The effects of feed intake and purified cellulose on the endogenous ileal amino acid flow in growing pigs

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The effects of level of feed intake (0·8, 1·2 and 1·6 kg/d) and body-weight of the pig (49 and 92 kg) in Expt 1, and dietary neutral-detergent fibre (NDF; 30, 60, 90, 120 and 150 g/kg) in Expt 2 on the endogenous ileal flow of amino acids (AA) and nitrogen were studied with protein-free diets into which purified wood cellulose was incorporated at the expense of maize starch. In Expt 1, one of the protein-free diets containing 90 g NDF/kg was used. Female pigs were fitted with a simple 'T' cannula at the terminal ileum. In Expt 1, the endogenous ileal AA and N flow, expressed as g/kg dry matter (DM) intake, decreased significantly ($P < 0.05$) with increasing DM intake, except for proline. By contrast, the values expressed as g/d remained constant. There was no significant difference in endogenous ileal flow ($P > 0.05$) between initial body-weights of 45 and 90 kg except for histidine, isoleucine, phenylalanine, threonine, valine and serine, in which the ileal flow determined at the higher body-weight was significantly higher ($P < 0.05$). In Expt 2, the effects of dietary cellulose levels on the endogenous ileal flow of AA and N were not significant ($P > 0.05$), although the values tended to increase as dietary cellulose levels increased for most AA and for N. It is concluded that the daily endogenous ileal flow of AA and N remains relatively similar at different DM intake and cellulose levels. Therefore, correction of apparent ileal digestibility of AA and N to the true ileal digestibility should be made with the endogenous ileal flow values expressed on a daily amount basis, not the values expressed on a DM intake basis.

Amino acids: Endogenous ileal flow: Pig

The determination of true ileal amino acid (AA) digestibility is important to the improvement of feed formulation in pigs (Furuya & Kaji, 1991). When determining true digestibility it is necessary to know the endogenous ileal AA flow. Dry matter (DM) intake is the most commonly used reference base for the endogenous ileal AA. This base assumes that the amounts of endogenous ileal AA are directly related to DM intake; but there have been no studies specifically designed to evaluate the influence of feed intake levels on endogenous ileal AA output and the basis for the endogenous connection is doubtful. Green *et al.* (1987) found a decrease in apparent ileal AA digestibility with decreasing feed intake and suggested that the endogenous flow remained relatively similar at different DM intakes. An increase in endogenous ileal AA flow with higher levels of fibre in the diets has been demonstrated (Sauer *et al.* 1977; Taverner *et al.* 1981). By contrast, Drake (1990) found no effect of increased dietary fibre intake on endogenous ileal N flow. Additionally, an increasing intake of indigestible DM apparently caused no increase in the losses of endogenous protein (Taverner *et al.* 1981). In order to clarify this controversy the present study was designed to determine the effects of feed (Expt 1) and cellulose (Expt 2) intakes on the ileal flow of endogenous AA and nitrogen in pigs.

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MATERIALS AND METHODS
Animals

In Expt 1, six 4-month-old female pigs (Hampshire × (Large White × Landrace)) weighing approximately 45 kg initially were used in a replicated 3 × 3 Latin square design, involving three feed intake levels and three periods. The same pigs were used again when they reached 90 kg (6 months old) in an experiment with the same design.

In Expt 2, a 5 × 5 Latin square design, involving five cellulose levels and five periods, was conducted with five 3-month-old female pigs (Hampshire × (Large White × Landrace), approximately 32 kg initially). All pigs in both experiments were fitted with a simple 'T' cannula at the terminal ileum, approximately 300 mm anterior to the ileo-caecal junction. The cannula and surgical technique were identical to those described by Furuya *et al.* (1974). The pigs were housed and fed in individual concrete-floored pens with no bedding. The room temperature was not controlled. The experiment at 49 kg in Expt 1 and Expt 2 was conducted in the summer and experiment at 92 kg in Expt 1 was conducted in the autumn.

Diets

The composition of the diets used in Expts 1 and 2 is shown in Table 1. Purified wood cellulose was incorporated into diets, replacing maize starch, to provide five levels of neutral-detergent fibre (NDF) from 30 to 150 g/kg. Chromic oxide was added to each diet at a level of 1 g/kg as an indigestible marker. The chemical composition of the diets is given in Table 1. Crude protein (N × 6·25) and indispensable AA composition were determined on only the diet that contained 30 g NDF/kg.

Feeding regimen and sampling of ileal digesta

In Expt 1, the protein-free diet with 90 g NDF/kg was fed at three levels, i.e. 0·8, 1·2 and 1·6 kg/d (air-dry basis). In Expt 2, the pigs were given 1·2 kg protein-free diets/d at five levels of cellulose intake in each period.

Each period of treatment with the diets lasted 4 d. Equal amounts of feed were given every 8 h at 01.00, 09.00 and 17.00 hours each day. Water was supplied *ad lib.* Each treatment period started with the 17.00 hours feeding. Samples of ileal digesta were obtained on the 2nd, 3rd and 4th days of treatment between 13.00 and 15.00 hours, i.e. starting 44 h after initiating treatments. Similar procedures were used previously (Furuya *et al.* 1986; Furuya & Kaji, 1989).

For 3 d between each of the 4 d treatments, the pigs were given 1·2 kg/d of a normal grower diet containing 160 g crude protein/kg. Again this feed was provided as three equal meals at 8 h intervals.

Analytical and statistical procedures

The analysis of N, DM and crude fibre in feed and ileal digesta were carried out according to the Association of Official Analytical Chemists (1975). Dietary NDF content was determined by the method of Van Soest & Wine (1967) and Cr_2O_3 according to the method of Fenton & Fenton (1979). The AA composition of acid-hydrolysates was determined using a Shimadzu (model LC-6A) AA analyser. Protein hydrolysis was carried out using 6 M-hydrochloric acid in sealed, evacuated tubes maintained at 110° for 24 h. Because of a poor resolution between the peaks on the chromatogram for tyrosine and some unknown substance(s), results of tyrosine have been excluded. Tryptophan and cystine were not determined and caution may be required in interpreting methionine data due to its possible underestimation because of oxidation during hydrolysis.

Table 1. *Composition (g/kg) of experimental diets**

Dietary NDF level (g/kg)...	30	60	90	120	150
Ingredients					
Maize starch	826·9	793·7	760·6	727·4	694·3
Purified cellulose†	33·1	66·3	99·4	132·6	165·7
Others‡	140·0	140·0	140·0	140·0	140·0
Chemical composition					
Dry matter	856	857	854	860	865
Crude protein§ (N × 6·25)	3				
Crude fibre‖	22	44	66	88	109
NDF	30	60	90	120	150
Indispensable amino acid composition					
Arginine	0·13				
Histidine	0·07				
Isoleucine	0·11				
Leucine	0·31				
Lysine	0·12				
Methionine	0·06				
Phenylalanine	0·14				
Threonine	0·09				
Valine	0·16				

NDF, neutral-detergent fibre.

* Air-dry basis.

† KC-floc® (purified wood cellulose made from pulp, passed through a 100 mesh screen); Toyo Kokusaku Pulp Co., Ltd.

‡ All diets also contained (g/kg): dextrose 100, tricalcium phosphate 20, sodium chloride 5, potassium carbonate 8, magnesium sulphate 2, vitamin and mineral mixtures 4, chromic oxide 1. Vitamin and mineral mixtures supplied the following quantities (mg/kg diet): retinol 1·3, cholecalciferol 22 μg, α-tocopherol 45, thiamin 6, riboflavin 14, nicotinic acid 36, pyridoxine 6, pantothenic acid 42, biotin 2 μg, cyanocobalamin 20 μg, pteroylmonoglutamic acid 4·8, choline 690, zinc 96, iron 80, manganese 80, copper 16, iodine 1·6.

§ Crude protein and amino acid composition were determined only for dietary NDF level of 30 g/kg.

‖ Calculated from the chemical analyses of the purified cellulose.

The data were analysed by analysis of variance. In Expt 1, feeding level and body-weight effects were tested as well as a feeding level × body-weight interaction. An adjustment for unequal numbers was made by the method of Snedecor & Cochran (1967). The values obtained at the different levels of feeding or cellulose were subjected to simple linear regression analysis.

Calculation of endogenous ileal flow of AA and N

The flows of AA and N through the terminal ileum were calculated using Cr_2O_3 in the diet: Cr_2O_3 in the ileal digesta values according to the following equation:

$$\begin{pmatrix} \text{ileal flow of AA} \\ \text{or N (g/d)} \end{pmatrix} = \begin{pmatrix} \text{ileal AA or} \\ \text{N (g/g)} \end{pmatrix} \times \begin{pmatrix} \dfrac{\text{diet } Cr_2O_3 \text{ (g/g)}}{\text{ileal } Cr_2O_3\text{(g/g)}} \end{pmatrix} \times \begin{pmatrix} \text{feed} \\ \text{intake(g/d)} \end{pmatrix}$$

RESULTS

Endogenous ileal AA output expressed on a daily basis

A protein-free diet contained 3 g crude protein/kg as shown in Table 1, but the calculated ileal AA and N flows were defined as the endogenous ileal flow on a protein-free diet. The endogenous ileal AA and N flows in Expt 1 are shown in Tables 2 and 3. The values for one pig (given 1·2 kg/d at 92 kg) were discarded as the AA:Cr_2O_3 and N:Cr_2O_3 ratios of

Table 2. Expt 1. Endogenous ileal output of amino acids and nitrogen (g/d) at three levels of feeding determined at average body-weights of 49 and 92 kg in pigs given a protein-free diet containing 90 g NDF/kg

(Mean values for no. of pigs shown in parentheses)

| Feeding level (kg/d)... | Body-wt 49 kg | | | | Body-wt 92 kg | | | | Pooled SD† | Statistical significance of: | | Slope of regression§ | Sb |
	0·8 (6)	1·2 (6)	1·6 (6)	Overall mean	0·8 (6)	1·2 (5)	1·6 (6)	Overall mean		L‡	W‡		
Indispensable													
Arginine	0·67	0·69	0·70	0·69	0·78	0·82	1·03	0·88	0·31	NS	NS	0·18NS	0·16
Histidine	0·27	0·27	0·25	0·27	0·31	0·37	0·38	0·36	0·08	NS	**	0·03NS	0·05
Isoleucine	0·40	0·45	0·38	0·41	0·48	0·58	0·54	0·53	0·15	NS	*	0·03NS	0·08
Leucine	0·75	0·74	0·69	0·73	0·79	0·97	0·91	0·88	0·25	NS	NS	0·03NS	0·13
Lysine	0·71	0·70	0·65	0·69	0·62	0·73	0·69	0·68	0·20	NS	NS	0·01NS	0·10
Methionine	0·16	0·14	0·16	0·15	0·19	0·19	0·17	0·18	0·08	NS	NS	−0·01NS	0·04
Phenylalanine	0·49	0·45	0·39	0·45	0·63	0·71	0·76	0·70	0·21	NS	**	0·02NS	0·12
Threonine	0·78	0·69	0·69	0·72	0·89	1·02	0·93	0·94	0·25	NS	*	−0·03NS	0·13
Valine	0·62	0·55	0·53	0·57	0·70	0·81	0·75	0·75	0·20	NS	*	−0·03NS	0·11
Dispensable													
Alanine	0·92	0·82	0·79	0·84	0·91	1·02	1·04	0·99	0·26	NS	NS	0·00NS	0·13
Aspartic acid	1·27	1·23	1·19	1·23	1·32	1·59	1·55	1·48	0·39	NS	NS	0·10NS	0·20
Glutamic acid	1·67	1·56	1·47	1·56	1·63	1·85	1·76	1·74	0·45	NS	NS	−0·04NS	0·23
Glycine	2·22	1·77	1·64	1·88	2·10	2·37	2·90	2·46	1·24	NS	NS	0·14NS	0·63
Proline	3·42	4·31	4·18	3·97	4·71	4·28	7·17	5·45	4·58	NS	NS	2·00NS	2·25
Serine	0·83	0·77	0·78	0·79	0·98	1·13	1·09	1·06	0·25	NS	**	0·04NS	0·14
Nitrogen	3·13	3·34	3·01	3·16	3·74	3·91	4·43	4·03	1·23	NS	*	0·36NS	0·64

NDF, neutral-detergent fibre; Sb, standard error of slope; NS, not significant; L, W, effects of feeding level and body-weight respectively.

* P < 0·05, ** P < 0·01.

† Pooled SD, square root of mean square for error with 29 df.

‡ L × W interactions were not statistically significant.

§ Slope of the regression of endogenous output v. feeding level.

Table 3. *Expt 1. Endogenous ileal output of amino acids and nitrogen (g/kg dry matter (DM) intake) at three levels of feeding determined at average body-weights of 49 and 92 kg in pigs given a protein-free diet containing 90 g NDF/kg*

(Mean values for no. of pigs shown in parentheses)

Feeding level (kg/d)...	Body-wt 49 kg			Body-wt 92 kg			Pooled SD†	Statistical significance of:		Slope of regression§	Sb
	0·8 (6)	1·2 (6)	1·6 (6)	0·8 (6)	1·2 (5)	1·6 (6)		L‡	W‡		
Indispensable											
Arginine	0·98	0·68	0·52	1·14	0·80	0·75	0·34	*	NS	−0·53**	0·17
Histidine	0·40	0·27	0·18	0·46	0·36	0·28	0·09	**	*	−0·25***	0·05
Isoleucine	0·59	0·44	0·28	0·70	0·56	0·39	0·15	**	*	−0·38***	0·08
Leucine	1·10	0·73	0·50	1·16	0·94	0·66	0·26	**	NS	−0·68***	0·13
Lysine	1·05	0·68	0·48	0·91	0·72	0·51	0·21	**	NS	−0·61***	0·11
Methionine	0·24	0·14	0·12	0·28	0·19	0·13	0·09	**	NS	−0·17***	0·04
Phenylalanine	0·72	0·44	0·29	0·92	0·70	0·56	0·23	**	**	−0·50***	0·13
Threonine	1·15	0·68	0·51	1·30	0·99	0·68	0·29	**	*	−0·79***	0·15
Valine	0·91	0·54	0·39	1·02	0·79	0·55	0·21	**	*	−0·62***	0·11
Dispensable											
Alanine	1·35	0·80	0·58	1·33	1·00	0·76	0·30	**	NS	−0·84***	0·15
Aspartic acid	1·86	1·20	0·87	1·93	1·55	1·13	0·44	**	NS	−1·11***	0·22
Glutamic acid	2·44	1·52	1·07	2·38	1·81	1·29	0·51	**	NS	−1·54***	0·25
Glycine	3·25	1·72	1·20	3·08	2·31	2·12	1·49	*	NS	−1·87*	0·74
Proline	5·01	4·20	3·06	6·90	4·17	5·24	5·18	NS	NS	−2·25NS	2·53
Serine	1·21	0·76	0·57	1·43	1·10	0·80	0·30	**	*	−0·79***	0·16
Nitrogen	4·58	3·26	2·20	5·48	3·81	3·24	1·47	**	NS	−2·88***	0·74

NDF, neutral-detergent fibre; Sb, standard error of slope; NS, not significant; L, W, effects of feeding level and body-weight respectively.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

† Pooled SD, square root of mean square for error with 29 df.

‡ L × W interactions were not statistically significant.

§ Slope of the regression of endogenous output v. feeding level.

Table 4. *Expt 2. Endogenous ileal output of amino acids and nitrogen (g/d) in pigs given protein-free diets with different dietary NDF levels*

(Mean values with their standard errors for five pigs)

NDF level in diet (g/kg)...	30	60	90	120	150	SEM	Slope of regression* ($\times 10^{-3}$)	Sb ($\times 10^{-3}$)
Indispensable								
Arginine	0·70	0·74	0·82	0·77	0·67	0·17	−0·12NS	1·64
Histidine	0·29	0·26	0·30	0·30	0·32	0·04	0·35NS	0·38
Isoleucine	0·40	0·36	0·42	0·41	0·46	0·05	0·58NS	0·55
Leucine	0·69	0·61	0·72	0·73	0·80	0·10	1·12NS	1·00
Lysine	0·53	0·49	0·56	0·56	0·62	0·06	0·81NS	0·64
Methionine	0·14	0·13	0·14	0·14	0·16	0·02	0·14NS	0·20
Phenylalanine	0·52	0·51	0·59	0·56	0·64	0·09	0·94NS	0·85
Threonine	0·63	0·57	0·69	0·69	0·76	0·10	1·26NS	1·00
Valine	0·55	0·50	0·60	0·60	0·66	0·08	1·01NS	0·81
Dispensable								
Alanine	0·78	0·70	0·81	0·77	0·77	0·11	0·18NS	1·09
Aspartic acid	1·12	1·06	1·16	1·15	1·16	0·15	0·60NS	1·53
Glutamic acid	1·39	1·23	1·42	1·41	1·45	0·16	0·96NS	1·64
Glycine	1·73	1·87	2·78	2·12	1·70	0·57	0·63NS	5·92
Proline	4·31	3·66	5·44	5·15	2·80	1·52	−5·16NS	15·66
Serine	0·77	0·69	0·83	0·81	0·83	0·12	0·80NS	1·16
Nitrogen	2·97	2·79	3·67	3·44	2·82	0·50	1·19NS	5·19

NDF, neutral-detergent fibre; Sb, standard error of slope; NS, not significant.
* Slope of the regression of endogenous output v. NDF level.

the ileal digesta sample were inordinately high (approximately twice the value of other pigs on the same level of feeding).

The endogenous ileal AA and N flows, expressed as g/d, were not affected ($P > 0.05$) by the level of intake of protein-free diet (Table 2). None of the regressions relating endogenous flow to feeding level was significantly different from zero at each body-weight, although for some AA there was a tendency for a decrease in endogenous flow with increasing feeding levels at the lower body-weight and an increase at the higher body-weight, this being marked for glycine and alanine.

Comparison between the rates of endogenous flow at 49 and 92 kg indicated no significant differences for arginine, leucine, lysine, methionine, alanine, aspartic acid, glutamic acid, glycine and proline. However, for histidine, isoleucine, phenylalanine, threonine, valine, serine and N, the daily output determined at 92 kg was significantly higher ($P < 0.05$) than that at 49 kg.

Endogenous ileal AA output expressed on a DM intake basis

The endogenous ileal AA and N outputs, expressed as g/kg DM intake, are shown in Table 3. On this basis endogenous ileal N and AA flows decreased with the increasing feed intake. The slopes of the regression equations relating endogenous output to feeding level were significantly different ($P < 0.05$) from zero, for N and for all AA except for proline.

Effect of cellulose levels in the diets

As shown in Table 4, the endogenous ileal AA and N flows were not affected by cellulose intake, although for most AA and for N values tended to increase as dietary NDF levels increased. The regressions were positive for all AA and for N except those for arginine and

proline which were negative; however, they were not significant. Proline and glycine were the most prominent dispensable AA of the endogenous ileal AA, while arginine, leucine and threonine were the most prominent indispensable AA.

DISCUSSION

On the assumption that the endogenous flow is divided into two fractions, one a constant fraction and one which varies directly with DM intake, the relationship between the endogenous ileal flow (EI; g/d) and DM intake can be expressed as follows:

$$EI = a + b \times DM \text{ intake (kg/d)},$$

in which a is the constant and b is the slope of this equation. The endogenous flow per unit DM intake can be calculated as follows:

$$EI \text{ (g/kg DM intake)} = \frac{a}{DM \text{ intake (kg/d)}} + b.$$

Since in the present study the slopes of the regression equations were not significantly different from zero for all AA and for N (Table 2), the slope constant b can be neglected. Thus, for lysine, for example, the relationship between the endogenous ileal flow (y; g/kg DM intake) and DM intake (x; kg/d) is expressed by $y = 0.68/x$, in which the constant a, 0.68, represents the average endogenous lysine flow (g/d) determined at the two body-weights (Table 2). The values for lysine obtained in Expt 1 (Table 3) v. DM intake are shown in Fig. 1.

The present observations explain an increase in the apparent ileal AA digestibility with increased DM intake (Haydon et al. 1984; Green et al. 1987). Although Sauer et al. (1982) found that the apparent ileal digestibility of AA was largely unaffected by DM intake, a high level of crude protein, 194 g/kg DM, was used in their experiment; therefore, such effects would have been difficult to detect, as suggested by Green et al. (1987).

Several workers (Sauer et al. 1977; Taverner et al. 1981) have reported an increase in the endogenous ileal AA output per unit DM intake with increasing dietary fibre. However, in the present study with wood cellulose (Expt 2) this effect was not found to be significant. A similar lack of effect was also found by de Lange et al. (1989a) and Drake (1990). In the study of Sauer et al. (1977), with pigs fed on protein-free diets containing increasing levels of cellulose (50, 100 or 150 g/kg), it was found that the total ileal AA flow was 10.95, 13.79 and 14.13 g/kg DM intake. However, the increase in dietary cellulose was associated with a decline in voluntary food intake and if the values are expressed as daily flows the total ileal AA flows at different levels of cellulose were not significantly different: 17.0, 18.7 and 15.7 g/d with cellulose inclusions of 50, 100 and 150 g/kg respectively (Sauer et al. 1977). Taverner et al. (1981) observed significantly greater ($P < 0.05$) endogenous ileal losses with pigs given a protein-free diet containing 50 g cellulose/kg than with no added cellulose, and slight increases in the endogenous ileal flow when dietary NDF level was increased further to approximately 50, 140 and 190 g/kg; the magnitudes of the increases were generally similar to those observed with dietary NDF levels ranging from 30 to 150 g/kg in the present study (Table 4). Furthermore, Taverner et al. (1981) reported that an increase in the amount of indigestible DM passing through the ileum caused no apparent increase in endogenous protein losses. From the findings of the present study and other studies (Sauer et al. 1977; Taverner et al. 1981; de Lange et al. 1989a; Drake, 1990), it may be concluded that cellulose levels do not greatly affect the endogenous ileal AA flow except when the cellulose levels are very low.
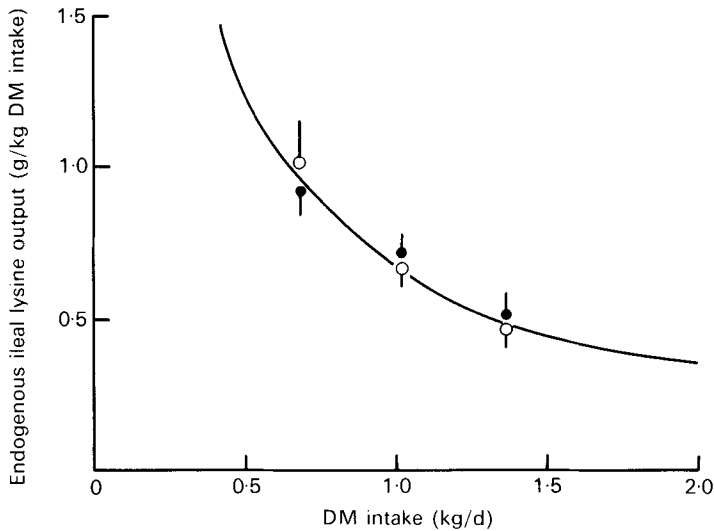
Fig. 1. Expt 1. Effect of dry matter (DM) intake (kg/d; x) on endogenous ileal lysine output (g/kg DM intake; y) in pigs; $y = 0.68/x$, in which the constant value represents the average endogenous ileal lysine output (g/d) obtained at both average body-weights (for details see Table 2). Values are means with their standard errors represented by vertical bars for five or six pigs, determined at 49 kg (○) and 92 kg (●). For details of diets, see Table 1.

The findings of the present study lead to the conclusion that the daily endogenous ileal flow of AA and N remains relatively similar at different DM intake and cellulose levels. This conclusion contrasts with that of Mitchell (1924) who reported on faecal rather than ileal N losses from rats, finding this varied with both feed intake and the fibre content of the diet. A similar finding has also been reported for pigs (Schneider, 1935; Whiting & Bezeau, 1957). The increase in the endogenous faecal N output with DM intake and dietary fibre level is probably a result of the action of the microflora in the large intestine, since a large proportion of faecal N from pigs is of bacterial origin (Mason et al. 1976). The rate of fermentation and, hence, bacterial protein in faeces can be increased by the additional substrate provided on increasing DM intake, more specifically indigestible DM intake, as suggested by Taverner et al. (1981) and Low (1982). Again compared with endogenous faecal N, endogenous ileal flow of AA and N is suggested to be little influenced, if at all, by the action of the microflora (Mason et al. 1976; Laplace et al. 1989).

The endogenous ileal AA flow values have been determined by giving a protein-free diet (Holmes et al. 1974; Sauer et al. 1977; Taverner et al. 1981; de Lange et al. 1989 a, b; Wang & Fuller, 1989) or by regression to zero AA intake using a series of diets containing graded levels of the test source of protein (Taverner et al. 1981; Leibholz, 1982; Furuya & Kaji, 1989), and the two methods have given similar estimates (Taverner et al. 1981; Leibholz, 1982; Kies et al. 1986; Furuya & Kaji, 1989). In the present study, the endogenous ileal flow values of AA and N were determined using protein-free diets. However, the protein-free method is open to some criticism (Sauer et al. 1977; Low, 1982). Sauer et al. (1977) found true digestibility values exceeding 1.00 for proline and glycine due to their overestimated endogenous values. Furthermore, they suggested that endogenous estimates of all other AA were probably also overestimated. However, the results of a regression method by Taverner et al. (1981) suggested that proline and glycine might be exceptional. Recently, de Lange et al. (1989 b) reported that the recovery of endogenous protein in ileal digesta was lower when AA were administered intravenously and that a major part of this difference was due

to a decrease in the recovery of proline and glycine in the ileum. Therefore, it may be concluded that the endogenous ileal AA flow estimated by giving a protein-free diet or by regression analysis can be used to calculate the true ileal digestibility for at least the indispensable AA.

Another problem in the determination of the endogenous ileal AA flow is related to the body-weight of the pig. In the present study the endogenous ileal flow values were shown to vary slightly with body-weight changes, although a significant increase ($P < 0.05$) was observed with increasing body-weight for some AA (Table 2). Armstrong & Mitchell (1955) showed no significant change in faecal N output from a protein-free diet with increasing body-weight in pigs. However, an increase in the endogenous ileal N output with increasing body-weight was observed by Drake (1990), indicating that a heavier animal will have a higher N secretion. Green et al. (1987) fed pigs on two protein-free diets of different cellulose levels at a different body-weight for each diet and suggested that the observed increase in the endogenous ileal AA flow might be due to the dietary fibre levels, but the body-weight changes could also be an explanation for the increase.

In Expt 1 two different ages of the pigs were studied at a different body-weight, and the observed increase in the endogenous flow might be due to the effect of age, although no obvious fact to prove the suggestion has been obtained. Therefore, further studies on endogenous ileal N and AA flow relative to body-weight and age of pigs may be required.

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