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Dietary Levels of Energy and Protein for Optimal Growth of Crossbred Anglo-Nubian Goats in Samoa

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ABSTRACT

Eighteen crossbred Anglo-Nubian does, 20-24 months of age; 20.9 ± 0.12 kg, BW were used to investigate dietary levels of energy and protein for growth in the tropical environment of Samoa. The goats were divided on the basis of weight, to three groups in a completely randomized design experiment and offered experimental diets at three protein and energy levels: 16.6, 13.4 and 12.4% CP and 11.3, 13.4 and 14.4 MJ GE/kg for eight weeks. The diets were designated as high protein low energy (HPLE), medium protein medium energy (MPME) and low protein high energy (LPHE). Voluntary dry matter (DM) intake (concentrate and forage) was 1217, 1158 and 1096 g/kg$^{0.75}$/d/doe for the HPLE, MPME and LPHE diets, respectively. Voluntary intake of the concentrate portion and total DM intake decreased with increase in the levels of energy but not with levels of protein. ADG were 95, 130 and 89 g/doe/day for HPLE, MPME and LPHE diets, respectively. Organic matter (OM) digestibility by goats fed HPLE, MPME and LPHE diets were 67.8±0.04, 69.2±0.02 and 63.2±0.08%. Crude protein digestibility was significantly higher ($P<0.05$) with goats fed in HPLE and MPME diets, while digestibility of energy was higher ($P<0.05$) in LPHE and MPME, respectively. CF digestibility was significantly lower in the goats on HPLE diet. Daily CP and ME intakes of goats were 0.202, 0.161 and 0.132 (g protein N/kg$^{0.75}$/d) and 6.2, 7.9 and 9.3 (KJ/kg$^{0.75}$/day) for HPLE, MPME and LPHE diets, respectively. Based on data from this study the estimated protein and energy requirements for optimum growth of crossbred Anglo-Nubian goats is 13.4% CP and 13.4 MJ GE/kg BW.

Key Words: Dietary; Energy; Protein; Crossbred Anglo-Nubian goats; Optimal growth

INTRODUCTION

All over the world, there are different breeds of goats and each is adapted to particular environmental conditions and has different nutritional requirements. Anglo-Nubian goats and their crosses found in the Pacific Island countries (PICs), were introduced some years ago (Amoah, 1985). Information on dietary levels of protein and energy of tropical breeds of goats are scant, however, few attempts have been made to determine their requirements for growth and maintenance (Onwuka & Akinsoyinu, 1989) reproduction and lactation (Akinsoyinu, 1974; Osuagwuh, 1984; Osuagwuh & Akinsoyinu, 1990; Aregheore *et al.*, 1992).

In the PICs, the traditional system of feeding goats is based on the use of kitchen waste, browsing and to a less extent the use of agricultural by-products. This practice is perhaps the major cause of low productivity from these animals, as the feeds consumed may be inadequate both in quality and quantity to meet their requirements. There is limited information on the feed intake and nutrient utilization of this breed of goats under the traditional or organized systems of production. Therefore, it has not been possible to formulate complete rations adequate in nutrients, particularly energy and protein that are capable of promoting good growth and efficient meat production.

No attempts have been made to establish the dietary levels of energy and protein of the crossbred Anglo-Nubian goats in the Pacific Island countries. An estimate of optimal dietary protein and energy levels at which efficiency of utilization is optimal is essential for the understanding of the nutritional requirements for the growth of crossbred Anglo-Nubian goats in the tropical environment of Samoa, South Pacific region. The objective of this trial, therefore, was to assess the energy and protein requirements of growing crossbred Anglo-Nubian goats in Samoa.

MATERIALS AND METHODS

Animals, feed preparation and management. Eighteen growing female crossbred Anglo-Nubian goats between 20-24 months of age and pre-trial average live weight of 20.9 ± 0.12 kg were divided on the basis of weight to three treatment groups in a completely randomized design experiment. In each treatment there were six replicates. Two animals were housed in a pen. For each treatment three pens that had previously been disinfected were allocated. Pens had concrete floors covered with wood shavings as litter. Feed and water troughs for group feeding were provided in each pen. Also attached to each pen was a secured plastic container for forage.

The eighteen goats were fed experimental diets at the following three protein and energy levels: 16.6, 13.4 and

12.4% crude protein (CP) and 11.3, 13.4 and 14.4 MJ GE/kg for eight weeks. The diets were designated as high protein low energy (HPLE), medium protein medium energy (MPME) and low protein high energy (LPHE). The letters P and E stands for protein and energy, respectively**.**

The feed ingredients used in the preparation of the experimental diets (concentrates) were cassava flour, dried brewers' grains, urea (46% N), mineral and vitamin premix and salt. Cassava tubers of a sweet variety (*Manihot dulcis*) were harvested from the Crop Science Discipline Farm located in the School of Agriculture. The tubers were peeled with a bush knife and the pulp cut into chips. These were dried in the sun and ground in a hammer chipper passing through 6 mm screen. The brewers' grains were obtained wet from the Western Samoa Breweries Limited, Apia. These were spread on a concrete floor and sun dried to a constant moisture content. These ingredients were used to compound the experimental diets. The percent composition of experimental diets offered to the goats is provided in Table I. For each pen, goats were given 2.5 kg of the concentrate portion and 2.0 kg of forage (guinea grass – *Panicum maximum*). The concentrate portion for each pen was weighed out for a week. Concentrate and forage portions were offered *ad libitum* to the goats (10% in excess of the previous day's intake) during which they also had free access to fresh clean water. Records of feed intake and weekly body weight changes were kept. Feeds not consumed within 24 h were collected, weighed, the amount recorded and feed residue discarded. The animals were allowed a 10 d adaptation period to get used to the concentrate supplement followed by 56 d of feeding. The difference between the initial and final average live weights was used to compute live weight gain.

Digestibility study. At the end of the experiment, all the animals in each treatment group were used for metabolic studies. Since, they were still on the same diet and environment digestibility study started two days after the end of the growth phase. Concentrate and forage portions were given in two equal portions at 8:30 and 17:30 h. The total faecal collection method was used (Aregheore, 1997). Faeces voided were collected for seven days. Total daily faecal outputs for animals in each pen were weighed and a 25% sample was removed for dry matter determination. Samples of forage, experimental diets and faeces were later dried in a forced draught oven at 70^0C for 48 h. The dried daily samples of forage, experimental diets and faeces were then bulked separately and milled with a simple laboratory mill and stored in air-tight bottles until required for analysis.

Analytical procedures. The AOAC (1995) method was used for nutrient contents of feed ingredients, forage, experimental diets and faeces. All analyses were done in triplicate. . Dry matter was determined by drying at 102^0C for 24 h, ash by firing at 600^0C for 24 h, protein by the micro-Kjeldahl procedure (N x 6.25). Gross energy values were determined by a bomb calorimeter (Adiabatic bomb, Parr Instrument Co., Moline, IL) using thermochemical benzoic acid as standard. Crude fibre of the feed ingredients, forage, experimental diets and faeces were determined according to AOAC (1995). Apparent nutrient digestibility coefficients were calculated by difference.

Statistical analysis. Voluntary feed intake, growth rate and apparent nutrient digestibility coefficients were subjected to analysis of variance for completely randomized designs (Snedecor & Cochran, 1980). Where significant differences were observed Duncan's New Multiple Range Test compared treatment means.

Table I. Composition and proximate chemical of experimental diets and forage* (% air dry)

	Diets*		
Ingredients	**HPLE**	**MPME**	**LPHE**
Cassava flour**	39.50	48.50	60.50
Dried brewers' grains***	54.00	46.00	35.50
Urea (46% N)	4.50	3.50	2.00
Mineral/vitamin	1.50	1.50	1.50
Salt	0.50	0.50	0.50
Total	100.00	100.00	100.00
Nutrients (%)			
Dry matter (DM)	94.6	95.1	94.9
Analysis of DM			
Crude protein	16.6	13.4	12.4
Crude fibre	30.8	33.6	35.4
Ether extract	5.5	5.3	5.2
Ash	5.2	5.6	5.8
Organic matter	94.8	94.4	94.2
NFE**	36.5	37.7	36.1
GE (MJ/kg)+	11.3	13.4	14.4

*Forage - Dry matter - 85.2; crude protein - 6.6; crude fibre - 34.8; ether extract - 1.5; ash - 9.4; organic matter - 90.6; nitrogen free extract - 32.9; gross energy - 14.4 (MJ/kg DM); **Dry matter - 90.7; crude protein - 4.6; crude fibre - 2.6; ether extract - 1.0; ash - 0.8; organic matter - 99.2; nitrogen free extract - 82.0; gross energy -11.0 (MJ/kg DM); ***Dry matter - 96.1; crude protein - 23.5; crude fibre - 38.3; ether extract - 8.5; ash - 5.6; organic matter - 94.4; nitrogen free extract -24.1; gross energy - 17.5 (MJ/kg DM); +HPLE - high protein low energy; MPME - medium protein medium energy, and LPHE - low protein high energy

RESULTS

Ingredient chemical composition of ration is shown in Table I. Voluntary concentrate and forage intakes of 734, 700 and 650 g/day/doe and 483, 458 and 446 g/day/doe were obtained for goats on HPLE, MPME and LPHE, respectively (Table III). Total dry matter intake (concentrate and forage) was 1217, 1158 and 1096 g/kg$^{0.75}$/d/doe for HPLE, MPME and LPHE, respectively. Voluntary concentrate intake was higher (P<0.05) in goats offered HPLE followed by MPME and the lowest LPHE. Concentrate intake was observed to decrease with increase in the level of energy concentration. Daily protein and metabolizable energy intakes of goats were 0.202, 0.161 and 0.135 (g protein N/kg$^{0.75}$/d) and 6.2, 7.9 and 9.3 (KJ/ kg$^{0.75}$/d) for HPLE, MPME and LPHE, respectively. Forage intake followed the same trend as concentrate intake (P<0.05).

Average daily live weight gains (ADG) were 95, 130 and 89 g/doe/day for HPLE, MPME and LPHE, respectively. Goats on MPME diet were better (P<0.05) in live weight gain than those goats on HPLE and LPHE diets. Between goats on HPLE and LPHE diets slight differences in live weight gains were observed however; the differences were not statistically significant (P>0.05). Feed efficiency was better in the goats that received MPME diet.

Table II presents data on apparent nutrient digestibility coefficients of goats offered the experimental diets. Apparent digestibility coefficient of CP was significantly higher (P<0.05) for goats on HPLE and MPME diets, respectively while energy was better digested in LPHE and MPME compared to the HPLE diet. Crude fibre (CF) digestibility was significantly lower in the goats on HPLE diet.

Digestible crude protein (DCP) and digestible energy were 12.5, 9.8 and 8.7 (g/kg$^{0.75}$/d) and 7.5, 9.7 and 11.3 (MJ/kg DM) for the goats in HPLE, MPME and LPHE diets, respectively. Apparent organic matter (OM) digestibility of goats in HPLE, MPME and LPHE diets, were 67.8±0.04, 69.2±0.02 and 63.2±0.08%, respectively. Goats in the MPME diet had the highest (P<0.05) OM digestibility, but lower in goats in the LPHE. Organic matter digestibility by goats in MPME and HPLE diets were close in value. Apparent digestibility coefficients of CF, OM, nitrogen free extract (NFE) and total digestible nutrients (TDN) were comparatively higher (P<0.05) in the MPME diet.

DISCUSSION

The nutrient value of the cassava flour used in the experimental diets corresponded with values reported by Gohl (1981). Nutrient values of brewers' dried grains and guinea grass used in this trial were also similar to those reported by Susumu (1999) and Cawa (1999).

Total dry matter intake (concentrate + forage) decreased with increase in the levels of energy and not with levels of protein. Goats in the MPME and LPHE diets

Table II Performance characteristics of goats fed the experimental diets

Parameters	Diets+		
	HPLE	MPME	LPHE
Initial live weight (kg)	21.0 ± 0.08	20.8 ± 0.09	21.1 ± 0.20
Final weight (kg)	26.3 ± 0.32	28.1 ± 0.46	26.0 ± 0.38
Body weight gain (kg)	5.3 ± 0.24b	7.3 ± 0.37a	4.9 ± 0.18b
Daily gain (g)	95b	130a	89b
Average daily concentrate intake (g)	734a	700ab	650b
Average daily forage intake (g)	483a	458ab	446b
Total dry matter intake (conc. + forage) (g/kg $^{0.75}$/day)	1217a	1158ab	1096b
Daily protein (N x 6.25) intake (g protein N/kg$^{0.75}$/d)	0.202	0.161	0.135
Metabolizable energy intake (KJ/kg$^{0.75}$/day)	6.2	7.9	9.3
Feed efficiency (feed/gain)	12.8	8.9	12.3

Table III Apparent digestibility coefficients of nutrients

Nutrients (%)	Diets*		
	HPLE	MPME	LPHE
Dry matter	63.2 ± 0.22ab	66.2 ± 0.06a	61.5 ± 0.18b
Crude protein	75.5 ± 0.05a	72.9±0.02a	64.6±0.18b
Crude fibre	62.1 ± 0.04b	73.3 ± 0.06a	70.1 ± 0.10ab
Organic matter	67.8±0.04a	69.2±0.02a	63.2 ± 0.08b
Nitrogen free extract	46.3 ± 0.16b	50.1 ± 0.12a	52.2 ± 0.08c
Total digestible nutrients	60.1 ± 0.06a	62.1 ± 0.04a	53.2 ± 0.20b
Gross energy	66.2 ± 0.03c	72.6 ± 0.08ab	78.6 ± 0.16a
Digestible crude protein (g/kg $^{0.75}$/day)	12.5±0.28	9.8±1.10	8.7±0.90
Digestible energy (MJ/kg DM)	7.5±1.40	9.7±0.86	11.3±0.29

*HPLE - high protein low energy; MPME - medium protein medium energy; LPHE - low protein high energy; Figures in the same row not marked by the same prefix are significantly different from one another (P<0.05); ± sd

therefore consumed smaller amounts of concentrates to meet their requirements for growth. It has been reported that animals tend to consume less if a diet is high in energy (Aregheore, 1988). Therefore, the high concentrate intake observed in goats fed HPLE compared to MPME and LPHE could be due to its low energy concentration. It is well known that animals on *ad libitum* feeding will tend to equalise their digestible energy consumption.

Live weight gains of the goats fed the three diets were within the values reported by Susumu (1999), but higher than those of Solomona (1988) for the same breed and age of goats used in this trial. Results of goats' fed the HPLE and LPHE diets demonstrated that high energy and high protein fed separately have effect on growth rate of crossbred Anglo-Nubian goats. The final live-weight range of 26 - 28.1 kg (Table III) indicated that goats were yet to attain full adult live-weight, because under the tropical environment of Samoa full adult live-weight of crossbred Anglo-Nubian ranges between 29 - 32 kg and 34- 40 kg for the doe and buck, respectively (Aregheore, 1999, unpublished data).

Goats fed MPME had the highest OM digestibility and ADG was also higher in that group, portraying the superiority of MPME diet over LPHE and HPLE diets. The results obtained therefore demonstrate that dietary energy and protein should be in equilibrium as attained in MPME diet to meet requirements for growth of crossbred Anglo-Nubian goats under the tropical environment of Samoa.

Increased dietary protein had been observed to cause depression in CF digestibility (Adeneye & Oyenuga, 1976). Depression in CF digestibility in the HPLE diet was a resultant implication of high protein intake. Data on the digestibility of CP and energy demonstrated that the goats responded to the level of concentration of the two critical nutrients and subsequently their utilization for growth. Daily CP and ME intakes of goats in HPLE, MPME and LPHE diets were 0.202, 0.161 and 0.132 (g protein $N/kg^{0.75}/d$) and 6.2, 7.9 and 9.3 ($KJ/kg^{0.75}$/day), respectively and these values meet the requirements of protein and energy for growth (NRC, 1981). However, the best ADG was obtained in the goats that had daily protein and metabolizable energy intakes of 0.161 (g protein $N/kg^{0.75}/d$) and 7.9 ($KJ/kg^{0.75}$/day), respectively.

Dietary protein and energy levels of 13.4% CP plus 13.4 MJ GE/kg BW (MPME diet) seems to be the best among the three diets to satisfy the protein and energy requirements for optimum growth of goats in the tropical environment of Samoa. ADG among goats in the three diets was highest in the MPME diet. NRC (1981) suggested that 11 – 12% CP concentration was adequate to meet requirements for moderate gains in goats however in this experiment goats offered the LPHE diet (12.4% CP) had the lowest growth rate.

In conclusion, goats fed diets containing 13.4% CP and 13.4 MJ GE/kg BW performed better in the tropical environment of Samoa, South Pacific region.

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REFERENCES

Adeneye, J.A. and V.A. Oyenuga, 1976. Energy and protein requirements of West African Dwarf sheep. 1. Effect of feeding four levels of dietary energy to sheep. *East African Agric. Forestry J*., 42: 89–97

Akinsoyinu, A.O., 1974. Studies on protein and energy utilization of the West African Dwarf goats. *Ph.D Thesis*, p. 206. Univ. of Ibadan, Ibadan, Nigeria

Amoah, E.A., 1985. Goat production in the Pacific region, *Alafua Agric. Bull.*, 3: 37–53

AOAC, 1995. *Official Methods of Analysis*, 15th Editions. Association of Official Analytical Chemist, Washington, DC

Aregheore, E.M., 1988. The value of different cassava (*Maniholt esculenta*, Crantz) by-products in sheep nutrition. *East African Agric. Forestry J.*, 54: 223–38

Aregheore, E.M., 1997. Effect of sex on fed intake, growth and nutrients digestibility of Blackhead sheep fed complete mash rations of crop residues. *J. Anim. Feed Sci*., 6: 71–9

Aregheore, E.M., C.O.C. Chibanga and J.C.N. Lungu, 1992. Effect of plane of nutrition on body weight and birth weight of pregnant Gwembe Valley goats in Zambia. *Small Rum. Res.*, 201–8

Cawa, K., 1999. Performance of crossbred Anglo-Nubian goats fed water hyacinth (*Eichhornia crassipes*) in the South Pacific. *B. Agric. Special Project.* p. 20. The University of the South Pacific, School of Agriculture, Apia (Samoa)

Gohl, B., 1981. *Tropical Feeds. Feed Information Summaries and Nutritive Values.* Food and Agricultural organization of the United Nations (FAO), Rome

National Research Council (NRC), 1981. *Nutrient Requirements of Domestic Animals.* Nutrient requirements of goats: Angora, Dairy and meat goats in Temperate and Tropical countries. No.15. National Academy Press, Washington, D.C.

Onwuka, C.F.I. and A.O. Akinsoyinu, 1989. Protein and energy requirements for maintenance and gain by West African Dwarf goats fed cassava (*Manihot utilissima*) leaves with peels as supplement. *Small Rum. Res.*, 2: 291–8

Osuagwuh, A.I.A., 1984. Studies on the protein, energy and mineral utilization by pregnant West African Dwarf goat in humid tropical zone of Ibadan. *Ph.D. Thesis*, University of Ibadan, Nigeria

Osuagwuh, A.I.A. and A.O. Akinsoyinu, 1990. Efficiency of nitrogen utilization by pregnant West African dwarf goats fed various levels of crude protein in the diets. *Small Rum. Res*., 3: 363–71

Sengar, O.P.S., 1980. Indian research on protein and energy requirements of goats. *J. Dairy Sci*., 63: 1655–70

Snedecor, G.W. and W.G. Cochran, 1980. *Statistical Methods.* 7th Ed. Iowa State University Press, Ames, IO

Solomona S.L., 1988. The productivity of goats grazing batiki grass pastures and supplemented with locally produced concentrate diets. *B. Agric. Special Project.* p. 27. University of the South Pacific, School of Agriculture, Apia (Samoa)

Susumu, G.T., 1999. Nutritional value of breadfruit in the diets of growing goats. *B. Agric. Special Project.* p. 17. The University of the South Pacific, School of Agriculture, Apia (Samoa)

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