Protein deposition in pigs as influenced by sex, type and livemass. 2. Estimation of the requirements of digestible ideal protein

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Protein deposition rate was measured in 100 lean and obese pigs of both sexes (boars and gilts) fed *ad lib*. The intakes of digestible ideal protein (DIP) and deposition rates of body protein was used to calculate conversion ratios of DIP to body protein at various livemasses for the different groups. The efficiency of DIP conversion to body protein decreases with increased bodymass. Estimations of DIP requirements were finally made.
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Proteïenneerleggingstempo is in 100 maer- en vet varke van beide geslagte (bere en sôe) wat *ad lib* gevoer is, gemeet. Verteerbare ideale proteïen (VIP)-innames en proteïenneerleggingstempo's is gebruik om omsetverhoudings van VIP na liggaamsproteïen by verskillende lewende massas vir die verskillende groepe varke te bepaal. Die doeltreffendheid van VIP-omset na liggaamsproteïen neem af met toenemende liggaamsmassa. VIP-behoeftes is laastens beraam.
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Introduction

Lysine is generally considered the first limiting essential amino acid. According to Henry, Duee & Sevé (1979) the second limiting factor is nitrogen or non-essential amino acids. Different modes of expression of amino acid requirements have been proposed. It can either be expressed as a percentage of the entire diet (NRC, 1973; ARC, 1981), in relation to the energy content of the diet (Henry, *et al.*, 1979; Henry, 1980; Wiesemüller, 1983), or in terms of an 'ideal protein' (Cole, 1979; Cole, Yen & Lewis, 1980; ARC, 1981).

The concept of an 'ideal protein' as described by Cole (1979) and Cole, *et al.* (1980) is based on the assumption that the relative amounts of the different essential amino acids needed for the deposition of 1 g of lean should be the same for pigs growing at different rates and for different sexes, breeds and livemasses. Pigs of different classes (i.e. livemass, sex, breed, etc.) would then require different amounts of a particular quality of protein which is defined as the 'ideal protein' (Cole, 1979).

Henry, *et al.* (1979) stated that the most precise parameter for estimating amino acid requirements is to determine lean tissue gain (deposited protein) and that the development of the requirement for each essential amino acid and total protein is reflected by the pattern of protein deposition in tissues, the latter being dependent on age. They furthermore suggested that more experimental data on the characterization of lean tissue growth as influenced by the genetic and physiological capabilities of the animal are required before a more accurate modelling of the amino acid requirements of the animal can be considered.

A study was consequently performed to characterize and quantify protein deposition during growth in pigs different in type (lean and obese) and sex (boars and gilts). The results obtained were used to calculate digestible 'ideal protein' requirements.

Materials and methods

Growth rate and the rates of feed intake and protein deposition were determined in 25 lean boars (LB), 25 lean gilts (LG), 25 obese boars (OB) and 25 obese gilts (OG) at various livemasses using the allometric autoregression (AA) growth model as described by Siebrits, Kemm, Ras & Barnes (1985). A diet containing 18% protein, 1% lysine and 13,46 MJ DE/kg on an 'as is' basis was fed *ad lib* to the pigs from 6 weeks of age to 110 kg livemass. They were slaughtered sequentially at intervals of 5 kg.

In Table 1 the calculated amino acid composition of the

Table 1 Calculated amino acid composition of the experimental diet containing 18,17% crude protein

Amino acid	Percentage of diet	g/kg protein	Relative to lysine
Lysine	1,07	59,0	100
Methionine + cystine	0,68	37,2	63
Threonine	0,73	40,3	68
Tryptophan	0,19	10,4	18
Leucine	1,6	88,1	150
Isoleucine	0,82	45,0	76
Histidine	0,41	22,7	39
Tyrosine + phenylalanine	1,18	64,9	110
Valine	0,93	51,2	87

experimental diet fed is expressed relative to protein and lysine content.

According to Table 1 the amino acid balance of the diet relative to the lysine content was adequate in terms of the 'ideal protein' as described by the ARC (1981). The lysine content relative to crude protein was, however, only 84,1% (i.e. $\frac{58,9}{70}$) of that recommended by the ARC (1981), so that the ideal protein content of the diet was 84,1% of the crude protein content. Assuming an arbitrary digestibility figure of 82,1%, the calculated digestible ideal protein (DIP) content was 69% of the dietary crude protein. The conversion ratio of DIP to body protein was calculated by dividing intake by protein deposition (Siebrits, *et al.*, 1985).

Results and Discussion

By multiplying the factor 0,69 with the crude protein intake of the LB group at 30 kg (294 g), a value of 203 g/day was obtained which corresponds exactly with the figure given by the ARC (1981) for a 33 kg pig depositing 124 g protein per day. The LB group deposited 125 g/day at 30 kg livemass. DIP intakes of the LB group at different livemasses could therefore be calculated by multiplying crude protein intake by 0,69. The OB group deposited 106 g protein per day at 30 kg requiring a DIP intake of 167 g/day according to ARC (1981). Their intake of crude protein was 274 g which means the 'effective DIP' content of the diet was 61% of the crude protein content and that the surplus ideal protein was possibly deaminated and utilized as energy. The corresponding 'effective DIP' figures for the LG and OG groups were 0,55 and 0,46 respectively. Assuming that these DIP content figures do not change during the growth period, that maximum rates of protein deposition were attained and that 'effective DIP' intakes were therefore equal to requirements, DIP requirements were calculated for the experimental groups at different livemasses (Table 2).

The conversion ratios of DIP to body protein of the experimental groups at different livemasses are presented in Table 3 from where it is evident that the conversion ratio varies according to type, sex and livemass.

However, the variation between types and sexes is not very large in the case of LB, LG and OB groups. The LB and OB groups had practically the same conversion ratios whereas the LG group was consistently 10% more efficient than the boars. The development of the conversion ratio of the OG group was entirely different from that of the other groups. It is probable that the difference between the DIP conversion ratios of the sexes is an artifact due to the procedures employed in calculating 'effective DIP' intakes. The ARC (1981) listed factors affecting the efficiency of protein utilization as being: digestibility, protein quality, amino acid availability, and dietary energy which are all taken account of or do not vary between groups and livemasses. They furthermore named livemass and stated that the efficiency of utilization falls with increasing livemass. Animals which deposit protein at different rates when given the same amount of diet must also have different efficiencies (ARC, 1981). Fowler (1984) calculated daily ideal protein requirements factorially by using a constant gross efficiency of ideal protein utilization between 10 and 100 kg livemass of 0,5. This is clearly a procedure followed in the absence of available data.

Table 2 Digestible ideal protein requirements (g/day) at different livemasses calculated from crude protein intakes assuming that 'effective digestible ideal protein' remains constant

Livemass (kg)	Experimental group			
	Lean boars	Obese boars	Lean gilts	Obese gilts
30	203	167	138	138
40	250	211	172	172
50	286	248	198	198
60	311	277	217	216
70	325	300	228	227
80	330	316	233	229
90	325	325	230	224
100	312	328	220	211

Table 3 Conversion ratios of digestible ideal protein to body protein at different livemasses (kg/kg)

Livemass (kg)	Experimental group			
	Lean boars	Obese boars	Lean gilts	Obese gilts
30	1,63	1,58	1,42	1,44
40	1,77	1,74	1,57	1,71
50	1,89	1,87	1,69	1,97
60	2,00	1,99	1,79	2,20
70	2,09	2,09	1,89	2,42
80	2,17	2,19	1,97	2,62
90	2,24	2,27	2,05	2,82
100	2,31	2,36	2,13	3,01

Henry (1980) warned that the concept of an ideal protein for growth should be considered with caution because of differences in tissue distribution and amino acid metabolism (differential rates of synthesis and degradation and variable contributions to tissue metabolism and maintenance).

An alternative way of calculating DIP requirements was to assume that the LB group utilized their ingested DIP optimally and could therefore be used as a model to describe the development of DIP conversion ratio with increasing livemass in the other groups. By using the DIP conversion ratios of the LB group at different livemasses, the dietary DIP requirements of the other groups were calculated from their respective protein deposition rates (Siebrits, *et al.*, 1985) and tabulated in Table 4.

Requirements calculated according to the latter procedure (Table 4) are approximately the same as those calculated from intakes (Table 2) for the boars, about 10% higher for LG, and completely different for the OG.

Conclusions

Both of the methods of calculation of DIP requirements are probably erroneous because so many assumptions had to be made. However, both methods illustrate that the efficiency

Table 4 Digestible ideal protein requirements estimated from protein deposition rate (g/day)

		Experimental group			
Livemass	Conversion	Lean boars	Obese boars	Lean gilts	Obese gilts
30	1,63	204	173	158	156
40	1,77	250	214	195	179
50	1,89	285	249	221	191
60	2,00	312	278	242	192
70	2,09	326	299	253	196
80	2,17	330	312	256	189
90	2,24	325	320	251	177
100	2,31	312	321	238	162

of ideal protein utilization varies, at least, with livemass and possibly also with sex and type. These differences could be due to differences in the synthesis and degradation of body protein. The requirements presented in Tables 2 and 4 were calculated assuming that the dietary energy level was sufficient (13,46 MJ DE/kg). According to Henry (1980) the feeding of an optimal supply of amino acids would result in an increase in carcass adiposity due to an improved utilization of available energy. Further work is needed where the calculated DIP requirement is fed at various energy levels.

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