
Faecal nitrogen (g/day	5.18 ± 1.39	4.78 ± 3.38	4.48 ± 1.21
Urinary nitrogen (g/day)	7.76 ± 1.08	12.12 ± 3.73	9.99 ± 2.87
Nitrogen balance (g/day)	7.59 ± 2.73	6.03 ± 4.34	11.77± 7.54
Nitrogen balance, % intake	36.97± 10.24	26.30± 19.90	44.86± 23.57
Nitrogen balance, % digested	49.45± 11.42	33.22± 21.88	54.09± 25.94

T_1: 14.5% CP; T_2: 16.7% CP; T_3: 18.7% CP
Values are means± SD of 3 animals.
Means in the same row without superscripts are not significantly different (P>0.05).

The lowest N-balance value was obtained with T_2; this may be due to high urinary excretions since the faecal N excretion was almost the same in all the treatments. N- balance, as a percentage of N intake or digested, did not differ significantly between treatments (the highest values were found in lambs fed 18.7% CP and maximal quantity of N retained occurred in lambs fed 18.7% CP also).

The positive N-balance found in all treatments indicates that N was sufficient to meet the requirements of the organism.

N intake tended to increase with the increase of CP level. This confirms the findings of Willms *et al.* (1991) who reported linear increase in N intake as CP level increased from 6% to 16%. Cole (1999) obtained similar results.

The amount of N excreted in the faeces was not significantly affected by protein level. This confirms the findings of Varma *et al*. (1975) and Bunting *et al*. (1989). Cole (1999) observed increased faecal-N excretion with the increase of dietary CP concentration. Although the urinary N excretion was not affected by protein level, greater amounts were found at T_2 (16.7% CP;12.12 g/day) followed by T_3 (18.7% CP; 9.99 g/day).There was a tendency of increased urinary N excretion as the N concentration of the diet increased from 14.5% to 16.7% CP and tended to decrease thereafter (at 18.7% CP); no explanation is apparent. These results agree, in part, with those reported by Bunting *et al*. (1987; 1989) and Willms *et al*. (1991) and Cole (1999) who reported increased urinary N excretion with incremental increases in CP.

Effect of N level on urine volume, rectal temperature and respiration rate

No significant effects of treatments on urine volume, rectal temperature and respiration rate were obtained (Table 4). Respiration rate showed higher value (55.83/min.) with lower N concentration. The insignificant effect of CP level on urine volume agrees with the results obtained by Cole (1999). Urine volume increased with the increase of N digestibility of the diet. This confirms the findings of Bunting *et al*. (1987) and Archibeque *et al*. (2007) who found that the increase in the amount of digestible N consumed by the ruminant usually increases the amount of urea-N excreted and, subsequently, the volume of urine that must be eliminated if normal urine osmolality is to be maintained. Consequently, increased water consumption is often observed with elevated N intake (Bunting *et al*. 1989).

Apart from the treatment effect, rectal temperature and respiration rate values were within the normal range of variation reported for sheep (Hassouna 2003). This indicates that the animals were not disturbed physiologically.

Table 4. Urine volume, rectal temperature and respiration rate as affected by nitrogen level

Treatment	Urine volume (ml)	Rectal temperature (˚C)	Respiration rate (min.)
T_1	1506.91± 822.39	39.12± 0.73	55.83± 28.67
T_2	1962.44± 1035.18	38.78± 0.48	38.83± 13.67
T_3	1973.99± 1375.00	39.28± 0.26	50.20± 7.19

T_1: 14.5% CP; T_2: 16.7%CP; T_3: 18.7% CP
Means with similar superscripts within each column are not significant different (P>0.05).

CONCLUSIONS

Neither digestibility of nutrients nor N-balance is affected by the level of protein consumed. However, there was a tendency of increase in nutrient utilization with increasing protein concentration (the best nutrient utilization was obtained when the ration contained 18.7% CP) despite the fact that the dietary CP was likely in excess of needs for these animals. The effects of increasing protein concentration on animal performance, under practical feeding conditions and production levels of feed intake, need to be studied.

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تأثير مستوي البروتين علي الهضمية وميزان النيتروجين في الضأن الصحراوي السوداني عند تغذيته علي علائق تسمين كاملة مبنية أساساً علي المولاس

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المستخلص: إستخدمت ثلاثة ذكور غير مخصية من الضأن الصحراوي السوداني (صنف الحمري), والبالغة من العمر سنة ووزنها بين 26 و30 كجم في تصميم 3x3 مربع لاتيني بهدف دراسة تأثير التغذية علي ثلاثة مستويات من البروتين الخام (14.5% و 16.7% و 18.7%) في علائق تسمين كاملة مبنية أساساً علي المولاس ومتساوية في محتواها من الطاقة علي ميزان النيتروجين, وهضمية المواد الغذائية, ودرجة حرارة المستقيم, ومعدل التنفس. مستوي النيتروجين لم يكن له تأثير معنوي علي معاملات الهضم الظاهري للمواد الغذائية المختلفة, والمواد الكلية المهضومة, وميزان النيتروجين. لم يتأثر حجم البول, ودرجة حرارة المستقيم, ومعدل التنفس بمستوي النيتروجين.