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Endogenous N losses at the terminal ileum of young piglets fed diets based on four different protein sources

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ABSTRACT

Fourteen piglets, initially weighing 8 kg, were each fitted with a Post Valve T-Caecum (PVTC) cannula and two catheters, one in a jugular vein and one in a carotid artery. Piglets received one of four experimental diets containing either skimmilk powder (SMP), soyabean meal (SBM), soya protein isolate (SI) or fish meal (FM) as the sole protein source; the crude protein content in the diets was from about 17 to 18.4% of DM. The diets were given in equal amounts at 12 h intervals. ^{15}N-L-leucine was intravenously infused continuously at a rate of about 40 mg ^{15}N-L-leucine per kg body weight per day. Apparent and true faecal nitrogen (N) digestibilities were 94.0 and 97.3, 84.0 and 93.5, 90.8, and 98.1 and 89.1 and 96.4% for the SMP, the SBM, the SI and the FM diets, respectively. Daily endogenous faecal N losses were 315, 963, 715 and 697 mg and daily endogenous ileal N losses were 786, 1422, 1970 and 1558 mg for diets SMP, SBM, SI and FM, respectively. Apparent ileal nitrogen (N) digestibilities were 84.4, 76.5, 78.4 and 73.0%, true ileal N digestibilities were 92.7, 90.6, 98.4 and 89.3% for diets SMP, SBM, SI and FM, respectively.

It was concluded that true N digestibilities were high for all four protein sources, both at the ileal and at the faecal level. Differences in apparent N digestibility were mainly caused by differences in endogenous N secretion.

KEY WORDS: piglet, endogenous nitrogen losses, protein, ileum, faeces

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INTRODUCTION

Ileal apparent protein digestibility values are considered to be good measures for the nutritional value of protein in the diet. The remaining undigested part of the dietary protein, however, is partly from feed protein (exogenous) and or partly from endogenous protein (secreted enzymes, mucus, sloughed off mucosal cells). To distinguish between endogenous and exogenous protein, different methods have been proposed (Souffrant, 1991). Until recently, protein-free diets and regression techniques have been used to measure endogenous nitrogen losses and thus calculate "true" as opposed to "apparent" digestibilities (Souffrant, 1991). Protein-free diets and different protein sources may themselves lead to different levels of endogenous excretion (Huisman, 1990; De Lange et al., 1989). To obtain results on endogenous excretion in normally-fed pigs, the feed protein or protein in the animal body can be labelled with a stable isotope in order to distinguish between endogenous and exogenous protein. From this true protein digestibility (also referred to as "real" protein digestibility) can be calculated (Souffrant, 1991).

Recently, the ^{15}N infusion method for labelling the animal body protein has been introduced and evaluated (Souffrant et al., 1981; De Lange et al., 1990; Krawielitzki et al., 1996 a,b). With this technique a distinction can be made between endogenous and exogenous nitrogen at the faecal or ileal level. Total endogenous nitrogen originates from different sources: saliva, gastric and pancreatic juice, bile, gut wall secretions, sloughed off gut wall cells and bacteria.

The TCA-soluble fraction of the blood plasma is considered to be the precursor (amino acids, small peptides, urea) pool for synthesis of endogenous protein (Herrmann et al., 1986; Souffrant et al., 1981, 1986; Souffrant, 1991). The endogenous nitrogen in digesta or faeces can be calculated through isotope dilution and hence true protein digestibilities can be calculated. Nitrogenous compounds secreted by enterocytes can be synthesized from absorbed resources, therefore the endogenous nitrogen losses measured using the TCA-soluble plasma as the precursor pool will, generally, be somewhat underestimated.

The technique assumes comparable absorption of both labelled and unlabelled amino acids. Also, the extent of labelling of the endogenous nitrogen secretion should not change significantly during the course of the experiment. However, because of the continuous (albeit slow) rise in body protein labelling due to recycling of labelled amino acids, calculated endogenous N values tend to be underestimated (Souffrant et al., 1993).

Especially with young animals, low apparent protein digestibilities are sometimes found at the ileal and the faecal level, especially when vegetable protein (e.g., soya protein) is fed instead of protein of animal origin (e.g., milk proteins). Endogenous N losses can give information on the causes of low apparent digestibilities.

Not much is known about the causes of low apparent digestibilities of different dietary protein sources in young piglets. Digestibility of soya protein is lower for piglets than for older pigs, digestibility of milk protein is high for pigs of all ages (Wilson and Leibholz, 1981 a,b,c). For the development of feeds for newly weaned piglets, it is important to know endogenous nitrogen losses and apparent protein digestibility after weaning. An experiment was undertaken to compare endogenous nitrogen losses derived with the ^{15}N-L-leucine infusion method in young piglets fed diets based on different protein sources.

MATERIAL AND METHODS

Animals, diets and experimental scheme

Fourteen castrated male piglets (Great York, initial live weight 7.5-8.5 kg) were used to measure apparent and true ileal protein digestibilities of four different diets. Piglets did not receive any creep feed during the suckling period. Piglets were weaned between 3 and 4 weeks of age and housed individually on mesh floors, tethered to prevent cannula and catheter damage.

Piglets were fed twice daily at 8.00 h and 20.00 h. Two piglets were fed the diet based on skimmilk powder (SMP), three piglets were fed the diet based on soyabean meal (SBM), six piglets (four experimental and two spare piglets) were fed the diet based on soya isolate (SI) and three piglets were fed the diet based on fish meal (FM). The diets were fed at a level of 380 g per day throughout the experiment (approx. 4% of live weight per day). Composition of the protein sources and diets is given in Tables 1 and 2. The diets were balanced with regard to net energy, crude protein, crude fat, crude fibre and essential amino acids. Chromium oxide at a level of 0.1% was included as a marker for digestibility calculation.

After a 6 day 'cage adaptation' period and an overnight fasting period, the piglets were anaesthetized through inhalation anaesthesia (N_2O, O_2, halothane) and fitted with a Post Valve T-Caecum cannula (Van Leeuwen et al., 1991) at an age of 4 to 5 weeks (approximately 8 kg live weight). Immediately before surgery, lidocaine with epinephrine was administered, subcutaneously and intramuscularly in the area of the incision. The flank area was shaved and disinfected with a general disinfectant. An incision was made in the right abdominal wall in the entera-paralumbar area and at some distance above the mammary tissue. The caecal apex and the terminal portion of the ileum were located, exteriorized and the caecum was removed. The ileum and the large intestine at the site of the

TABLE 1

Composition of the protein feeds

Ingredients	SMP	SBM	SI	FM
Dry matter, %	96.2	87.5	95.2	94.4
In dry matter, %				
ash	8.3	7.1	4.1	13.8
crude protein	35.4	52.6	89.5	75.8
ether extract	0.5	1.7	3.6	10.3
crude fibre	0.0	7.1	1.3	0.1
N-free extractives	55.8	31.5	1.5	0.0
Amino acids				
lysine, % of CP	8.24	5.84	6.01	7.52
threonine, % of CP	4.23	3.72	3.66	4.04
methionine, % of CP	2.70	1.39	1.21	3.01
cystine, % of CP	1.00	1.61	1.12	1.02
tryptophan, % of CP	1.30	1.22	1.04	0.96
trypsin inhibitor, mg inhibited trypsin per g product	–	3.64	6.27	–

SMP = skimmilk powder; SBM = soyabean meal; SI = soya protein isolate; FM = fish meal

removed caecum was exteriorized. The cannula barrel (internal diameter 19 mm, external diameter 24 mm) was placed through the opening which was made not larger than necessary to aid in securing and positioning the cannula barrel. Thus, surgery consisted of a caecectomy in which an opening for the cannula appeared directly opposite the ileocaecal valve (Van Leeuwen et al., 1991).

This cannula allows nearly quantitative collection of ileal chyme (Köhler et al., 1992). Figure 1 shows the location of the cannula. After surgery, a 7 day recovery period was allowed before blood vessel catheterization. Catheters were placed in the external jugular vein (for continuous ^{15}N infusion) and in the carotid artery (for blood sample collection). After catheterization, another 4 day recovery period followed before ^{15}N infusion started. The continuous intravenous ^{15}N-L-leucine infusion was performed at a rate of approximately 40 mg ^{15}N-L-leucine (95% ^{15}N enrichment) per kg body weight per day (Perfusor®-Secura-Dauerinfusionsgerät, Fa. B. Braun, 34212 Melsungen, Germany). Two additional piglets on the SI diet were excluded from ^{15}N infusion.

Sample collection and analysis

From the start of ^{15}N infusion, quantitative faeces and urine collections were made daily. During the first 6 days of infusion the PVTC cannula was closed. Apparent and true faecal N digestibilities were determined from the ingested feed and the excreted faeces during these 6 days. Faeces were collected in plastic bags

TABLE 2

Diet composition

Components	SMP	SBM	SI	FM
Skimmilk powder (35.3% CP)	45.50	–	–	–
Soyabean meal (48% CP)	–	34.40	–	–
Soya isolate	–	–	18.20	–
Fish meal	–	–	–	22.15
Maize starch	29.60	39.84	52.79	52.91
Dextrose	15.00	15.00	15.00	15.00
Sunflower/soya oil	2.00	2.00	2.00	0.50
Cellulose	5.00	2.85	5.00	5.00
Vit/min premix	1.00	1.00	1.00	1.00
Ground limestone	0.80	1.35	1.40	0.75
Mono Ca phosphate	0.50	2.10	2.20	0.60
NaCl	–	0.50	0.50	0.10
$KHCO_3$	0.10	–	1.50	1.00
$NaHCO_3$	0.30	0.40	–	0.80
L-LYS-HCl	–	0.16	0.10	–
DL-MET	0.10	0.20	0.17	0.03
L-THR	–	0.10	0.04	0.05
L-TRY	–	–	–	0.01
Cr_2O_3	0.10	0.10	0.10	0.10
Analyzed composition, %:				
Dry matter	91.0	89.8	90.7	89.6
In dry matter, %:				
crude protein (CP)	16.9	18.4	17.6	18.4
crude fibre	4.1	5.7	4.2	4.4
LYS	1.39	1.21	1.14	1.39
MET	0.56	0.48	0.40	0.59
CYS	0.17	0.30	0.20	0.19
THR	0.71	0.79	0.69	0.81
TRP	0.22	0.22	0.18	0.19
Metabolizable energy, MJ/kg DM	16.63	16.51	17.00	17.30
Net energy, MJ/kg DM	11.64	11.56	11.90	12.11

SMP = skimmilk powder; SBM = soyabean meal; SI = soya protein isolate; FM = fish meal

attached to the animals by means of a colostomy system as used in human medicine (Combihesive-system, Squibb BV, NL 2285 VL Rijswijk). Quantitative urine collections were made and twice daily aliquots were taken and frozen for nitrogen determination. At day 7, 9 and 11 after the start of ^{15}N infusion, ileal chyme was collected for 24 h per day. Digesta were hourly collected and weighed. After freezing they were pooled per animal per day. Digesta and faeces were freezedried and ground (1 mm) before analysis. Feed samples were also ground before analysis. Apparent ileal and faecal N digestibilities were determined from the concentration of marker (Cr_2O_3) in feed and in digesta or faeces.

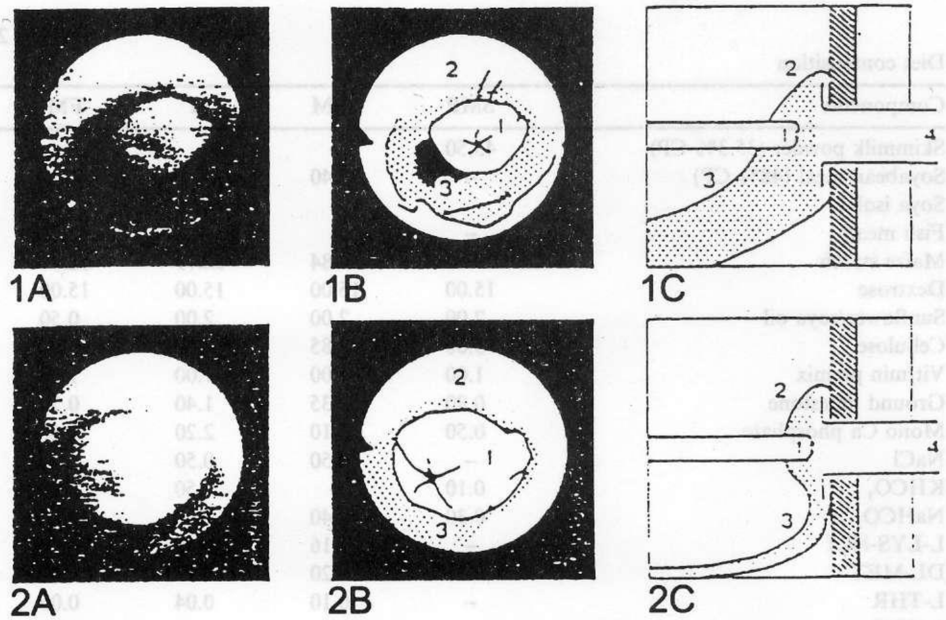

Figure 1. Photographic and schematic presentation of the position of the ileocaecal valve in a PVTC cannulated pig. After opening the cannula the position of the valve changes. Instead of protruding into the intestinal lumen after 15 min it protrudes into the cannula. – Panels 1 (A-C) Directly after opening of the cannula. Panels 2 (A-C) About 15 min after opening of the cannula; A. Endoscopie views through the cannula; B. Schematic linedrawings of 1A and 2A; C. Schematic transsecion through cannula and intestines (1. Ileocaecal valve, 2. Caecum, 3. Colon, 4. PVTC cannula) (Van Leeuwen et al., 1991)

Cr_2O_3 was analyzed in feed, digesta and faeces through flame atom absorption spectrophotometry (Perkin-Elmer 300). Amino acids were analyzed using ion exchange chromatography. Except for MET and CYS, analyses were carried out after hydrolysis with 6N HCI during 24 h at 110^{0}C. CYS and MET were oxidized by formic acid treatment to cysteic acid and methionine sulphone before hydrolysis.

Trypsin inhibitor contents were analyzed according to the method of Van Oort et al. (1989). Blood samples were taken twice daily from the carotid catheter during feeding at 8.00 and 20.00 h. After centrifugation (2500 rpm,10 min), the supernatant was collected and blood plasma protein was precipitated using 20% trichloroacetic acid (TCA). Total N was analyzed in supernatant, precipitate, digesta, urine and faeces according to the Kjeldahl method. After Kjeldahl-N-analysis, the amount of ^{15}N was measured in the NH_4CI-solutions using an emission spectrometer (Isonitromat 5201 or NOI-6, Fa. Statron,15517 Furstenwalde, Germany).

The corrections for ileal and faecal endogenous nitrogen were made from the ^{15}N enrichment excess in TCA soluble fraction of blood plasma and in digesta or faeces during the days of ^{15}N infusion. The contribution of endogenous to total N in ileal chyme or faeces can be calculated from the ratio of ^{15}N enrichment excess in ileal chyme or faeces and in the blood TCA soluble fraction, assuming that the ^{15}N excess in the endogenous N and in the blood TCA soluble fraction is similar. The calculations are carried out according to Souffrant et al. (1986) using the following formula:

$$N_{en} = N_{tot}\ x = \frac{N_{ex\ c/f}}{N_{ex\ bl}}$$

N_{tot} = total N in chyme or faeces (g/day); N_{en} = endogenous N in chyme or faeces (g/day); $N_{exc/f}$ = ^{15}N excess in chyme or faeces; $N_{ex\ bl}$ = ^{15}N excess in the TCA soluble fraction of the blood.

True nitrogen digestibilities were calculated from the apparent digestibilities by subtracting the endogenous nitrogen from the total nitrogen recovered from faeces or ileal chyme. True amino acid digestibilities were calculated from the average amino acid composition of endogenous protein as described by Wünsche et al. (1987).

Statistical analysis was done by one-way analysis of variance and Tukey multiple comparisons ($a = 0.05$) were used to compare means of experimental groups (Snedecor, 1956; Rasch et al., 1978; SAS, 1985).

RESULTS

In Figure 2 ^{15}N enrichment excess in digesta, urine, organs and TCA-soluble blood plasma during ^{15}N-L-leucine infusion is shown. After 6 days of infusion, the percentage enrichment levels off indicating suffcient labelling of animal body protein.

Apparent faecal N digestibility (Table 3) was highest in piglets fed the SMP diet (94.0%) and lowest for the SBM diet (84.0%). Apparent faecal N digestibilities for the SI and FM diets were intermediate (90.8 and 89.1%, respectively). Endogenous N (Table 3) losses at the faecal level were lowest for the SMP diet (315 mg/d) and highest for the SBM diet (963 mg/d). Endogenous N losses on the SI and FM diets were intermediate (715 and 697 mg/d, respectively). True faecal N digestibility (Table 3) was highest for the SI and SMP diets (98.0 and 97.3%, respectively) and lowest for the SBM diet (93.5%). True faecal N digestibility was lowest on the SBM diet (93.5%). True faecal N digestibility on the FM diet was intermediate (96.4%). True faecal N digestibilities were high (>90%) on all diets.

The (apparent and truc) faecal digestibility of LYS was very similar to the digestibility of nitrogen. The true faecal amino acid digestibilities were all higher than 90% while apparent digestibilities were lower, especially for MET with the soya diets and for CYS with the SI and the FM diets.

Apparent ileal N digestibility (Table 4) was highest with the SMP diet – 84.4 compared to 78.4, 76.5 and 73.0% for the SI, the SBM and the FM diet, respectively. Endogenous N losses at the terminal ileum (Table 4) were about twice as high with the SBM diet and the FM diet compared to the SMP diet, resulting in almost similar truc ileal N digestibilities for the three diets: 92.7, 90.6 and 89.3% with the SMP, the SBM and the FM diet, respectively. Especially with the non-milk diets, apparent ileal CYS digestibility was quite low compared to the other amino acids. With the SI diet endogenous losses were about 2.5 times higher compared to the SMP diet. The true ileal N digestibility for the SI diet was 98.4%.

No differences were found in either apparent or true ileal LYS digestibility between the diets. For MET and CYS, differences between diets were only found in apparent ileal digestibility, not true ileal digestibility. Ileal LEU digestibility was highest for the SMP diet – 94.0 and 97.0% for apparent and true values,

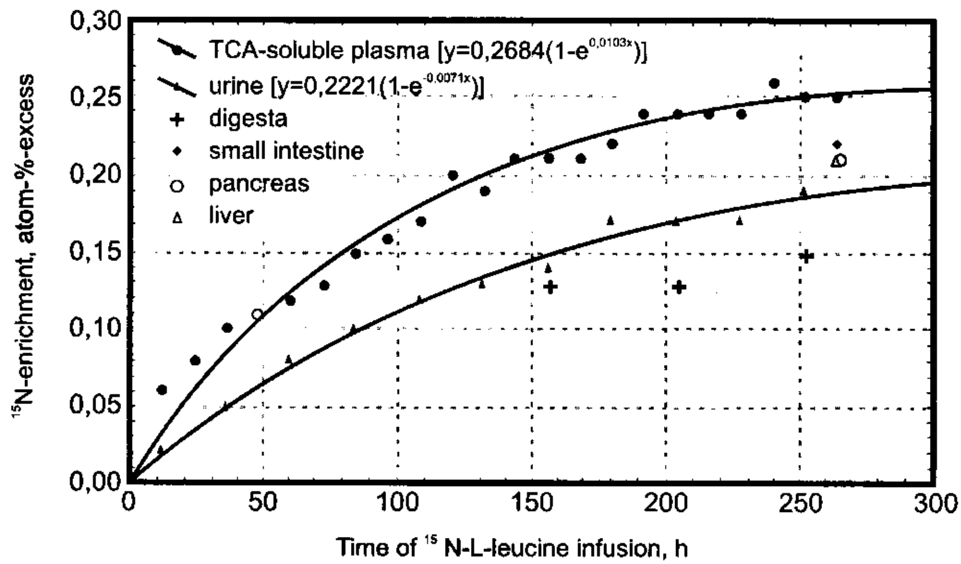

Figure 2. ^{15}N enrichement excess (%) in urine, ileal digesta, and TCE-soluble plasma, soyabean meal diet (means of three animals)

TABLE 3

Results of ^{15}N infusion experiment, digestibility and endogenous losses, faecal data

Indices	SMP	SBM	SI	FM	root MSE
Number of piglets	2	3	5*	3	
Apparent faecal digestibility, %:					
N	94.0^{a}	84.0^{b}	90.7^{a}	89.1^{a}	1.75
LYS	96.2^{a}	84.5^{b}	91.6^{a}	92.8^{a}	2.26
MET	95.6^{a}	75.9^{c}	84.1^{bc}	90.3^{ab}	3.83
CYS	89.4^{a}	85.1^{a}	84.5^{a}	82.2^{a}	2.98
LEU	96.2^{a}	85.4^{b}	90.4^{ab}	90.8^{ab}	2.47
Number of piglets	2	3	4	3	
Endogenous faecal losses:					
N, mg/day	315^{b}	963^{a}	715^{ab}	697^{ab}	204.7
CP, g/100 g DM intake	0.56^{b}	1.77^{a}	1.30^{ab}	1.28^{ab}	0.372
CP, g/100 g CP intake	3.4^{b}	9.6^{a}	7.4^{ab}	7.2^{ab}	2.06
CP, mg/kg LW	174^{b}	561^{a}	425^{ab}	404^{ab}	120.8
True faecal digestibiiity, %:					
N	97.3^{a}	93.5^{b}	98.1^{a}	96.4^{a}	0.78
LYS	98.4^{a}	93.3^{b}	98.1^{a}	97.9^{a}	0.92
MET	98.3^{a}	91.1^{b}	97.6^{a}	95.9^{a}	1.30
CYS	95.4^{a}	95.7^{a}	96.3^{a}	94.9^{a}	1.36
LEU	98.2^{a}	93.3^{a}	96.1^{a}	97.1^{a}	1.65

SMP = skimmilk powder; SBM = soyabean meal; SI = soya protein isolate; FM = fish meal means within a row bearing the same superscript do not differ (Tukey, $P>0.05$)

* different number of siglets for apparent digestibility are caused by inclusion of one of the two spare piglets without ^{15}N-infusion on the SI-diet

respectively, and lowest for the SBM diet – 83.2 and 90.0% for apparent and true values, respectively. Ileal LEU digestibilities for SI and FM were intermediate (Table 4).

Apparent N digestibilities (faecal and ileal) did not differ between SBM and SI diet ($P>0.05$, Tables 3 and 4), however, true digestibilities (faecal and ileal) did differ ($P<0.05$, Tables 3 and 4). The SMP caused higher apparent N digestibilities (faecal and ileal) than the other protein sources. In general, differences in true N digestibilities between protein sources were smaller than differences in apparent N digestibilities.

The soya-based diets caused the highest endogenous protein losses (SI at the terminal ileal level and SBM at the faecal level). The true ileal digestibility of the SI protein was higher than of the other protein sources.

Nitrogen balance data and organ weights are given in Table 5. No differences in live weights between diets were noticed ($P>0.05$). Pancreas weights did differ between diet SI and diet FM ($P<0.05$). Small intestine weights did not differ

TABLE 4

Results of ^{15}N infusion experiment, digestibility and endogenous losses, ileal data

Indices	SMP	SBM	SI	FM	root MSE
Number of piglets	2	3	6*	2**	
Apparent faecal digestibility, %:					
N	84.4^{a}	76.5^{b}	78.4^{ab}	73.0^{b}	2.67
LYS	77.1^{a}	79.6^{a}	77.4^{a}	81.5^{a}	5.27
MET	94.1^{a}	87.4^{ab}	82.5^{b}	86.4^{ab}	3.15
CYS	77.7^{a}	71.3^{ac}	65.8^{bc}	57.8^{b}	3.97
LEU	94.0^{a}	83.2^{c}	87.0^{b}	85.7^{bc}	1.52
Number of piglets	2	3	4	2**	
Endogenous ileal losses:					
N, mg/day	786^{b}	1422^{ab}	1970^{a}	1558^{ab}	359.3
CP, g/100 g DM intake	1.41^{b}	2.61^{ab}	3.56^{a}	2.86^{ab}	0.641
CP, g/100 g CP intake	8.3^{b}	14.1^{ab}	20.4^{a}	16.2^{ab}	3.69
True ileal diaestibility, %:					
N	92.7^{b}	90.6^{b}	98.4^{a}	89.3^{b}	1.29
LYS	79.9^{a}	86.3^{a}	87.7^{a}	87.4^{a}	3.39
MET	96.4^{a}	95.0^{a}	96.1^{a}	90.4^{a}	2.38
CYS	90.0^{a}	84.4^{a}	91.4^{a}	81.7^{a}	5.21
LEU	97.0^{a}	90.0^{bc}	96.3^{a}	93.5^{ab}	1.72

SMP = skimmilk powder; SBM = soyabean meal; SI = soya protein isolate; FM = fish meal
means within a row bearing the same superscript do not differ (Tukey, $P > 0.05$)

* different number of piglets for apparent digestibility is caused by inclusion of two spare piglets without ^{15}N-infusion

** one piglet on FM diet was excluded due to aberrant values on nitrogen content in ileal digesta

between diets ($P > 0.05$). Nitrogen intake differed between diets, due to different crude protein contents in the diets. Urinary N excretion was highest with the SI diet and lowest with the SMP diet. Faecal N excretion was highest with the SBM diet and lowest with the SMP diet. The difference in N balance between SMP and SI was significant ($P < 0.05$).

In Table 6 comparisons are given between faecal and ileal data and between apparent and true digestibilities. At the ileal level and at the faecal level, true N digestibility was higher than apparent N digestibility with all protein sources (Table 4). The ranking for apparent ileal N digestibility (SMP-SI-SBM-FM) was not similar to the ranking for true ileal N digestibility (SI-SMP-SBM- FM).

DISCUSSION

The ^{15}N-L-leucine infusion method was used to assess the endogenous N losses in the faeces and at the distal ileum in young piglets. The ^{15}N label will

TABLE 5

Organ weights and N balance data, from day 1 till day 6 of ^{15}N-leucine infusion

Indices	SMP	SBM	SI	FM	root MSE
Number of animals, n	2	3	5*	3	
Live weight, kg	11.3^{a}	10.7^{a}	10.4^{a}	10.8^{a}	0.52
Pancreatic weight, g	19.3^{ab}	22.1^{ab}	23.0^{a}	15.9^{b}	2.53
Small intestine weight, g	317^{a}	375^{a}	401^{a}	355^{a}	75.4
N intake, mg/day	9438^{c}	10048^{a}	9646^{b}	9626^{b}	27.0
N urine, mg/day	1935^{ab}	2014^{b}	3409^{a}	2171^{ab}	576.7
N urine as % of N intake	20.5^{ab}	20.0^{b}	35.4^{a}	22.6^{ab}	6.07
N faeces, mg/day	568^{b}	1611^{a}	1040^{ab}	1048^{ab}	304.6
N faeces as % of N intake	6.0^{b}	16.0^{a}	10.8^{ab}	10.9^{ab}	3.12
N balance, mg/day	6936^{a}	6423^{ab}	5198^{b}	6407^{ab}	582.4
N balance as % of N intake	73.5^{a}	63.9^{ab}	53.9^{b}	66.6^{ab}	5.91

SMP = skimmilk powder; SBM = soyabean meal; SI = soya protein isolate; FM = fish meal
means within a row bearing the same superscript do not differ (Tukey, $P>0.05$)
* including one spare piglet without ^{15}N-infusion

TABLE 6

Comparisons of LS means (T-tests) for ileal vs faecal and true vs apparent data for each protein source

Faecal-ileal	SMP diff.(p)	SBM diff.(p)	SI diff.(p)	FM diff.(p)
Apparent N digestibility, %	9.65	7.50	12.75	15.90
	(0.0099)	(0.0053)	(0.0060)	(-)
Endogenous losses:				
N, mg/day	−471	−459	−1256	−880
	(0.0041)	(0.0158)	(0.0297)	(0.1065)
CP, g/100g DM intake	−0.85	−0.84	−2.27	−1.62
	(0.0038)	(0.0156)	(0.0284)	(0.1035)
CP, g/100g CP intake	−4.95	−4.57	−13.00	−9.15
	(0.0064)	(0.0147)	(0.0168)	(0.1001)
CP, mg/kg LW	−260.5	−268.0	−733.6	−503.7
	(0.0041)	(0.0184)	(0.0338)	(0.1246)
True N digestibility	4.60	2.90	−0.33	6.75
	(0.0277)	(0.0151)	(0.7471)	(0.1437)
Apparent-true	SMP diff.(p)	SBM diff.(p)	SI diff.(p)	FM diff.(p)
ileal N digestibility, %	−8.35	−14.17	−20.48	−14.17
	(0.0267)	(0.0221)	(0.0031)	(0.0221)
faecal N digestibility, %	−3.30	−9.57	−7.40	−7.10
	(0.0768)	(0.0356)	(0.0053)	(0.0448)

SMP = skimmilk powder; SBM = soyabean meal; SI = soya protein isolate; FM = fish meal (diff. = difference between faecal and ileal or between apparent and true. When $P<0.05$ 'diff.' is significantly different from 0) also appear in other (though not all) amino acids due to transamination. Due to different levels of transamination, it is not feasible to measure the separate endogenous amino acid losses. These should be calculated by considering the amino acid composition of endogenous protein as measured with protein-free feeding.

Endogenous protein in faeces and ileal chyme as measured using the continuous ^{15}N-L-leucine infusion technique can be underestimated for two reasons: firstly, endogenous protein is synthesised not only from free amino acids in the TCA-soluble fraction of the plasma, but also directly from absorbed amino acids in the enterocytes of the intestinal wall; secondly, the labelling of body protein will continue to rise (slowly) during continuous infusion of ^{15}N-leucine, due to recycling of labelled amino acids. This will also result in an underestimation of the amount of endogenous nitrogen (De Lange et al., 1990).

Wilson and Leibholz (1981c) studied apparent and true N digestibilities of diets containing milk or soyabean protein with piglets (28 days of age). Endogenous N losses were determined by feeding a nitrogen-free diet. For the milk protein diet they found apparent and true ileal N digestibilities of 86 and 92%, respectively, which closely resembles our values of 84 and 93%, respectively. Apparent protein digestibility was expected to be higher for the milk protein diet because of the adaptation of newly weaned pig to this protein source. The relatively low digestibility could be due to differences between cow's milk protein and sow's milk protein.

Wilson and Leibholz (1981 c) reported apparent and true ileal N digestibilities for the soyabean meal diet of 51 and 62%, respectively. In our study we found apparent and true ileal N digestibilities for the SBM diet to be 77 and 91%, respectively. This difference could be due to age of piglets (in our study 35-50 days), protein level in the diet (Wilson and Leibholz, 1981 c, used diets containing $\pm$27% of crude protein), quality of soyabean meal or an interaction between age and diet composition. This latter option has been supported by Wilson and Leibholz (1981 a) who studied performance of piglets given milk and soyabean proteins at different ages. They found an interaction between protein source in the feed and age of the piglets: the performance of piglets fed milk protein did not change between 7 and 35 days of age. Performance of piglets fed soyabean protein, however, did increase with increasing age.

Wilson and Leibholz (1981c) studied endogenous N flow at different sites of the gastrointestinal tract of piglets (35 days of age) fed a protein-free diet. They reported an endogenous N flow at the terminal ileum of 0.82 g N per day. In our study we found N flows of 0.79 and 1.42 g N per day for piglets fed the SMP diet and the SBM diet, respectively. These data indicate that endogenous losses are lowest when milk proteins are fed to young piglets.

Endogenous N losses measured with animals fed protein-free diets may not reflect the normal, physiological situation when protein containing diets are fed. The fact that different protein sources in the feed induce different levels of endogenous N excretion (Huisman et al., 1993) stress this aspect. Since the amount of dietary protein could also affect the endogenous nitrogen losses, the regression method also is not very accurate in determining endogenous nitrogen losses in animals fed protein-containing diets.

Leibholz (1982) studied the endogenous nitrogen secretion in young pigs (4 weeks of age). She used the regression method to assess endogenous N losses with a feed based on milk protein. By means of regression analysis she calculated endogenous N flow at the terminal ileum to be 3.44 g N per kg dry matter intake, which amounts to 2.2 g endogenous ileal crude protein per 100 g of dry matter intake. In our study we calculated 1.41 g endogenous ileal crude protein per 100 g of dry matter intake for the SMP diet.

The weight of the pancreas is in agreement with data from Le Guen et al. (1991) obtained from piglets of 10 to 15 kg live weight fed diets based on casein and fish meal or pea proteins. The difference in pancreas weight between SI and FM fed piglets is difficult to explain: it is assumed (Huisman, 1990), that piglets do not show pancreas hypertrophy when fed trypsin inhibitor containing feedstuffs. The reason for the low pancreatic weight of FM fed piglets is unclear. The low N balance of SI fed piglets is caused by both urinary and faecal N excretion. The high faecal N excretion is caused by both endogenous and exogenous nitrogen. With young piglets (age 35 to 56 days), Newport and Keal (1983) found no effect of dietary protein source (soyabean meal versus combinations of fish meal, skimmilk powder and soyabean meal) on nitrogen retention with comparable nitrogen intakes. With diets containing fish meal, soyabean meal and skimmilk powder, Zhang et al. (1986) found a N retention of 7.1 g/day when 10.9 g of N was ingested daily by piglets aged 31 days on average.

From our data we concluded that the differences in apparent ileal N digestibility between the SMP, SBM and FM diet are not caused by differences in the (true) digestibility of the protein sources. From our experiment we also concluded that true ileal N digestibility of soyabean meal is not much different from true ileal N digestibility of skimmilk powder. Therefore, differences between these protein sources with regard to apparent ileal N digestibility and performance of piglets (growth, feed conversion ratio) must be caused by an increase in endogenous N secretion with piglets fed soyabean meal. The soya protein itself is highly digestible (90.6 % at the ileal level and 93.5% at the faecal level), but it either stimulates nitrogen secretion by the exocrine glands of the digestive tract and/or it causes excessive loss of gut wall cells by sloughing off, resulting in endogenous N losses. These endogenous N losses may lead to decreased performance (feed intake, growth) of piglets fed non-milk protein sources after weaning.

In terms of endogenous losses, the expenses for the digestion of vegetable protein are higher than for the digestion of milk protein.

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STRESZCZENIE

Straty azotu endogennego do końca jelita cienkiego u prosiąt otrzymujących dawki różniące się rodzajem paszy białkowej

Czternaście prosiąt o początkowej masie ciała 8 kg z przetoką T-typu w końcu jelita biodrowego i kateterami do żyły i tętnicy szyjnej podzielono na grupy i żywiono dawkami zawierającymi mleko odtłuszczone w proszku (SMP), śrutę sojową (SBM), wyizolowane białko sojowe (SI) lub mączkę rybną (FM) jako jedyne źródło białka. Paszę podawano w jednakowych ilościach co 12 godzin. ^{15}N-L-leucynę podawano dożylnie metodą infuzji ciągłej w ilości około 40 mg/kg masy ciała/dzień. Pozorna i rzeczywista strawność N wynosiła 94,0 i 97,3; 84,0 i 93,5; 90,8 i 98,1, oraz 89,1 i 96,4%

w grupach SMP, SBM, SI oraz FM, odpowiednio. Dzienne straty N endogennego w kale wynosiły 315, 963, 715 i 679 mg, a w jelicie cienkim 786, 1422, 1970 i 1558 mg. Pozorna strawność jelitowa N wynosiła 84,4; 76,5; 78,4 i 73,0% , a strawność rzeczywista 92,7; 90,6; 98,4 i 89,3% dla dawek SMP, SBM, SI i FM, odpowiednio. Stwierdzono, że rzeczywista strawność N była wysoka przy podawaniu badanych 4 pasz białkowych, tak do końca jelita cienkiego jak i całkowita. Różnice w pozornej strawności N były spowodowane głównie różnicami w ilości wydzielanego N-endogennego.