Digestion in the pig between 7 and 35 d of age
4. The digestion of amino acids in pigs given milk and soya-bean proteins

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1. In two experiments, forty-four pigs weaned at 4–5 d of age were given diets containing milk or soya-bean proteins until slaughtered at 14, 28 or 35 d of age.

2. Additions of methionine and methionine plus lysine to the diets did not increase the proportions of these amino acids in ileal digesta.

3. In the pigs given a nitrogen-free diet, ileal digesta contained more threonine, proline and glycine than in pigs given diets containing protein.

4. The apparent and true digestibility of amino acids were greater when milk protein was fed than when soya-bean proteins were fed.

5. The apparent digestion of amino acids to the ileum of pigs given isolated soya-bean protein (ISP; Supro 610) increased with increasing age of pigs from a mean of 0·82 at 14 d of age to 0·87 at 35 d of age.

6. When milk protein was fed apparent digestibilities of methionine and lysine to the ileum were 0·912 and 0·905. The apparent digestibility of threonine to the ileum was 0·800, 0·774 and 0·504 for pigs given the milk-, ISP and soya-bean-meal (SBM)-protein diets respectively.

7. Apparent digestibilities of total essential and non-essential amino acids were 0·79 and 0·69 respectively, and true digestibilities of both were 0·82.

Our previous papers (Wilson & Leibholz 1981 *a*, *b*, *c*) have shown that the performance of young pigs given soya-bean proteins is inferior to that of pigs given milk proteins. This can be partially explained by the lower digestibility of the nitrogen in the soya-bean proteins and the poorer hydrolysis of soya-bean proteins in the small intestines.

There is no evidence to show that there is absorption of intact amino acids in the caecum and large intestine of the pig, although a considerable loss of nitrogen does occur (Wilson & Leibholz, 1981 *c*). This must be assumed to be absorbed in the form of non-protein N. Hence, the absorption of essential amino acids can be considered to be complete at the ileum. In a further part of the present experiments, the absorption of essential amino acids to the ileum was measured in pigs given milk or soya-bean proteins, to determine if amino acid absorption could be limiting their performance.

EXPERIMENTAL

Animals and diets

Expt 3. Thirty-six pigs (mean weight 2·05 kg, mean age 7 d) were allocated to six diets as a 3 × 2 factorial with three replicates of two pigs per replicate. Three protein sources were compared in isonitrogenous diets: milk, isolated soya-bean protein (ISP) (Promine D; Central Soya Co., Chicago, Ill.) and soya-bean meal (SBM), each with and without methionine supplementation, and lysine supplementation of the ISP and SBM diets. The composition of the diets is given in Wilson & Leibholz (1981 *a*). After 17 d, one pig per pen was removed and the remaining eighteen pigs were given the experimental diets sprayed

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with indigestible markers for a further 5 d. The pigs were then slaughtered at 28 d of age as described by Wilson & Leibholz (1981 *b*).

Expt 4. Twenty-four pigs (mean weight 2·43 kg, mean age 7 d) were allocated to three diets: an all-milk-protein diet fed either pelleted or liquid or a pelleted diet in which the protein source was ISP (Supro 610; Ralston Purina, St Louis, Mo.). There were eight replicates of one pig per replicate. The composition of the diets is given in Wilson & Leibholz (1981 *a*). Twelve pigs were fed the diets *ad lib.* from 4–5 d of age until 9 d of age and then at 2 g nitrogen/kg live weight$^{0·75}$ per d for 5 d until slaughter at 14 d of age. The other twelve pigs were given the diets *ad lib.* until 30 d of age and then at 2 g N/kg live weight$^{0·75}$ per d for 5 d until slaughter at 35 d of age. An N-free diet was fed to a further two pigs from 30–35 d of age at 45 g DM/kg live weight$^{0·75}$ per d which was similar to the DM intakes of pigs given the protein diets. The pigs were given equal amounts of food every 2 h over the 5 d preceding slaughter. Indigestible markers were administered to the pigs immediately preceding each 2 h feed. The composition of the N-free diet is given in Wilson & Leibholz (1981 *b*).

Indigestible markers

The indigestible markers used were the ^{51}Cr complex of ethylenediaminetetra-acetic acid (EDTA) (^{51}Cr EDTA) (Downes & McDonald, 1964) and ^{103}Ru-labelled Tris-(1,10-phenanthroline)-ruthenium (II) chloride (^{103}Ru-P) (Tan *et al.* 1971). Flow rates were calculated as described by Wilson & Leibholz (1981 *b*).

Amino acid analyses

The amino acid compositions of the experimental diets are given in Tables 1 (Expt 3) and 2 (Expt 4).

Amino acid analyses were determined using ion exchange chromotography (TSM Amino Acid AutoAnalyser; Technicon Equipment Pty Ltd, Sydney). The samples were hydrolyzed in 6 M-HCl under N in an oil-bath at 136° for 24 h. Corrections were made for losses of cystine, methionine and threonine during hydrolysis.

Statistical methods

The data were subjected to analysis of variance with treatment means being statistically compared using least significant difference comparisons (Steel & Torrie, 1960).

RESULTS

Amino acid content of ileal digesta

The addition of methionine or methionine plus lysine to the protein sources in Expt 3 did not increase the proportion of these amino acids in the ileal digesta (Table 1). The glutamic acid content of the ileal digesta of pigs given isolated soya-bean protein (ISP; Promine D; Central Soya Co., Chicago, Ill.) was significantly greater than for pigs given milk or soya-bean meal (SBM). There was significantly less serine in the digesta of pigs given the SBM diet (Expt 3) than for pigs given the other two diets. The ileal digesta of the pigs given milk contained more leucine and less phenylalanine than that of pigs given the soya-bean protein diets.

In Expt 4 (Table 2) there were greater amounts of aspartic acid in the ileal digesta of 14- and 35-d-old pigs given ISP (Supro 610; Ralston Purina, St Louis, Mo.) than in that of pigs given milk protein. There was significantly more leucine, lysine and phenylalanine in the ileal digesta of 14-d-old-pigs given ISP than in the ileal digesta of those given milk.

Amino acids in the digesta from the ileum of 35-d-old pigs given an N-free diet, representing endogenous amino acids in the ileum, are also given in Table 2. There was

Table 1. *Expt* 3. *Proportions of individual amino acids (percentage by weight of the sum of seventeen amino acids) in the diet and ileal digesta of* 28-d-old pigs

Protein source...	Milk			Isolated soya-bean protein*			Soya-bean meal		
Amino acid	Diet	Ileum	Ileum†	Diet	Ileum	Ileum‡	Diet	Ileum	Ileum‡
Essential									
Arginine	3·4	4·6	4·7	8·5	5·9	5·0	6·4	4·8	3·9
Histidine	2·8	3·6	3·8	3·1	2·7	3·0	3·0	3·1	2·9
Isoleucine	5·9	5·3	5·1	5·7	5·2	5·5	5·2	5·5	4·8
Leucine	9·0	7·4	7·4	8·9	7·3	7·3	8·2	7·9	8·4
Lysine‖	8·2	5·4	8·4	7·2 (7·7)	5·4	5·7	7·0 (7·9)	6·9	6·1
Methionine‖	2·8 (4·6)	1·7	1·4	1·4 (4·8)	1·1	1·4	1·9 (4·9)	1·3	1·5
Cystine	1·1	0·6	0·9	1·1	0·7	0·7	1·5	1·1	1·2
Phenylalanine	5·0	3·9	4·2	5·9	5·4	5·1	5·3	5·3	5·6
Threonine	3·9	6·0	5·6	3·4	3·9	4·7	3·5	4·9	4·5
Valine	7·8	7·0	6·9	5·5	6·7	5·8	6·0	7·2	6·7
Non-essential									
Alanine	3·6	4·6	4·8	4·1	4·2	4·0	3·9	5·5	4·6
Aspartic acid	9·0	12·0	9·9	10·9	10·7	10·1	14·0	10·4	12·4
Glutamic acid	17·7	15·7	16·7	18·4	20·4	23·6	18·8	16·9	19·7
Glycine	2·1	6·0	4·4	4·0	5·5	4·9	3·9	6·7	5·0
Proline	9·2	7·3	8·1	5·8	7·2	6·2	5·3	6·9	7·9
Tyrosine	4·3	3·2	3·4	3·6	3·4	3·4	3·8	3·8	3·8
Serine	4·4	5·7	4·3	2·6	4·1	3·6	2·2	1·9	1·9

* Promine D; Central Soya Co., Chicago, Ill.
† Digesta samples from pigs receiving diet supplemented with methionine.
‡ Digesta samples from pigs receiving diet supplemented with lysine and methionine.
‖ Amino acid supplemented diets in parentheses.

significantly less isoleucine, lysine and glutamic acid but more lysine, serine and proline in the digesta of pigs given the N-free diet than in the digesta of pigs given protein diets.

Apparent and true digestion of amino acid

Methionine supplementation of the protein sources in Expt 3 increased the apparent digestion of methionine to the ileum, but resulted in a decrease in the apparent digestion of most other amino acids (Table 3).

In Expt 3, threonine and valine showed the lowest apparent digestibility of the essential amino acids while methionine, lysine and cystine had the highest apparent digestion. Of the non-essential amino acids, glycine and alanine were poorly digested. For both the essential and non-essential amino acids their apparent and true digestion were in the order of milk > ISP > SBM.

The pigs in Expt 4 all received 2 g N/kg live weight$^{0·75}$ per d and there were no differences (except for serine) in the amino acid intakes or amounts absorbed (g/d) (Tables 4 and 5). The apparent digestion of amino acids, however, showed significant differences between the three dietary treatments at 14 d of age. These differences in amino acid digestibility were in the order of liquid milk > pelleted milk > ISP (Supro 610). For 14-d-old pigs, threonine was the least digested from each dietary treatment. Methionine was the best-digested amino acid for pigs given milk protein (0·899 and 0·954) but was poorly absorbed (0·783) to the ileum of pigs given the ISP diet. The opposite situation was observed for arginine.

For pigs at 35 d of age, there were no differences in the apparent digestion of amino acids

Table 2. *Expt* 4. *Proportions of individual amino acids (percentage by weight of the sum of seventeen amino acids) in the diet and ileal digesta of* 14- *and* 35-*d-old pigs*

Protein source...	Milk					Isolated soya-bean protein*			Nitrogen-free
		Pelleted		Liquid					
Age (d)...		14	35	14	35		14	35	35
	Diet	Ileum	Ileum	Ileum	Ileum	Diet	Ileum	Ileum	Ileum
Essential									
Arginine	3·8	4·3	4·1	3·9	4·7	7·8	4·3	4·3	4·3
Histidine	3·0	2·3	2·4	2·1	2·5	3·2	2·2	2·2	2·1
Isoleucine	5·9	4·8	5·5	5·0	5·9	5·6	5·7	4·6	3·5
Leucine	9·2	6·5	8·1	6·1	7·7	8·7	7·9	7·0	6·4
Lysine	8·5	8·0	8·5	8·6	7·9	7·0	8·3	7·5	4·9
Methionine	2·9	1·9	2·1	1·8	2·1	1·3	1·7	1·9	1·2
Cystine	1·0	1·0	1·1	1·4	1·6	1·2	1·3	1·2	1·0
Phenylalanine	5·1	3·2	4·7	3·8	4·4	5·6	4·5	3·9	4·0
Threonine	4·1	6·7	4·8	9·1	5·9	4·1	5·8	5·0	6·1
Valine	7·3	7·3	6·9	6·2	6·1	5·2	6·3	6·0	6·7
Non-essential									
Alanine	3·4	4·6	5·6	6·6	5·7	3·8	5·6	5·4	5·8
Aspartic acid	9·3	8·7	7·8	7·6	8·2	10·7	11·3	11·9	8·6
Glutamic acid	17·6	17·7	18·6	14·9	15·1	19·1	15·8	16·8	11·0
Glycine	2·2	6·4	4·8	6·4	6·3	3·8	4·9	8·5	15·6
Proline	9·0	7·1	6·5	6·1	6·3	6·1	5·7	5·1	10·0
Tyrosine	4·1	2·7	3·7	3·0	3·6	4·0	3·0	2·8	3·2
Serine	3·7	6·7	5·1	7·3	6·0	2·8	5·8	5·5	5·8

* Supro 610; Ralston Purina, St Louis, Mo.

between the dietary treatments, except for arginine and methionine. A similar result was obtained with the 35-d-old pigs as with pigs at 14 d of age, in that methionine was well digested from milk-protein diets (0·879 and 0·915), but had the lowest apparent digestibility of the essential amino acids for pigs given the ISP diet (0·829). Again, the reverse situation was observed with arginine.

The apparent digestion of amino acids to the ileum differed from that of total N (Wilson & Leibholz, 1981*c*). For pigs given the milk-protein diet, the ileal digestibility of N was 0·80 and the apparent digestibility of amino acids ranged from 0·80 for glycine to 0·91 for methionine. For pigs given ISP, the N digestibility was 0·69 while the range of amino acid digestibilities was from 0·75 for glycine to 0·89 for cystine, and for pigs given SBM the ileal N digestibility was 0·51 with a range of amino acid digestibilities from 0·36 for glycine to 0·75 for methionine.

When pigs were fed regularly with restricted amounts (Expt 4), the differences in the ileal digestibilities of N were not as great as when the pigs were fed *ad lib*. However, lower apparent N digestibilities with 14-d-old pigs given the pelleted diets were associated with greater differences in the digestibilities of individual amino acids.

DISCUSSION

A number of workers have demonstrated a similarity between the amino acid composition of duodenal digesta of growing pigs and that of the diet fed (Zebrowska & Buraczewska, 1972; Zebrowska, 1973). This is taken to indicate that endogenous secretion of amino acids is not sufficient to maintain amino acid homoeostasis in the small intestine. However, Zebrowska & Buraczewska (1972) and Zebrowska (1973) found that the amino acid

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composition at the terminal ileum was similar for a range of diets fed, and also similar to the amino acid composition obtained from pigs given an N-free diet. This agrees with the results of Expt 4 for pigs given milk and soya-bean proteins. However, the amino acid composition (g/16 g N) of digesta reaching the ileum of pigs given an N-free diet differed from the ileal composition of pigs given the protein diets. This agrees with the results obtained by Holmes *et al.* (1974), and this may be partially explained by the pancreatic secretions which vary in composition in response to dietary changes (Corring & Saucier, 1972). The amino acid composition of intestinal juice is similar regardless of the diet fed (Horszczaruk *et al.* 1974).

The proportions of threonine, proline and glycine in the ileal digesta from pigs given an N-free diet were greater than for pigs given the protein diets. These amino acids constitute a major fraction of mucoproteins (Horowitz, 1967) and are also concentrated in the pancreatic juice and bile acids – hyocholic acid in particular (Corring & Jung, 1972). Endogenous N has been shown to be less digestible than dietary N (Zebrowska *et al.* 1976), which would account for the accumulation of some amino acids in the ileal contents, while Gitler (1964) has demonstrated that threonine, proline and glycine are among the most-slowly-absorbed amino acids from the intestines of rats. Purser (1976), however, suggests that the high threonine levels observed in ileal digesta are a result of the low affinity of threonine for the transport site.

In the present experiments, the net absorption of amino acid up to the terminal ileum varied between individual amino acids, and with the source of protein fed. Absorption of amino acids to the ileum followed a similar pattern as total N, being greater for milk-protein diets than for the ISP- or SBM-protein diets. Other workers have also found that pigs absorb amino acids from semi-synthetic casein diets more efficiently than other protein sources (Zebrowska, 1973; Zebrowska & Buraczewski, 1977; Zebrowska *et al.* 1978; Low, 1979).

The apparent digestion of individual amino acids obtained from pigs given milk-protein diets are very similar to values obtained with older pigs (60 kg live weight) given a similar diet (Zebrowska, 1973). The utilization of milk-protein diets has been shown not to change with increasing age of pigs (Wilson & Leibholz, 1981 *c*), and so the similarity between the apparent digestion of amino acids from young pigs in the present experiments and pigs of 35–60 kg live weight is as expected.

Utilization of N by pigs given soya-bean protein has been demonstrated to increase with increasing age of pigs (Hays *et al.* 1959; Wilson & Leibholz, 1981 *a*). This is demonstrated from the apparent digestion of amino acids to the ileum of pigs given ISP (Supro 610) which increased for pigs from 14–35 d of age. Also, the values reported in Expt 3 for pigs given SBM are considerably below values obtained with older pigs given SBM (Holmes *et al.* 1974; Zebrowska & Buraczewski, 1977). The apparent digestion to the ileum of lysine, methionine and threonine for example, obtained with 45 kg-live-weight pigs given SBM (Holmes *et al.* 1974) were 0·907, 0·967 and 0·822 respectively, which are greater than the values for 28-d-old pigs in the present experiment (approximately 3·5 kg live weight) of 0·729, 0·745 and 0·585 respectively.

The amino acids showing the greatest apparent digestion varied with the type of dietary protein. For pigs given milk and SBM protein, methionine and lysine showed the highest apparent digestion. For pigs given ISP, arginine had the greatest apparent digestion. The Promine D and Supro 610 diets both contained relatively high levels of arginine, 8·51 g/16 g N, which may acount for its greater digestibility. Faba beans (*Vicia faba*) also contain high arginine levels (7·24 g/16 g N) and Ivan & Bowland (1976) found that arginine was the most efficiently digested amino acid by 35 kg live weight pigs given faba beans.

Methionine and lysine supplementation of the diets resulted in a reduction in the apparent digestibility of other amino acids to the ileum. The digestion of N and DM was also depressed

Table 3. *Expt 3. Daily amounts of amino acids absorbed to the ileum and the apparent and true digestions of amino acids from the small intestine of 28-d-old pigs*

	Protein source	Amino acid supple-ment	Essential									
			Arginine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Cystine	Phenyl-alanine	Threonine	Valine
Apparent absorbtion (g/d)	Milk	−	3·06	2·50	5·59	8·44	7·92	2·72	1·02	4·76	3·31	7·22
		+	2·06	1·88	4·18	6·38	5·52	3·68	0·76	3·58	2·54	5·37
	ISP	−	6·26	2·15	3·92	6·30	5·19	0·97	0·81	4·08	2·21	3·53
		+	2·98	0·81	1·50	2·64	2·55	2·10	0·37	1·70	1·12	1·34
	SBM	−	3·56	1·42	2·48	4·15	4·02	1·09	0·83	2·61	1·65	2·63
		+	3·08	1·42	2·12	3·15	3·80	3·03	0·63	2·04	1·01	2·19
SEM			0·355***	0·281*	0·421***	0·702**	0·566***	0·222***	0·075**	0·424**	0·266***	0·566***
Apparent digestion	Milk	−	0·843	0·825	0·878	0·876	0·905	0·912	0·898	0·884	0·791	0·871
		+	0·717	0·788	0·830	0·841	0·797	0·942	0·841	0·844	0·775	0·821
	ISP	−	0·881	0·840	0·828	0·849	0·863	0·859	0·886	0·830	0·788	0·775
		+	0·729	0·551	0·552	0·619	0·666	0·873	0·707	0·602	0·689	0·512
	SBM	−	0·715	0·614	0·606	0·641	0·729	0·745	0·713	0·627	0·585	0·557
		+	0·721	0·700	0·590	0·550	0·671	0·870	0·633	0·540	0·423	0·513
SEM			0·068	0·056*	0·040***	0·044***	0·035**	0·020***	0·036**	0·052**	0·036***	0·049**
True digestion	Milk	−	0·945	0·884	0·927	0·867	0·953	0·979	0·973	0·948	0·913	0·939
		+	0·797	0·836	0·872	0·889	0·839	0·962	0·911	0·899	0·878	0·881
	ISP	−	0·902	0·867	0·854	0·866	0·892	0·894	0·913	0·859	0·861	0·828
		+	0·752	0·581	0·582	0·642	0·693	0·884	0·753	0·636	0·784	0·660
	SBM	−	0·725	0·631	0·626	0·654	0·748	0·770	0·774	0·651	0·663	0·595
		+	0·732	0·729	0·623	0·581	0·692	0·884	0·670	0·596	0·494	0·579
SEM			0·070	0·059*	0·041**	0·046*	0·039**	0·021**	0·039*	0·051*	0·037**	0·050*

Table 3. (*continued*)

	Protein source	Amino acid supplement	Non-essential: Alanine	Aspartic acid	Glutamic acid	Glycine	Proline	Tyrosine	Serine
Apparent absorption (g/d)	Milk	−	3·11	7·80	16·59	1·75	8·77	4·04	3·87
		+	2·18	5·98	11·95	1·11	6·30	3·07	3·11
	ISP	−	2·75	7·48	12·16	2·49	3·78	2·51	1·71
		+	1·08	3·06	3·56	0·83	1·46	0·98	0·83
	SBM	−	1·40	7·89	9·50	1·07	2·10	1·89	1·20
		+	1·33	5·90	6·81	1·22	1·75	1·46	0·98
SEM			0·359*	0·817*	1·305***	0·240**	0·680***	0·278***	0·264***
Apparent digestion	Milk	−	0·812	0·806	0·879	0·803	0·895	0·887	0·826
		+	0·721	0·790	0·797	0·642	0·808	0·855	0·844
	ISP	−	0·804	0·821	0·795	0·747	0·770	0·832	0·777
		+	0·548	0·580	0·405	0·434	0·517	0·566	0·672
	SBM	−	0·470	0·720	0·657	0·357	0·510	0·630	0·674
		+	0·477	0·607	0·531	0·431	0·450	0·561	0·645
SEM			0·079*	0·046*	0·055***	0·069**	0·076**	0·032***	0·032**
True digestion	Milk	−	0·937	0·862	0·947	1·438	0·976	0·947	0·931
		+	0·833	0·831	0·862	1·150	0·887	0·905	0·935
	ISP	−	0·863	0·853	0·819	0·898	0·846	0·868	0·868
		+	0·619	0·623	0·433	0·698	0·609	0·609	0·788
	SBM	−	0·518	0·735	0·663	0·510	0·573	0·658	0·781
		+	0·564	0·644	0·556	0·612	0·555	0·644	0·745
SEM			0·082*	0·046*	0·059**	0·068**	0·079*	0·033**	0·034*

−, Absent; +, present.
ISP, isolated soya-bean protein (Promine D; Central Soya Co., Chicago, Ill.); SBM, soya-bean meal.
* $P < 0·05$, ** $P < 0·01$, *** $P < 0·001$.

Table 4. *Expt 4. Daily amounts of essential amino acids ingested and absorbed to the ileum and the apparent digestion of amino acids from the small intestine of 14-d-old pigs*

Protein source...	Apparent absorption (g/d)				Apparent digestion				True digestion			
	Milk		ISP		Milk		ISP		Milk		ISP	
	Pelleted	Liquid		SEM	Pelleted	Liquid		SEM	Pelleted	Liquid		SEM
Arginine	0·76	0·83	1·88	0·064	0·822	0·927	0·909	0·020**	0·903	1·011	0·947	0·021**
Histidine	0·65	0·67	0·75	0·041	0·881	0·950	0·886	0·019*	0·945	1·000	0·929	0·020*
Isoleucine	1·26	1·30	1·26	0·085	0·873	0·937	0·836	0·018**	0·917	0·986	0·881	0·020**
Leucine	2·01	2·06	1·96	0·133	0·891	0·952	0·847	0·018**	0·951	1·009	0·909	0·019**
Lysine	1·78	1·92	1·52	0·117	0·852	0·958	0·817	0·029*	0·900	1·005	0·866	0·032*
Methionine	0·64	0·65	0·28	0·041	0·899	0·954	0·783	0·019***	0·930	0·983	0·857	0·020***
Cystine	0·21	0·21	0·26	0·015	0·842	0·901	0·813	0·025	0·958	1·000	0·875	0·027
Phenylalanine	1·14	1·14	1·31	0·074	0·903	0·948	0·870	0·012**	0·968	1·008	0·921	0·013**
Threonine	0·75	0·81	0·82	0·056	0·741	0·849	0·764	0·029*	0·879	0·969	0·862	0·031
Valine	1·47	1·61	1·10	0·118	0·817	0·940	0·797	0·024**	0·899	1·011	0·891	0·025**

ISP, isolated soya-bean protein (Supro 610; Ralston Purina, St Louis, Mo.).
* $P < 0·05$, ** $P < 0·01$, *** $P < 0·001$.

Table 5. *Expt 4. Daily amounts of essential amino acids ingested and absorbed to the ileum and the apparent digestion of amino acids from the small intestine of 35-d-old pigs*

Protein source...	Apparent absorption (g/d)				Apparent digestion				True digestion			
	Milk		ISP		Milk		ISP		Milk		ISP	
	Pelleted	Liquid		SEM	Pelleted	Liquid		SEM	Pelleted	Liquid		SEM
Arginine	1·91	1·77	3·91	0·177	0·836	0·866	0·935	0·018**	0·913	0·961	0·983	0·018**
Histidine	1·57	1·44	1·57	0·096	0·866	0·901	0·921	0·019	0·917	0·950	0·971	0·020
Isoleucine	3·04	2·79	2·74	0·174	0·850	0·882	0·903	0·021	0·894	0·925	0·953	0·022
Leucine	4·76	4·42	4·22	0·271	0·855	0·897	0·905	0·021	0·911	0·959	0·969	0·023
Lysine	4·34	4·08	3·29	0·208	0·842	0·892	0·876	0·016	0·884	0·956	0·931	0·017
Methionine	1·53	1·41	0·58	0·072	0·879	0·915	0·829	0·017*	0·908	0·942	0·900	0·018
Cystine	0·50	0·44	0·57	0·032	0·828	0·819	0·885	0·028	0·902	0·907	0·953	0·028
Phenylalanine	2·63	2·48	2·78	0·161	0·847	0·901	0·918	0·021	0·906	0·964	0·969	0·022
Threonine	1·99	1·80	1·88	0·112	0·812	0·829	0·855	0·028	0·911	0·950	0·931	0·028
Valine	3·71	3·48	2·41	0·192	0·844	0·894	0·863	0·025	0·913	0·967	0·935	0·025

ISP, isolated soya-bean protein (Supro 610; Ralston Purina, St Louis, Mo.).
* $P < 0·05$, ** $P < 0·01$.

(Wilson & Leibholz, 1981 *b*, *c*), and this may be partly attributed to the lower feed intake. It may also be partly due to a competition for absorption sites and perhaps the extent of hydrolysis of the protein sources.

Methionine supplementation of the protein sources in Expt 3 increased the apparent digestion of methionine. This is in contrast to the findings of Wapnir *et al.* (1972) who found that when an amino acid was fed to rats in excess of normal requirements it caused a depression in the subsequent absorption of that amino acid.

A greater absorption of an amino acid has been shown to result following the feeding of a diet low in that amino acid (Nakamura *et al.* 1972; Wapnir & Lifshitz, 1974), while Ivan & Bowland (1976) have shown that methionine was poorly absorbed by pigs given faba beans, which are deficient in methionine. The true digestibility of methionine to the ileum of pigs given ISP (Supro 610) was lower than for milk diets. ISP has been shown to be deficient in methionine for young pigs (Maner *et al.* 1961). The lower digestibility may be attributed to the lower hydrolysis of soya-bean protein in the small intestine (Wilson & Leibholz, 1981 *c*).

The true digestion of amino acids to the ileum of pigs given the milk diets approached 1·00. The proportion of amino acids in the ileal digesta of pigs given these diets would be expected to be similar to the proportions of amino acids in the ileal digesta of pigs given the N-free diet, and thus constitute the endogenous supply of amino acids. This situation was, however, not observed.

For pigs given the liquid milk diet, the true digestibility of amino acids to the ileum of 14-d-old pigs was complete, but the true digestion of N was 0·938. From this it appears that other nitrogenous fractions are less digestible than the amino acids.

From these results it is concluded that the reduced performance of young pigs given soya-bean proteins is the result of the lower digestion of amino acids to the ileum as compared with pigs given milk protein. The apparent digestion of amino acids to the ileum of young pigs given milk protein was similar to that of adult pigs, while the apparent digestion of amino acids to the ileum of pigs given SBM was considerably below the values obtained using older pigs. The apparent and true digestions of amino acids increased from 14–35 d of age for pigs given ISP (Supro 610).

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