©South African Society for Animal Science
Peer-reviewed paper: 8th International Conference on Goats

Essential amino acid requirements of meat and milk goats

A.V. Ferreira
Department of Animal Sciences, Faculty of Agricultural & Forestry Sciences, University of Stellenbosch,
Private Bag X1, Matieland 7602, South Africa

Abstract
The essential amino acid (EAA) profile of the Boer goat and Saanen kids was investigated. The EAA composition of the components differed from the whole empty body (WEB) concentration. No significant differences between the two species WEB EAA composition were found. Therefore, the average empty body EAA composition (g EAA/100 g crude protein) for goats was as follows: 5.65 arginine; 2.69 histidine; 2.94 isoleucine; 7.86 leucine; 6.83 lysine; 1.83 methionine; 3.04 phenylalanine; 5.55 threonine; 4.86 valine. This composition can serve as the ideal EAA requirements for growth in meat and milk goats.

Keywords: Boer goat, Saanen, essential amino acids, carcass, offal, whole empty body
E-mail: avf@sun.ac.za

Introduction
Ruminants utilize protein for growth most efficiently when provided with a supply of amino acids that matches tissue requirements (Hussein *et al.*, 1991). It is also recognized that the balance of amino acids required for growth in mammals can be determined from the amino acid composition of body protein (Cole & Van Lunen, 1994). According to Boisen *et al*. (2000) the ideal protein can be defined as the perfect ratio among individual amino acids and nitrogen required for optimal performance. Once the amino acid profile of the ideal protein has been established, it can be used indirectly to identify the limiting amino acids in the diet supplied to the animal in order to achieve a particular productive performance (Chen & Ørskov, 1994). In an attempt to obtain more information on the EAA requirements of goats, the ideal protein concept can be used to determine the optimal amino acid profile required for growth. Ferreira *et al*. (1999) recommended that in ruminants the WEB should be used for this purpose. The potential of the Boer goat as a meat-producing animal was recognised by early researchers such as Owen & Norman (1977). On the other hand most of the male Saanen kids on a dairy farm are being culled at a very early age mainly because of their low growth rates. This may be improved with better knowledge about their nutrient requirements. Since there is no information regarding the EAA requirements of goats, further research is required. The purpose of the present study was to determine: (a) the proportional protein contribution in the carcass, external and internal offal of Boer and Saanen goats relative to whole empty body (WEB) protein, (b) to compare the EAA composition of the carcass, internal and external offal of Boer and Saanen kids and (c) the EAA requirements (ideal protein) for WEB growth of meat and milk goats.

Materials and Methods
A group of 20 castrated goats, 10 Boer goat and 10 Saanen kids, all aged seven months, was slaughtered after receiving a feedlot diet for 60 days. The average live weight of the Boer goats and Saanen kids were 35.03 ± 1.24 kg and 34.90 ± 1.95 kg, respectively. The carcasses were split medially through the vertebrae. The right side of the carcass, external offal (head, feet and skin) and internal offal (heart, heart fat, liver, lungs and trachea, kidneys, kidney fat, gastro-intestinal fat, spleen, diaphragm, stomachs and intestines) were stored at –20 °C. All the body components were milled twice through a carcass mill while still frozen. The EAA composition of the carcass, external offal and internal offal were determined separately. Representative samples of all the components were mixed, according to weight, to obtain a WEB sample. The freeze-dried samples were then milled through a 1 mm screen, thoroughly mixed and stored at –10 °C. The EAA composition of the WEB samples was determined with a BECKMAN SYSTEM 7300 high performance analyser after 22 h of acid hydrolysis (6N HCL) at 110 °C (AOCA, 1997). Analyses of variance were performed on the data using SAS (2000).

©South African Society for Animal Science

Results and Discussion

The mean protein concentration of the WEB was similar between Boer goats (27.64 ± 0.8%, as is) and Saanen kids (28.34 ± 0.9%, as is). There were no significant differences in the proportional protein contribution (Table 1) in the carcass, external offal and internal offal relative to the WEB protein content between the two goat species. Comparing the proportional percentage of protein in the carcass of the goat species to that of sheep (MacRae *et al*., 1993; Ferreira *et al*., 1999) the goats have a higher proportional percentage of protein in the carcass than sheep (38.4 – 49.2%), but a lower proportional percentage of protein in the external offal (34.0 – 38.1%).

Table 1 Proportional protein contribution (%) (mean ± s.e.) in the carcass, external and internal offal of Boer goat and Saanen kids (n = 10) relative to whole empty body protein

Component	Protein distribution (%)	
	Boer goat	Saanen
Carcass	56.51 ± 2.3	56.26 ± 2.3
External offal	21.46 ± 3.1	18.69 ± 2.6
Internal offal	22.03 ± 2.8	25.04 ± 2.7
Whole empty body	100 ± 0.0	100 ± 0.0

The WEB EAA composition remained similar regardless of species and data were therefore pooled (Table 2). The comparison of the EAA composition of carcass, internal and external offal exhibited significant differences in and between species. This illustrates that different organs and tissues have different required amino acid ratios. The average amino acid concentrations of the carcass, internal and external offal also differed ($P < 0.05$) with that of the WEB. This confirms the importance to use WEB values for predicting EAA requirements for growth.

Table 2 The amino acid composition (mean ± s.d.) of carcass, internal-, external offal and whole empty body of Boer goats (BG) and Saanen kids (g EAA/100 g CP) (n=10)

EAA	Carcass		Internal offal		External offal		Whole
	BG	Saanen	BG	Saanen	BG	Saanen	empty body[1]
Arg	5.93 [c] ±0.51	6.23 [b] ±0.31	4.51 [d] ±0.35	3.94 [e] ±0.21	6.33 [b] ±0.62	6.79 [a] ±0.32	5.65 [c] ±0.22
His	2.67 [c] ±0.26	2.80 [c] ±0.18	3.74 [a] ±0.22	3.13 [b] ±0.31	1.33 [d] ±0.18	1.43 [d] ±0.17	2.69 [c] ±0.16
Iso	3.44 [a] ±0.43	3.64 [a] ±0.17	1.99 [d] ±0.30	1.99 [d] ±0.23	2.40 [c] ±0.24	2.57 [c] ±0.17	2.94 [b] ±0.19
Leu	7.32 [d] ±0.81	7.76 [c,d] ±0.32	10.49[a] ±0.77	8.70 [b] ±0.59	5.97 [f] ±0.59	6.50 [e] ±0.40	7.86 [c] ±0.36
Lys	6.37 [b] ±0.99	6.78 [b] ±0.56	6.82 [b] ±0.59	5.19 [c] ±0.64	8.88 [a] ±0.98	9.24 [a] ±0.52	6.83 [b] ±0.42
Met	2.05 [a] ±0.31	2.21 [a] ±0.13	1.79 [b] ±0.18	1.55 [c] ±0.19	1.11 [d] ±0.12	1.07 [d] ±0.10	1.83 [b] ±0.15
Phe	2.79 [d] ±0.27	2.99 [c] ±0.13	4.27 [a] ±0.23	3.39 [b] ±0.35	2.27 [e] ±0.18	2.38 [e] ±0.15	3.04 [c] ±0.13
Thr	5.23 [c] ±0.64	5.60 [b] ±0.23	6.58 [a] ±0.40	5.96 [b] ±0.25	4.61 [d] ±0.49	5.19 [c] ±0.46	5.55 [b] ±0.29
Val	4.55 [c] ±0.51	4.83 [c] ±0.18	6.08 [a] ±0.41	5.36 [b] ±0.22	3.97 [d] ±0.38	4.19 [d] ±0.26	4.86 [c] ±0.23
Σ EAA	40.35 [b] ±1.85	42.84 [a,b] ±1.96	46.27 [a] ±2.71	39.21 [b] ±2.1	36.87 [b,c] ±2.61	39.96 [b] ±2.77	41.27 [a] ±2.07

[a,b,c,d,e,f]Values in rows bearing different superscript letters are significantly different at $P < 0.05$
[1]Average for Boer and Saanen empty body

Table 3 Average body essential amino acid (EAA) composition (g EAA/100 g protein), chemical score (mean ± SD) and EAA index for microbial protein of goats (n = 20)

EAA	Goats	Chemical score[1]	Bacteria[2]
Arg	5.65 ± 0.22	90.2 ± 4.31	5.1
His	2.69 ± 0.16	74.3 ± 8.13	2.0
Iso	2.94 ± 0.19	193.8 ± 3.39	5.7
Leu	7.86 ± 0.36	103.0 ± 4.39	8.1
Lys	6.83 ± 0.42	115.6 ± 5.25	7.9
Met	1.83 ± 0.15	142.1 ± 5.61	2.6
Phe	3.04 ± 0.13	167.6 ± 2.46	5.1
Thr	5.55 ± 0.29	104.5 ± 4.93	5.8
Val	4.86 ± 0.23	127.6 ± 3.67	6.2
EAA Index (%)[3]		96.1	

[1] Chemical score presents the proportion of a specific EAA relative to that of WEB protein; [2] NRC (1996)
[3] EAA index presents the proportion of all the EAA studied relative to that of WEB protein

In order to identify a first- and second-limiting amino acid for goats, the chemical score and resulting EAA index were calculated (Table 3). The chemical score in Table 3 suggests that the first- and second-limiting amino acids in bacterial protein are histidine and arginine. More than adequate ratios are presented for the other amino acids. Richardson & Hatfield (1978) reported that methionine, lysine and threonine were the first three limiting amino acids in growing steers when rumen microbial protein was the sole source of protein. It should, however, be mentioned that, according to Newbold (1988) the importance of arginine may be overestimated when comparing the amino acid composition of tissues with that of the duodenal digesta. Arginine tends to be only semi-essential for ruminants (Boisen *et al.*, 2000) and it is not known if arginine is synthesized or released at adequate rates to meet arginine requirements (Zinn & Owens, 1993). Furthermore, histidine requirements may also be overestimated by using tissue chemical scores, since histidine is found in large endogenous reservoirs as non-protein dipeptides, carnosine and serine (Zinn *et al.*, 2000). Based on the EAA index (Table 3), the microbial protein contains 96.1% of the total EAA needed by the WEB for optimal growth in goats.

Conclusion

The proportion of protein in the carcass of the two goat species investigated was much higher, compared to sheep. The carcass also represents the major site of protein deposition (56%). The EAA required for carcass muscle growth would therefore be required at higher dietary concentrations than the EAA needed for non-carcass proteins. The significant differences in EAA concentration between body components emphasized the use of WEB values for predicting EAA requirements. There were no differences in the EAA composition of the WEB of the meat and milk goats investigated.

References

AOAC, 1997. Official methods of analysis (15th ed.). Association of Official Analytical Chemists, Arlington, VA, USA.

Boisen, S., Hvelplund, T. & Weisbjerg, M.R., 2000. Ideal amino acid profiles as a basis for feed protein evaluation. Livest. Prod. Sci. 64, 239-251.

Chen, X.B. & Ørskov, E.R., 1994. Amino acid nutrition in sheep. In: Amino Acids in Farm Animal Nutrition. Ed. D'Mello, J.F.P., Guildford, UK.

Cole, D.J.A. & Van Lunen, T.A., 1994. Ideal amino acid patterns. In: Amino Acids in Farm Animal Nutrition (Chapter 5). Ed. D'Mello, J.F.P., Guildford, UK.

Ferreira, A.V., Van der Merwe, H.J., Loëst. C.A. & Fair, M.D., 1999. Amino acid requirements of South African Mutton Merino lambs. 2. Essential amino acid composition of the whole empty body. S. Afr. J. Anim. Sci. 29, 27-39.

Hussein, H.S., Jordan, R.M. & Stern, M.D., 1991. Ruminal protein metabolism and intestinal amino acid utilization as affected by dietary protein and carbohydrate sources in sheep. J. Anim. Sci. 69, 2134-2146.

MacRae, J.C., Walker, A., Brown, D. & Lobely, G.E., 1993. Accretion of total protein and individual amino acids by organs and tissue of growing lambs and the ability of nitrogen balance techniques to quantitate protein retention. Anim. Prod. 57, 237-245.

Newbold, J.R., 1988. Nutrient requirements of intensively reared beef cattle. In: Recent Advances in Animal Nutrition (vol 2). Eds. Haresign, W. & Cole, D.J.A., Butterworths, London.

Owen, J.E. & Norman, G.A., 1977. Studies of the meat production characteristics of Botswana goats and sheep. 2. General body composition, carcass measurements and joint composition. Meat Sci. 1, 283-306.

Richardson, C.R. & Hatfield, E., 1978. The limiting amino acids in growing cattle. J. Anim. Sci. 46, 740-745.

SAS, 2000. Statistical Analysis Systems user's guide (Version 8.2). SAS Institute Inc., Cary, N.C., USA.

Zinn, R.A. & Owens, F.N., 1993. Ruminal escape protein for lightweight feedlot calves. J. Anim. Sci. 71, 1677-1687.

Zinn, R.A., Alvarez, E.G., Monto, M.F. & Ramirez, J.E., 2000. Interaction of protein nutrition and laidlomycin on feedlot growth performance and digestive function in Holstein steers. J. Anim. Sci. 78, 1768-1778.