ISSN 1819-1878

Asian Journal of Animal Sciences

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Asian Journal of Animal Sciences 6 (5): 230-239, 2012
ISSN 1819-1878 / DOI: 10.3923/ajas.2012.230.239

Digestibility and Nitrogen Balance of Sudan Goat Ecotypes Fed Different Energy/Protein Levels

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ABSTRACT

Goat (*Capra hircus*) as small ruminants is reared in Sudan for its milk, meat, skin and wool. The present study was conducted to evaluate the effects of different levels of energy/protein on apparent digestibility coefficients and nitrogen balance of different Sudan goat ecotypes (Nubian, Desert and Swiss Nubian). Nine male goat kids (2-3 months and average weight 9.23 kg) of either ecotypes were used in a 3×3×3 arrangement, fed three experimental diets A (control), B and C, with varying energy: protein 1:0.14, 0.16 and 0.18, respectively. Animals were housed in metabolism cages and diets were fed for a 3 day adjustment period followed by a 4 day collection period. Feed, feed refusal and feces were taken daily to measure digestibility. Urine was collected daily and measured in mL and preserved with sulfuric acid. Then urinary nitrogen was analyzed. The study showed a significant difference ($p<0.05$) between species only for Ether Extract (EE), Nubian kids recorded best digestibility of Digestible Dry Mater (DDM), Digestible Organic Mater (DOM), Digestible Crude Protein (DCP), Digestible Ether Extract (DEE) and Digestible Nitrogen Free extract (DNF) Effect of ration was significant ($p<0.05$) for DDM, DOM, DEE and DNFE. The highest values of apparent digestibility coefficient of Dry Mater (DM), Organic Matter (OM), Ether Extract (EE) and Nitrogen Free Extract (NFE) were observed in ration B and C. Nitrogen balance was not significantly varied for treatment. Animal species were in positive N balance for all three experimental diets. Nitrogen retention and nitrogen retention percentage was highest in ration B and C. The digestibility of nutrients of experimental diets indicated that the digestibility increased significantly ($p<0.05$) with increasing energy: protein in the test diets. Therefore, increasing energy protein levels gave better results, with overall higher nitrogen retention in Nubian goats than the other two ecotypes which were similar. It is likely that Nubian goats are well adapted to be raised under intensive condition due to their efficient utilization of nutrients.

Key words: Desert, ether extract, nitrogen, digestibility

INTRODUCTION

Small ruminants, especially goats, are very important livestock throughout the world. They contribute obviously in meat, milk, fiber production in urban and rural areas. Inadequate small availability of high quality feed is widely regarded as a major constraint to most of the prevalent

ruminant production systems in many parts of the developing world (Anbarasu *et al*., 2004). The economic importance of goats in the provision of animal proteins in developing countries has been extensively reviewed (Devendra, 1981). Goats are recognized as the most effective livestock for promoting health and economy of poor people in the developing countries of the world (Sengar, 1980).

Growth, maintenance, reproduction and general performance of goats in tropical environments are largely limited by forage quality and this is reflected in low voluntary intake and digestibility (Minson, 1971, 1990; Adjei, 1995; Michiels *et al*., 2000). Dry matter intake, nutritive value, digestibility and herbage are lowest during the dry season (Aregheore, 2001). However, goats are well adapted to utilize fodders in the dry season when pasture grasses decline both in quantity and quality due to their high digestive capability compared to that of cows (Le Houerou, 1987) and other domesticated ruminants (Silanikove, 2000).

Ruminants in the majority of developing countries are reared on crop residues and poor-quality roughage based diets. The potentially available fraction of lingo-cellulosic complex of crop residues are highly resistant to rumen micro-organisms which limits their effective digestion, thereby causing unavailability of a vast source of energy (Sahoo *et al*., 2002). Williamson and Payne (1978) mentioned that rationing of goats should be realistic and should be based on cheap feed such as browse, pasture and agro-industrial by-products. Goats generally have higher feed intake (5-6% LBWT) than sheep (Wahed and Owen, 1986) and furthermore, they have better digestive efficiency than sheep for low quality forages. Nutrient requirements depend on body size and growth or production potentials of animals, environmental conditions and quality of feed. Temperature, humidity, sunshine and wind velocity may increase or decrease nutrient needs depending upon the region (NRC, 1981). The Sudan is a vast country of great animal wealth and diversified climatic conditions. It is considered amongst those countries having a great agricultural potential.

The objective of this study was to evaluate the effects of different levels of energy/protein on apparent digestibility coefficient and nitrogen balance of different Sudan ecotypes goat.

MATERIALS AND METHODS

Animals and experimental design: Twenty seven animals, nine male of Nubian, Desert and Swiss Nubian goat kids (2-3 months old) with an average weight 9.23 kg were used. The animals were rested, ear tagged and injected with abroad spectrum 5% antibiotic oxytetracycline, for four days and dewormed with broad spectrum anthelmintic Ivermectin. We have followed the "International Animal Ethics Committee guideline" for use of animals in the study.

Experimental feed (rations): Three experimental diets (Table 1) were labeled A, B and C subject to treatment groups. Ration A served as the control. The three rations were based on sorghum, wheat bran, groundnut cake and groundnut hulls.

Feeding management: Mixing of the experimental rations was done manually after weighing the recipe. The dry small quantity ingredients were mixed first then finally with the molasses and left to dry by air and then packed in labeled sacks (A, B and C).

Table 1: Percent experimental ration composition (fresh basis) and analyzed percent chemical composition (dry matter basis) of experimental rations

Rations	A	B	C
Ingredients (%)			
Sorghum	11.00	30.00	51.00
Wheat bran	40.00	25.00	18.00
Groundnut cake	8.00	10.00	9.00
Molasses	12.00	15.00	12.00
Groundnut hulls	27.00	18.00	8.00
Minerals/NaCl	2.00	2.00	2.00
CP (%)	14.49	14.72	14.91
Energy (ME Mcal kg^{-1})	2.08	2.41	2.74
Energy/protein ratio	1/.14	1/.16	1/.18
Analyzed (%)			
DM	97.38	94.97	92.87
EE	1.03	2.75	2.75
CP	13.28	14.22	13.60
CF	16.02	11.13	8.25
Ash	9.20	9.51	7.66
NFE	57.85	57.36	60.61
Energy (ME Mcal kg^{-1})	2.58	2.66	2.73

DM: Digestible matter, EE: Ether extract, CP: Crude protein, CF: Crude fiber and NFE: Nitrogen free extract

Digestibility measurements: Animals were taken into the metabolic cages and were allowed to adapt to the cages over three days. This was followed by four days collection period. The diets were offered *ad libitum* and access to water was free. Feed was offered once a day at 8:30 a.m. after withdrawal of the refusals. Faeces were collected daily and weighed. At the end of the collection period, the dried faeces samples were composited and a representative sample was taken for proximate chemical analysis. Urine was collected daily and its volume was measured. Sulfuric acid was used as a preservative. Collected urine samples were also composited and a representative sample was taken for total urinary nitrogen estimation.

Proximate analysis: Sample of feed, urine and faeces were proximately analyzed for chemical components according to AOAC (1980).

Statistical analysis: Data were subjected to General Linear Model (GLM) procedure. The comparison of means at 0.05 level of significant was according to the Duncan's multiple range tests. (SAS, 1997).

RESULTS AND DISCUSSION

Apparent digestibility coefficient: The digestibility for nutrients of experimental diets indicated that the Dry Matter (DM) and the Organic Matter (OM) digestibility increased significantly ($p<0.05$) with increasing energy: protein ratio in the test diets. The results obtained in the present digestibility trial were in accordance with the results reported by Elfadil (2001).

The apparent digestibility coefficients of DM were found to be 59.15-63.94 (Table 2). There was no significant difference ($p<0.05$) between species. The results obtained for DM is lower

Table 2: Effect of species on apparent digestibility coefficients of nutrients Table 2 effect of species on apparent digestibility coefficients of nutrients

Item	Nubian	Desert	Swiss Nubian	Significance
DDM	63.94±10.33	62.14±11.27	59.15±8.98	ns
DOM	66.79±9.94	65.40±9.43	61.97±8.41	ns
DCP	69.68±10.55	67.12±10.42	65.25±12.88	ns
DEE	70.86±13.09	59.62±23.16	61.85±20.85	*
DNFE	77.14±9.76	74.90±7.29	70.73±6.30	ns

Values are Mean±SD, DDM: Digestibility coefficient of dry matter, DOM: Digestibility coefficient of organic matter, DCP: Digestibility coefficient of crude protein, DEE: Digestibility coefficient of ether extract, DNFE: Digestibility coefficient of nitrogen free fat, *Means are significantly different at $p<0.05$, ns: Non significant

than the result recorded by Kumagai and Ngampongsai (2006) and Robinson *et al.* (2006) but higher than the result showed by Zhang *et al.* (2008) for Cashmere goats fed with basal diet supplemented with 20 and 30 copper.

Table 2 shows that the species did not significantly ($p>0.05$) affected DOM. This DOM value was higher than that reported by Wildeus *et al.* (2007) for hair sheep breeds, but lower than that indicated by Costa *et al.* (2007).

Digestibility for Crude Protein (DCP) in this study were 69.68, 67.12 and 65.25 in Nubian, Desert and Swiss Nubian, respectively. There were no significant differences ($p>0.05$) between species, these estimates were higher than the result showed by Moore *et al.* (2004) and Atti *et al.* (2004) but lower than those reported by Mani and Chandra (2003) for goat fed with irradiated soybean.

Table 2 shows that there were significant differences ($p<0.05$) between species and the digestibility values for Ether extract (DEE) obtained were lower than those reported by Zhang *et al.* (2007) but higher than the result indicated by Anbarasu *et al.* (2004).

The digestibility values for nitrogen free extract (DNFE) in this experiment were found to be 77.14, 74.90 and 70.73 in the three species, respectively. There were no significant differences ($p>0.05$). These estimates were higher than those reported by Mani and Chandra (2003).

Table 2 shows that there was a significant difference ($p<0.05$) between species only for DEE. The highest digestibility values of DM, OM, CP, EE and NFE were recorded by the Nubian kids whereas the Desert kids ranked in second except for digestibility value of EE while the Swiss Nubian showed lowest digestibility values.

Table 3 shows that rations significantly ($p<0.05$) affected all traits studied except DCP, generally, the highest values were obtained in ration C followed by ration B and then ration A. Values for DDM obtained in the present digestibility trial were higher than the result recorded by Anbarasu *et al.* (2004) and Hindrichsen *et al.* (2002) but were lower than the values reported by El Amin *et al.* (1990). Values for DOM in this study were 56.73, 65.25 and 72.19 in treatments A, B and C, respectively. Values of DOM increases as the energy protein ratio increased. Obtained estimates agreed with the findings of Costa *et al.* (2007) and Kumagai and Ngampongsai (2006), but were higher than results reported by Atti *et al.* (2004) and Aregheore (2004) for goat fed with sweet potato forage.

Table 3 shows that the energy protein levels did not significantly ($P>0.05$) affected DCP. This result was comparable with the result reported by Zhang *et al.* (2008) and higher than results

Table 3: Rations effects on apparent digestibility coefficients

Item	Ration A	Ration B	Ration C	Significance
DDM	52.76±5.92	62.31±7.48	70.16±8.12	*
DOM	56.73±5.78	65.25±6.71	72.19±7.69	*
DCP	61.90±11.50	71.18±7.13	68.98±12.69	ns
DEE	40.50±14.71	75.33±6.87	76.48±4.21	*
DNFE	69.66±9.59	74.63±4.85	78.49±7.24	*

Values are Mean±SD, DDM: Digestibility coefficient of dry matter, DOM: Digestibility coefficient of organic matter, DCP: Digestibility coefficient of crude protein, DEE: Digestibility coefficient of ether extract, DNFE: Digestibility coefficient of nitrogen free fat, *Means are significantly different at $p<0.05$, ns: Non significant

Table 4: Apparent digestibility coefficients of nutrients fed to experimental goat kids

Species	Rations	DDM	DOM	DCP	DEE	DNFE
Nubian	A	74.34±16.25	55.56±09.62	64.69±03.52	57.28±04.08	53.93±03.90
	B	75.43±03.17	76.48±06.38	72.14±02.58	67.50±03.58	64.67±03.28
	C	81.66±07.78	80.54±03.60	72.22±19.24	75.60±10.64	73.22±10.97
Desert	A	70.24±05.29	30.95±13.26	61.64±14.43	60.95±07.08	56.20±07.75
	B	74.01±09.03	72.52±10.13	67.50±10.90	61.80±11.67	57.75±12.81
	C	80.45±04.83	75.38±03.44	72.22±04.81	73.44±04.87	72.47±06.50
Swiss Nubian	A	64.39±01.00	35.00±08.66	59.37±16.94	51.94±02.35	48.16±03.65
	B	74.44±00.96	77.01±05.24	73.89±06.73	66.44±01.85	64.51±01.46
	C	73.36±08.09	73.53±02.55	62.50±12.50	67.53±06.85	64.78±05.94

Values are Mean±SD, DDM: Digestibility coefficient of dry matter, DOM: Digestibility coefficient of organic matter, DCP: Digestibility coefficient of crude protein, DEE: Digestibility coefficient of ether extract, DNFE: Digestibility coefficient of nitrogen free fat, Mean in a row are significant at $p>0.05$

reported by Atti *et al.* (2004) but were observed lower than those values reported by Elfadil (2001) and El-Khidir and Ahmed (1992). Values of DEE in this experiment were found to be 40.50, 75.33 and 76.48 in the three treatments A, B and C, respectively. The values of DEE observed in the present study were comparable with the results reported by Ibrahim (1999) but were lower than the result reported by Mani and Chandra (2003) and Zhang *et al.* (2007). It was clear that DEE increased as the level of energy protein increased in the diet.

Table 3 shows that the values of DNFE in this result was higher than the result indicated by Mani and Chandra (2003), Gihad *et al.* (1989) and El-Tayeb (1981) for goats fed wheat bran and sorghum bran with and without monensin; but he reported greater values for NFE (88.9 and 86.5) for goats fed sorghum grain with and without monensin, respectively.

Table 4 show that the interaction was not significant at $p<0.05$ for species and ration, best apparent digestibility coefficients of DM, OM and NFE were showed by the Nubian kids followed by the Desert for ration B and C, but the highest values of DCP and DEE was recorded by the Swiss Nubian kids for ration B. For the control ration the best apparent digestibility coefficients for DM and OM were showed by the Desert kids while the Nubian kids showed highest digestibility for CP, EE and NFE.

Nitrogen balance: Monitoring the nitrogen balance is a useful and accurate method of assessing the value of protein to ruminant animals and therefore it is used widely for this purpose.

Table 5 shows that differences in species did not significantly ($p>0.05$) affected nitrogen intake. Obtained results for nitrogen intake were lower than the result reported by Wildeus *et al.* (2007),

Table 5: Effect of species on nitrogen balance

Items	Nubian	Desert	Swiss Nubian	Significance
Nitrogen intake (mg)	11.76±2.23	10.59±3.70	9.02±2.58	ns
Faecal nitrogen (mg)	4.40±1.94	3.28±0.98	3.03±1.28	ns
Urinary nitrogen (mg)	4.01±1.80	3.60±1.09	3.27±1.01	ns
Nitrogen retention (mg)	3.37±2.43	3.71±2.84	2.72±1.22	ns
Nitrogen retention (%)	27.20±19.42	31.91±14.41	30.49±12.90	ns

Values are Mean±SD, ns: Non significant

Luo *et al.* (2004) and Castro-Gonzalez *et al.* (2008) but higher than that indicated by Kahindi *et al.* (2007). Faecal nitrogen was found to be in the range of 3.03-4.40 mg. There were no differences ($p<0.05$) among species in faecal nitrogen. The results obtained in this study were lower than the results reported by Sahoo *et al.* (2002), Wildeus *et al.* (2007) and Castro-Gonzalez *et al.* (2008) but higher than those depicted by Mani and Chandra (2003) and Hindrichsen *et al.* (2002).

Table 5 also shows that the species did not significantly ($p>0.05$) affected urinary nitrogen. Urinary nitrogen ranged from 3.27-4.01 g day^{-1}. These result were higher than results reported by Sahoo *et al.* (2002), Hindrichsen *et al.* (2002) and Castro-Gonzalez *et al.* (2008) but lower than the results indicated by Wildeus *et al.* (2007) and Luo *et al.* (2004).

Nitrogen retention in this study was 3.37, 3.71 and 2.72 for Nubian, Desert and Swiss Nubian kids, respectively. There were no significant ($p>0.05$) differences among species. These estimates were higher than those reported by Castro-Gonzalez *et al.* (2008), Anbarasu *et al.* (2004) and Wildeus *et al.* (2007) for Blackbelly and St. Croix breeds. The higher apparent digestibility coefficients for crude protein in goats and the lower production of ammonia should result in better nitrogen retention (El-Tayeb, 1981).

Table 5 shows that the species did not significantly ($p>0.05$) affected nitrogen retention percentage. Obtained results were higher than estimates reported by Wildeus *et al.* (2007) and Anbarasu *et al.* (2004) but lower than estimates showed by Zhang *et al.* (2008) and Kahindi *et al.* (2007). Excreted faecal and urinary nitrogen was positively related to nitrogen intake. Moreover, faecal nitrogen was also affected by crude protein digestion. The kidney also possesses a specific mechanism in addition to the gastrointestinal tract to modify excretion or retention of urea according to metabolic needs of animals (Gihad *et al.*, 1989). Therefore, the data of these two parameters, as well as total excreted nitrogen, showed fluctuating results among the various animal species fed different rations.

The highest values for nitrogen intake, faecal nitrogen and urinary nitrogen were recorded by the Nubian kids (11.76, 4.40 and 4.01, respectively). The Desert kids recorded highest values of nitrogen retention and nitrogen retention percentage while Swiss Nubian kids showed lowest values.

Table 6 shows that the effect of rations on nitrogen intake was not significant ($p>0.05$). The results obtained in the present study were higher than the results recorded by Zhang *et al.* (2008), Kahindi *et al.* (2007) and Anbarasu *et al.* (2004) but were lower than the estimates reported by Zhang *et al.* (2007) and Luo *et al.* (2004).

Faecal nitrogen values in this study were 3.79, 3.57 and 3.35 mg (Table 6) in treatments A, B and C, respectively. There were no significant differences ($p>0.05$) between treatments. Obtained estimates agreed with the findings of Table 6 shows that the energy protein levels did not

Table 6: Effect of rations on nitrogen balance

Items	Ration A	Ration B	Ration C	Significance
Nitrogen intake (mg)	10.22±2.97	11.56±3.73	9.59±3.17	ns
Faecal nitrogen (mg)	3.79±1.41	3.57±1.40	3.35±1.87	ns
Urinary nitrogen (mg)	3.86±1.01	3.72±1.27	3.30±1.71	ns
Nitrogen retention (mg)	2.60±2.48	4.27±2.24	2.93±1.75	ns
Nitrogen retention (%)	23.06±16.33	36.01±11.57	30.54±16.40	ns

Values are Mean±SD, Means in a row are significant at p>0.05, ns: Non significant

Table 7: Nitrogen balance values of experimental goat kid fed different levels of energy/protein

Species	Rations	Nitrogen intake (mg)	Faecal nitrogen (mg)	Urinary nitrogen (mg)	Nitrogen retention (mg)	Nitrogen retention (%)
Nubian	A	10.05±04.14	05.00±01.53	03.85±01.87	01.28±01.54	10.52±12.05
	B	13.96±02.35	03.97±02.11	04.40±00.88	05.59±00.87	40.58±10.97
	C	11.26±02.67	04.24±02.73	03.77±02.90	03.25±02.61	29.01±25.80
Desert	A	10.97±03.89	03.18±01.52	03.75±00.61	04.04±03.84	32.55±22.40
	B	12.63±04.32	03.80±00.50	04.40±01.19	04.44±03.67	31.69±16.95
	C	08.18±02.40	02.88±00.78	02.65±00.82	02.66±01.20	31.48±06.41
Swiss Nubian	A	09.65±01.20	03.21±00.29	03.97±00.46	02.47±01.45	24.60±11.80
	B	08.08±01.71	02.93±01.49	02.35±00.28	02.79±00.11	35.75±08.28
	C	09.33±04.48	02.95±02.04	03.49±01.30	02.89±01.92	31.12±19.08

Values are Mean±SD

significantly (p>0.05) affected Urinary nitrogen. This result was higher than results reported by Sahoo *et al.* (2002) and Atti *et al.* (2004) but lower than those values reported by Zhang *et al.* (2008), Luo *et al.* (2004) and Snyder *et al.* (2007).

Table 6 shows that the energy protein levels did not significantly (p>0.05) affected Urinary nitrogen. This result was higher than results reported by Sahoo *et al.* (2002) and Atti *et al.* (2004), but lower than those values reported by Zhang *et al.* (2008), Luo *et al.* (2004) and Snyder *et al.* (2007).

Nitrogen retention in this experiment was found to be 2.60, 4.27 and 2.93 in the three treatments A, B and C, respectively. There were no significant differences (p>0.05) between treatments. The values of nitrogen retention observed in the present study were comparable with the results reported by Atti *et al.* (2004) for low and medium protein levels, but were higher than the result reported by Zhang *et al.* (2007, 2008), Hindrichsen *et al.* (2002) and Sahoo *et al.* (2002). Table 6 shows that there were no significant differences (p<0.05) between treatments for nitrogen retention percentages Obtained results were higher than the result indicated by Zhang *et al.* (2008) and Hindrichsen *et al.* (2002), but lower than the results reported by Mani and Chandra (2003).

Table 6 shows that the highest values of nitrogen intake observed in ration B (11.56) while ration A showed highest values of faecal nitrogen and urinary nitrogen. Nitrogen retention and nitrogen retention percentage was highest in ration B and C.

Table 7 show that the species×ration interaction was not significant (p>0.05) for studied traits, The highest values of nitrogen intake and nitrogen retention in ration B and C were observed in Nubian kids rather than Desert and Swiss Nubian kids. Highest value of faecal nitrogen was showed in Nubian kids in all experimental ration while urinary nitrogen was similar value in ration B for Nubian and Desert kids. Highest value of nitrogen retention percent was found in the Nubian kids for ration B.

CONCLUSION

The digestibility of nutrients of experimental diets indicated that the dry and organic matter, ether extract and nitrogen free extract digestibility increased significantly with increasing energy: protein in the test diets, with overall higher nitrogen retention in the Nubian goats than the other two ecotypes which were observed with similar responses. It is likely that the Nubian goats are well adapted to be raised intensive conditions due to their efficient utilization of nutrients.

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