JOURNAL OF AGRICULTURAL SCIENCE IN FINLAND
Maataloustieteellinen Aikakauskirja
Vol. 60: 673—683, 1988

Industrial amino acids in diets for piglets and growing pigs

J. INBORR[1] and K. SUOMI[2]

[1] *Finnish Sugar Co. Ltd., Finnfeeds Ltd., Forum House, Brighton Road, Redhill, Surrey RH1 6YS, England*

[2] *Agricultural Research Centre, Swine Research Station, SF-05840 Hyvinkää, Finland*

Abstract. Two production trials with piglets and one with slaughter pigs were carried out in order to investigate the effects of reducing the protein content in the diets followed by an addition of industrial amino acids on performance and health status.

In the first piglet trial the crude protein content of the control diet was decreased from 20 to 18.3 % and in the second from 18.3 to 16.7 %. In the trial with growing pigs, the protein content of the control diet was decreased from 17.0 to 15.5 %. Industrial L-lysine, DL-methionine and L-threonine were added to the low protein diets to get the same levels of these amino acids as in the control diets.

Piglet performance was similar on all treatments indicating equal availability of added and protein-bound amino acids. Health status of piglets on the low protein diets was considerably improved, indicating less predisposition to post weaning diarrhoea.

Pigs on the low protein amino acid fortified diet tended to gain weight faster (788 vs. 743 g/day; $p < 0.07$) and had higher carcass quality than pigs on the control diet. Feed utilization was improved by 4 % on the low protein diet, although, the improvements were not significant.

Index words: industrial amino acids, lysine, methionine, theorine, piglet, pig, performance, diarrhoea

Introduction

In Finland, as in many other countries, protein is both quantatively and pricewise a limiting factor in pig feed manufacture. Finnish domestic production of protein raw materials (rape, peas, beans, meat and bone meal etc.) cannot meet the demand and, therefore, substantial amounts of soybean (SBM) and fish meal have to be imported.

The protein supply of growing pigs is a question concerning the content of amino acids in the diet. Appropriate amounts of essential amino acids have to be provided to achieve maximum protein utilization. According to FULLER et al. (1979) are lysine, threonine and histidine the first limiting amino acids in barley for growing pigs. When feeding barley and SBM, the most limiting amino acids are lysine, methionine and threonine (MADSEN et al. 1987). However, diets deficient in one or more amino acids can be supplemented with free or synthetic amino acids to achieve an optimum balance in the diets.

The pig cannot use surplus amino acids for lean production. Any surplus of absorbed amino acids will be oxidized. The carbon skeletons of the amino acids are included in the energy yielding metabolic pathways, while nitrogen, after transamination and deamination, is excreted from the body in the form of urea. To achieve maximum protein utilization, an "ideal protein", as described by COLE (1980), should be formed containing the exact amounts of essential amino acids to meet the requirements of the pig. The increased production and use of industrial amino acids makes this possible. However, there is not enough data regarding the amino acid requirements of growing pigs and bioavailability of protein-bound amino acids to apply this concept to practical feed formulation of today.

There is some inconsistency in the results reported from performance trials regarding the effect of adding industrial amino acids to diets for growing pigs (EGGUM et al., 1985 a; 1985 b). Supplementation of low protein piglet feeds with industrial amino acids resulted in satisfactory performance and amino acid balance equivalent to that of the corresponding high protein unsupplemented feeds (ROGERSON and CAMPBELL, 1982; MILLER et al. 1986 b; CAMPBELL, 1978). However, when the crude protein content of the feeds was gradually decreased, other amino acids than the added ones become limiting, resulting in poorer performance (NIELSEN et al., 1984; GUNTHER and KRUSE, 1986; EGGUM et al., 1985 a and 1985 b).

The protein content and quality of piglet feeds can influence the health status of young pigs. MILLER et al. (1986 a) showed that some proteins, due to their antigenicity, can induce immunological reactions in the small intestine of newly weaned piglets causing morphological changes in the gut wall. This immune-mediated intestinal damage, referred to as the malabsorption syndrome, may predispose the pig to postweaning diarrhoea. By decreasing the protein content of creep and post weaning diets, the hypersensitivity response to the feeds can be reduced resulting in improved performance and health status (BERTSCHINGER et al., 1986, MILLER et al. 1986 b).

Soybeans contain relatively large amounts of raffinose, which is poorly hydrolyzed and absorbed in the small intestine of pigs. Consequently, on SBM based diets, relatively large amounts of this sugar will arrive in the large intestine, where it may have a laxative effect (KATZ et al. 1973). Furthermore, SBM has been shown to give similar effects regarding secretion/absorption balance in the small intestine of piglets as E. coli (NABUURS and HOOGENDOORN, 1985). The factors involved are not clearly known. In conclusion, an improved health status of piglets following a reduced protein content of the feeds by reducing the inclusion rate of SBM may be consequent to reducing the amount of harmful factors in the feed rather than the protein content *per se*.

The purpose of the trials reported in this paper was to investigate the effects of adding industrial amino acids to piglet and pig feeds with reduced protein content on performance and health status.

Materials and methods

Animals and design

Trial 1. This trial was carried out at the Swine Research Station in Hyvinkää. A total of twenty-four new-born litters of L-, Y- and L*Y crossbred sows, comprising 7 or more piglets, were allotted to two treatments of twelve replicates each. Litters from sisters or closely related sows were allocated to different treatments, and litters were from both gilts and multiparous sows.

The piglets were accustomed to the experimental diets from one week of age, and had free access to the diets from two weeks to the end of the trial at eight weeks of age. The feeds were offered in self-feeders. Water was provided through nipples and available continuously.

The piglets were weaned at 5 weeks by removing the sow from the farrowing pen, in which piglets stayed until the end of the trial.

Trial 2. In this trial, carried out at Munkkila Experimental Station in Paimio, forty-eight crossbred (L*Y) piglets, weaned at an age of five weeks and averaging 14 kg in live weight, were allotted to two treatments of twenty-four animals, each group comprising 10 gilts and 14 castrates. Piglets on each treatment were allocated to four replicates into pens with six piglets on a sex and live weight basis. There was one pen with gilts only, one with four gilts and two castrates and two pens with castrates only on each treatment. During the three week experimental period, piglets were fed *ad lib* from self-feeders, having access to one feeder per pen. Water was provided through nipples (one per pen) and available continuously.

All piglets were penned in the same row of an automatically air-conditioned enclosed section with a row of pens on each side of the central passage. One third of the 1.6*2.4 m concrete floor of the pens was slatted. Pens were partitioned by a 60 cm high solid steel wall and an additional 30 cm steel-pipe construction. During the first week, temperature was 25°C and decreased 2°C weekly.

Trial 3. The trial was carried out at Munkkila Experimental Station in Paimio. Forty-eight crossbred (L*Y) young pigs, with an average live weight of 22.5 kg, were randomly allotted to six replicates of two treatments on a sex and live weight basis. There were four pens with castrates only and two with gilts only on each treatment. The pigs were fed twice a day (0800 and 1500 hours) in a trough according to general feeding recommendations based on energy requirements of growing slaughter pigs (Salo et al., 1982). Average daily feed intake was 2.2 kg per pig. Daily feed allowances were corrected weekly according to average per live weights. Water was provided through nipples (one per pen) and available one hour after each feeding.

The replicates were allotted to two similar, automatically air-conditioned enclosed departments and penned in the same type of pens as in trial 2. The feeding troughs, facing the central passage, provided 30 cm space per pig.

The experimental diets were fed from 30 kg LW to slaughter. Prior to the experimental period, all pigs were offered the same diet containing 17 % CP and 50 ppm carbadox (Mecadox).

Treatments

All diets were formulated to meet the nutritional requirements of weaned piglets (trial 1 and 2) and growing pigs (trial 3). The piglet feeds were crumbled and the pig feed was pelleted. L-lysine was added as the monohydrochloride. L-threonine and DL-methionine were added in pure crystalline form.

Trial 1. The diets were formulated to contain different amounts of crude protein (CP) and the same amounts of lysine and threonine. Soybean meal (SBM) and fish meal were substituted with barley to reduce CP content in diet 2. L-lysine and L-threonine were added to diet 2 and both diets were medicated with carbadox (Mecadox). The CP content of diet 1 and 2 was 20.0 and 18.3 %, respectively. The composition of the diets is shown in table 1.

Trial 2. The diets were formulated to contain different amounts of crude protein with the same amounts of lysine, methionine and threonine. The CP content of the diets were 18.3 and 16.7 % for treatment 1 and 2, respectively. Different amounts of L-lysine was added to the diets. In addition, DL-methionine and L-threonine were added to diet 2, in which SBM was substituted with barley to reduce the

Table 1. Composition of the experimental diets, g/kg.

Treatment	Trial 1		Trial 2		Trial 3	
	1	2	1	2	1	2
Barley	400	457	—	—	707	760
Barley, heat-treated	—	—	402	454	—	—
Oats	—	—	—	—	50	50
Dehulled oats, steamed	300	300	370	370	—	—
Soybean meal (SBM)	140	88	—	—	156	100
SBM, extruded	—	—	100	45	—	—
Fish meal	70	60	60	60	20	20
Fat blend	5	5	—	—	7	7
Skim milk powder	25	25	—	—	6	6
Whey powder	—	—	20	20	—	—
Glucose	35	35	20	20	—	—
Molasses (sugar beet)	—	—	—	—	15	15
Dicalcium phosphate	17	19	16	16	18	18
Calcium carbonate	3	3	6	6	6	6
Sodium chloride	1.5	1.5	—	—	2	2
Potassium lignosulph.	—	—	—	—	10	10
L-lysine HCl	—	1.8	2.0	3.3	1.3	2.6
DL-methionine	—	—	—	0.5	0.2	0.7
L-threonine	—	1.0	—	0.9	—	0.8
Premix*	4.0	4.0	4.0	4.0	1.7	1.7
Carbadox, ppm	50	50	50	50	—	—
Calculated values						
ME, MJ/kg	14.2	14.1	14.1	14.0	13.0	13.0
FU/kg	1.05	1.05	1.05	1.05	0.97	0.97
DCP, g/kg	180	160	160	145	150	130
Lysine, g/kg	11.5	11.5	11.7	11.7	9.8	9.8
Methionine, g/kg	4.3	4.3	4.0	4.0	3.2	3.2
Threonine, g/kg	8.0	8.0	7.2	7.2	6.1	6.1

* vitamins and trace elements according to requirements.

CP content. The composition of the diets is shown in table 1.

Trial 3. The diets were formulated to contain different amounts of crude protein with the same amounts of lysine, methionine and threonine. CP content of diet 1 and 2 was 17.0 and 15.5 %, respectively. In diet 2, SBM was substituted with barley to reduce the CP content. L-lysine and DL-methionine were added to both diets and L-threonine only to diet 2. The composition of the diets is shown in table 1.

Measurements

Trial 1. Piglets were individually weighed at birth, at weaning and at the end of the trial. Feed consumption, mortalities and the occurrance and severity of diarrhoea (scale of severity in table 4) were recorded. Scouring piglets were treated with antibiotics.

Trial 2. The piglets were individually weighed at the beginning and at the end of the trial. The feeders were refilled once a day according to feed consumption and the amounts consumed were recorded.

During the trial, the health status of the piglets was monitored and in case of diarrhoea, affected piglets were treated with an antibiotic (Orimysin).

Trial 3. All pigs were weighed at the beginning of the experiment and then at 14-day intervals up to an average LW of 70 kg. After that, pigs were weighed once a week and animals exceeding 102 kg LW were slaughtered the following day. Slaughter weights and

Table 2. Chemical composition of the experimental diets, g/kg.

Treatment	Trial 1		Trial 2		Trial 3	
	1	2	1	2	1	2
Dry matter	888	891	885	885	878	875
Crude protein	200	183	183	167	170	155
Ether extract	33	34	36	34	28	28
Crude fibre	37	34	37	30	43	41
Ash	62	54	47	43	43	53
N-free extracts	556	586	582	611	594	598
Calcium	11.6	10.3	8.8	8.5	9.6	9.1
Phosphorous	10.6	10.0	7.6	7.5	8.9	8.6
Lysine	10.7	10.8	11.8	10.9		
Available lysine	10.0	10.1	11.3	10.5		
Methionine	3.9	4.1	3.8	4.2		
Cystine	3.6	3.6	5.0	4.9		
Threonine	7.8	7.5	7.3	7.2		
Tryptophan (cal.)	2.7	2.4	2.4	2.2		

carcass quality were measured individually. Feed allowance of each replicate (pen) was weighed daily and recorded. In case of feed refusals or diarrhoea, daily feed allowances were temporarily decreased. The health status of the pigs was monitored during the experimental period.

Analytical methods

All feeds were compounded at the Munkkisaari feed mill in Helsinki. The dry matter, crude protein, crude fibre, crude fat (ether extract), ash and sodium chloride contents of the feeds were determined in the feed mill laboratory. Amino acid content of the feeds of trial 1 was determined at the National Laboratory of Agricultural Chemistry, whereas calcium, phosphorous of all feeds and the amino acid content of the feeds in trials 2 and 3 were analysed at Viljavuuspalvelu.

Proximate composition of the feeds was determined by standard methods. Amino acids were assayed at the National Laboratory of Agricultural Chemistry with an automatic amino acid analyser (Chromakon 400) following hydrolysis and separation by ion-exchange chromatography, and available lysine was determined by difference following pre-treatment of the samples with fluorodinitrobenzene (Pao et al. 1963), whereas the methods described by AOAC (1984) were used at Viljavuuspalvelu. Tryptophan was not assayed.

In a laboratory test, the pH of the diets in trial 2 was measured after mixing 20 g feed into 50 ml of a) distilled water (natural pH) and b) 0.2 M HCl solution (pH 1.70) at 40°C. A third diet (diet 3) was prepared by adding 1 % citric acid to diet 1. pH was measured at 5, 10, 20, 30, 40, 50 and 60 minutes after mixing. pH values were measured with a PHM 83 AUTOCAL meter.

Statistical analysis

Analysis of variance (one way classification) was used for the performance and feed intake measurements of trial 1. Results from trial 2 and 3 were calculated by using the RS1 statistical program (Digital Co.) and mean performance values were compared by unpaired Student's T-test. Diarrhoea index values were compared by Chi^2-test. Mortality values were compared by using F-test and unequal variance t-test.

Results and discussion

The chemical composition of the feeds is shown in table 2. Exept for the crude protein,

Table 3. Piglet performance during the experimental period, mean values.

Treatment	1	2	*	SEM
Piglets	123	120		
Live weight, kg/piglet				
— at birth	1.59	1.58	NS	0.028
— at 5 weeks of age	9.54	9.61	NS	0.186
— at 8 weeks of age	19.06	19.34	NS	0.350
Live weight gain, g/d/piglet				
— from birth to 5 weeks	227	230	NS	5.007
— from 5 to 8 weeks	451	464	NS	11.104
— from birth to 8 weeks	312	317		
Feed intake, kg/piglet				
— from birth to 5 weeks	0.32	0.49	NS	0.085
— from 5 to 8 weeks	15.50	15.88	NS	0.728
— from birth to 8 weeks	15.82	16.37		
Feed conversion, kg feed/kg gain				
— from 5 to 8 weeks	1.64	1.66	NS	

* $p<0.05$, NS = non significant

the corresponding feeds in each trial did not differ very much. Calcium and phosphorous levels were consistently somewhat higher in control diets (treatments 1). The higher inclusion rate of SBM may have increased the Ca and P content of these diets.

Trial 1

Performance results are shown in table 3. There were no significant differences in performance between treatments. Piglets on treatment 2 had equal LW at 5 and 8 weeks, a slight non-significant higher DWG and equal feed intakes than piglets on treatment 1. Feed utilization was equal on both treatments. Thus, energy utilization (FU/kg gain) was not affected by the amino acid addition, in contrast with the results of EGGUM et al. (1985 b).

The availability of added industrial amino acids has been considered to be 100 % (HANRAHAN, 1987; MADSEN and MORTENSEN, 1977; HUISMAN et al., 1985). Results from several trials, however, imply lower values for added amino acids than for protein-bound ones (EGGUM et al., 1985 a; JORGENSEN and FERNANDEZ, 1987). Increasing the frequency of feeding from one to two or more times per day improved availability of added amino acids (BATTERHAM, 1974; BATTERHAM and O'NEILL, 1978; PARTRIDGE et al., 1985; BURACZEWSKA and BURACZEWSKI, 1980). LEIBHOLZ et al. (1986) reported equal absorption rates of added and extruded (L-lysine HCl + maize, 142°C) L-lysine in pigs. KRAWIELITZKI et al. (1982) reported an absorption coefficient of approximately 94 % for orally administered ^{15}N-lysine and HUISMAN et al. (1985) 98—99 % for ^{14}C-L-methionine. There are also results indicating that added lysine was more efficiently utilized by pigs than natural lysine (FULLER et al. 1986; HANRAHAN, 1987).

The results from this trial indicate that the utilization of the added amino acids was equal to that of the protein-bound ones. In spite of a lower CP content, diet 2 provided sufficient amounts of essential amino acids and non-essential nitrogen to achieve equal performance to diet 1.

According to the diarrhoea index and mortality percentage, the health status of piglets on treatment 2 was considerably better than of those on treatment 1. Two litters on treatment 1 and none on treatment 2 were medicated due to diarrhoea (table 4). NIELSEN et al. (1984) and EGGUM et al. (1985 a, b) also

Table 4. Health status of the piglets during the experimental period, mean values of litters.

Treatment	1	2	significance
Diarrhoea index^	321	148	**
Mortality, %			
— from start to 5 weeks	2.44	0.83	NS
— from 5 to 8 weeks	3.33	—	*
— from start to 8 weeks	5.69	0.83	*
Litters with no diarrhoea	7	6	
Litters medicated due to diarrhoea	2	0	

* $p<0.05$, ** $p<0.001$

^ scale of severity; 1 = normal faeces, 2 = soft faeces, 3 = fluid faeces, 4 = moderate diarrhoea, 5 = severe diarrhoea index = severity * number of affected pigs * days

reported a decreased incidence of diarrhoea of piglets fed low protein, amino acid fortified diets. However, the reductions in CP content were greater than in this trial.

Reducing the SBM content in the feed per se may improve the health status of piglets, while it has been shown that SBM can give similar responses to E. Coli in the small intestine regarding the secretion/absorption balance (NABUURS and HOOGENDOORN, 1985). Furthermore, raffinose, which is abundant in SBM, is poorly hydrolyzed in the small intestine of the piglet. Consequently, on SBM based diets, substantial amounts of this laxative trisaccharide (galactose + sucrose) will arrive in the large intestine causing looser stools (KATZ et al. 1973) or fermentation diarrhoea in a similar way as when large amounts of sucrase are fed to young pigs (JUST, 1983). The reduction in the incidence of diarrhoea may also be due to a reduced antigenicity of the diet (MILLER et al., 1986 b and BERTSCHINGER et al., 1986).

Trial 2

There were no differences in performance between treatments during the 3 week period (table 5). Piglets on treatment 2 had slightly higher LW throughout the trial. Feed intake was the same on both treatments. Piglets on treatment 1 were treated on three occations and on treatment 2 on two occations due to diarrhoea. As in trial 1, the results indicate that despite a lower dietary protein concentration, diet 2 provided sufficient amounts of amino acids to achieve the same performance as diet 1. Moreover, the utilization of the added free amino acids seems to be equal to that of the protein-bound ones.

The pH values of the diets measured during one hour are plotted in figure 1. The natural (values at 0 minutes) pH of diet 1 was 0.17

Table 5. Performance and antibiotic treatments during the experimental period, mean values per piglet.

Treatment	1	sd.	2	sd.	*
Piglets	24		24		
Initial weight, kg	14.21	1.0	14.34	1.1	
Final weight, kg	24.56	2.6	24.75	2.0	
Weight gain, kg	10.35	2.3	10.41	1.5	
Daily weight gain, g	545	123	548	81	NS
Feed intake, kg	20.3	0.4	20.3	0.4	
Feed/gain, kg/kg	1.96	0.04	1.95	0.03	NS
Antibiotic treatments, total number	3		2		

* $p<0.05$, NS = non significant

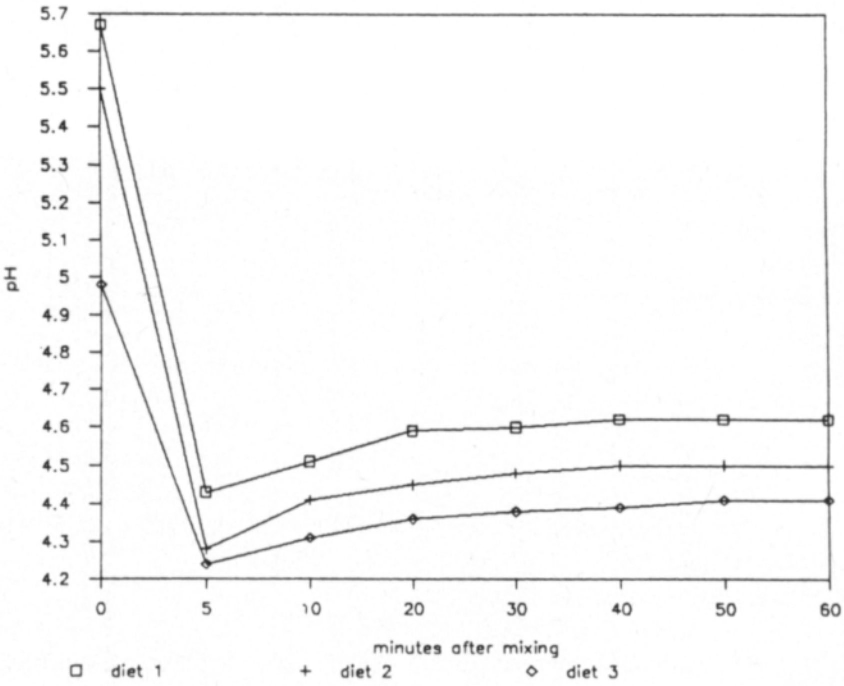

Fig. 1. Changes in pH levels of the diets in trial 2 during 1 hour after mixing with a 0.2 M HCl solution. The values at 0 minutes represent the natural pH of the diets.

units higher than for diet 2. When 1 % citric acid was added to diet 1, the pH decreased by 0.67 units. Mixing the feeds into a 0.2 M HCl solution (pH 1.7) decreased pH of the feeds rapidly followed by a slow increase. After 20 minutes, pH values of the mixtures increased very slowly. The pH of diet 1 was highest and that of diet 3 lowest, diet 2 having intermediate pH values.

PROHASZKA and BARON (1980) reported higher HCl-binding capacity of high protein diets compared with low protein ones. Gastric pH was higher in pigs receiving the high protein diets causing marked increases in the faecal E. Coli counts. The lower acid buffering effect of diet 2 compared to diet 1 may be a consequence of the higher inclusion rate of monohydrochloride L-lysine, but also due to a lower protein content. This might have a decreasing effect on the pH-level in the stomach of the piglet effectively preventing pathological bacteria from entering the small intestine and proliferate.

Trial 3

Exess protein is catabolized and the nitrogen is excreted in the urea. The formation of 1 mol urea requires 4 mol ATP and the synthesis of 1 mol ATP requires 85 kJ metabolizable energy. However, on experimental basis, SHIEMANN et al. (1971) and JUST (1982) estimated the energy cost of urea synthesis and excretion to be much higher showing that protein is a poor source of energy, and should not therefore be provided in surplus.

Pigs on treatment 2 had 6 % higher DWG and consumed 2 % less feed than pigs on treatment 1 (table 6). Consequently, feed utilization was improved on treatment 2. However, none of the performance parameters was significantly different between treatments ($p > 0.05$), but there was a tendency ($p < 0.07$) to higher DWG on treatment 2. Pigs on treatment 2 consumed 0.44 kg protein per kg gain resulting in a 12 % improvement in protein utilization compared to pigs on treatment 1.

Table 6. Performance and carcass quality, mean values per pig.

Treatment	1	sd.	2	sd.	*
Pigs	24		24		
Initial weight, kg	30.8	2.0	30.8	1.8	NS
Final weight, kg	104.4	4.0	105.8	2.8	NS
Weight gain, kg	73.7	3.7	75.0	3.0	NS
Feeding period, d	100		96		
Daily weight gain, g	743	83	788	84	NS
Feed intake, kg	216.9		212.6		
Feed/gain, kg/kg	2.95	0.13	2.84	0.12	NS
Protein, kg/gain, kg	0.50		0.44		
Slaughter weight, kg	75.5	3.7	76.3	2.8	NS
Killing-out percentage	72.3	2.0	72.1	1.9	NS
Carcass quality,					
% of carcasses in; E+	33.3		58.3		
E	33.3		16.7		
I	33.4		25.0		
R	—		—		

* $p<0.05$, NS = non significant

These results are in good agreement with the results reported by Näsi (1986) from a similarly designed trial in which the crude protein levels were 18 and 16.5 % up to 45 kg LW, and 16.5 and 15.0 % from 45 to 105 kg LW in the control and experimental diets, respectively. During the finishing period, pigs fed the amino acid fortified diets had significantly lower feed : gain ratios, which shows the energy sparing effect of feeding balanced protein. Also carcass quality was improved on the low-protein diets.

Pigs on barley-SBM based high protein diets had higher weight gains and lower food : gain ratios than pigs fed low protein, lysine supplemented diets (Fuller et al., 1986). The reductions in live weight gain and increases in food : gain ratio in response to reducing lysine concentration, however, were greater with soya meal than with free lysine. When feeding growing pigs with barley-SBM based diets, containing equal (diet 1 and 2) or decreased amounts (20 and 40 % less in diets 3 and 4, respectively) of SBM and adding synthetic lysine and methionine to diet 2, 3 and 4, Madsen and Mortensen (1987) did not find any difference in performance of pigs up to 90 kg LW between treatments. Up to 50 kg LW, however, pigs on treatment 4 had significantly lower DWG than pigs on treatments 1 and 2. Diet 2 had higher lysine content than the other diets, which were isolysinic. In the present trial, SBM content of diet 2 was reduced with 36 %.

Equal performance of growing pigs has also been reported by Easter and Baker (1983), Russell et al. (1983) and Hanrahan (1987) when low protein diets were fortified with synthetic amino acids to achieve levels equivalent to those in the corresponding high protein control diets.

Carcass quality was markedly better on treatment 2, resulting in 58.3 % of the carcasses beeing classified as E+ carcasses. On treatment 1, only 33.3 % of the carcasses were classified in the E+ category. Hanrahan (1987) reported less P2-backfat for pigs on lysine fortified diets than on isolysinic, SBM based diets. The reduction in backfat was not significant. According to Eggum et al. (1985 b), higher RPE (retained protein energy) values result in leaner pigs and higher DWG.

Health status was good on both treatments. Feed was withdrawn ten times on treatment 1 and five times on treatment 2 due to digestive upsets and/or feed refusals.

References

AOAC. 1984. Official methods of analysis. Ed. Association of Official Agricultural Chemists, Washington, D.C.

BATTERHAM, E.S. 1974. The effect of frequency of feeding on the utilization of free lysine by growing pigs. Br. J. Nutr. 31: 237—242.

— & O'NEILL, G.H. 1978. The effect of frequency of feeding on the response by growing pigs to supplements of free lysine. Br. J. Nutr., 39: 265—270.

BERTSCHINGER, H.U., EGGENBERGER, E., JUCKER, H. & PFIRTER, H.P. 1979. Evaluation of low nutrient, high fibre diets for the prevention of porcine Escherichia coli enterotoxaemia. Veterinary microbiology 3, 281—290.

BURACZEWSKA, L., LACHOWICZ, J. & BURACZEWSKI, S. 1980. The rate of absorption of synthetic lysine and dietary protein in the upper half of the small intestine of pigs. Arch. Tierernährung. 30: 751—758.

CAMPBELL, R.G. 1978. The response of early weaned pigs to suboptimal protein diets supplemented with synthetic lysine. Anim. Prod., 26: 11—17.

COLE, D.J.A. 1980. The amino acid requirements of pigs — the concept of an ideal protein. Pig news and information, Vol 1, No. 3: 201—205.

EASTER, R.A. & BAKER, D.H. 1980. Lysine and protein levels in corn-soybean meal diets for growing-finishing swine. J. Anim. Sci., 50, 467—471.

EGGUM, B.O., CHWALIBOG, A., NIELSIN, H.E. & DANIELSEN, V. 1985 a. The influence of dietary concentration of amino acids on protein and energy utilization in growing rats and piglets. 1. Fortification with lysine and methionine. Z. Tierphysiol. Tierernährg. u. Futtermittelkde. H. 53, 3—4, S. 113—123.

— 1985 b. 2. Fortification with lysine, methionine and threonine. Z. Tierphysiol., Tierernährg. u. Futtermittelkde. 53, H. 3—4, S. 124—134.

FULLER, M.F., WOOD, J., BREWER, A.C., PENNIE, K. & MacWILLIAM, R. 1986. The responses of growing pigs to dietary lysine, as free lysine hydrochloride or in soyabean meal, and the influence of food intake. Anim. Prod. 43: 477—484.

—, LIVINGSTONE, R.M., BAIRD, B.A. & ATKINSON, T. 1979. The optimal amino acid supplementation of barley for the growing pig. 1. Response of nitrogen metabolism to progressive supplementation. Br. J. Nutr., 41: 321—331.

GUNTHER, K.D. & KRUSE, H. 1986. Auswirkungen einer Threonin- und Tryptophan-Zulage zu einem Ferkelaufzuchtfutter auf einige Leistungsparameter. Lohmann Information, Mai/Juni, S. 1—4.

HANRAHAN, T.J. 1987. The response of growing pigs to incremental lysine levels as lysine hydrochloride or soyameat & bone meal when fed ad libitum or to a restricted scale. 38th annual meeting of the EAAP, Lisbon, Portugal. Manuscript, pp. 9.

HUISMAN, J., VRIES, P.H.U. DE., WEERDEN, E.J. VAN. & BERTRAM, H.L. 1985. The availability of synthetic methionine in pigs. J. Anim. Physiol. and Anim. Nutr., 55: 267—272.

JUST, A. 1982. The net energy value of crude (catabolized) protein for growth in pigs. Livest. Prod. Sci., 9: 349—360.

— 1983. The role of the large intestine in the digestion of nutrients and amino acid utilization in monogastrics. IVth Int. Symp. Protein metabolism and nutrition. Ed. INRA Publ. 1983, I (les Colloques de l'INRA, no 16).

JORGENSEN, H. & FERNANDEZ, J.A. 1987. Free amino acids versus soya protein as supplement to cereal based diets for growing pigs. 5th Int. Symp. on Protein metabolism and nutrition. Manuscript, pp. 4.

KATZ, R.S., BAKER, D.H., SASSE, C.E., JENSEN, A.H. & HARMON, B.G. 1973. Efficacy of supplemental lysine, methionine and rolled oats for weanling pigs fed a low-protein corn-soybean meal diet. J. Anim. Sci., 37, 1165—1168.

KRAWIELITZKI, K., SCHADEREIT, R., VÖLKER, T. & BOCK, H.D. 1982. Arch. Tierernährung 32, 445—454.

LEIBHOLZ, J., LOVE, R.J., MOLLAH, Y. & CARTER, R.R. 1986. The absorption of dietary L-lysine and extruded L-lysine in pigs. Anim. Feed Sci. Technol., 15: 141—148.

MADSEN, A., MORTENSEN, H.P. & HALL, D.D. 1987. Protein of aminosyrer till slagtesvin. 1. Beretning fra Statens Husdyrbrugsforsog, nr 627.

— & MORTENSEN, H.P. 1977. Feeding experiments with bacon pigs. 7. Essential amino acids and pig performance. Kgl. Vet.- og Landbohojsk. Årsskr., s. 58—67.

MILLER, B.G., JAMES, P.S., SMITH, M.W. & BOURNE, F.J. 1986 a. Effect of weaning on the capasity of pig intestinal villi to digest and absorb nutrients. J. agric. Sci., Camb. 107, 579—589.

—, STOKES, C.R. & BOURNE, F.J. 1986 b. Low-protein starter feeds reduce scours in young pigs. Feedstuffs, Oct. 20., pp. 11—12.

NABUURS, M.J.A. & HOOGENDOORN, A. 1985. Soybean products stimulating net excess of secretion in the LGT model. Proc. 3rd Int. Seminar on Digestive metabolism in the pig. (Just, A., Jorgensen, H and Fernandez, J.A. Eds.). p. 131—134.

NIELSEN, H.E., DANIELSEN, V., EGGUM, B.O. & CHWALIBOG, A. 1984. Tilskud af aminosyrerne lysin, metionin og treonin til foderblandninger med lavt proteininhold til fravaennede grise. Statens Husdyrbrugsforsog, Meddelelse nr 545.

NÄSI, M. 1986. Puhtaitten aminohappojen käyttö sikojen ja siipikarjan ruokinnassa. Maataloustieteen päivät. Suomen maataloustiet. seur. tiedote, No 7: 112—118.

PAO, S.R., CARTER, F.L. & FRAMPTON, V.L. 1963. Anal. Chem. 35, 1927—1930.

PARTRIDGE, I.G., LOW, A.G. & KEAL, H.D. 1985. A note on the effect of feeding frequency on nitrogen use in growing boars given diets with varying levels of free lysine. Anim. Prod. 40: 375—377.

Prohaszka, L. & Baron, F. 1980. The predisposing role of high dietary protein supplies to enteropathogenic E. Coli infections of weaned pigs. Zbl. Vet. Med. B, 27, 222—232.

Rogerson, J.C. & Campbell, R.G. 1982. The response of early-weaned piglets to various levels of lysine in diets of moderate energy content. Anim. Prod. 35: 335—339.

Russell, L.E., Cromwell, G.L. & Stahly, T.S. 1983. Tryptophan, threonine, isoleucine and methionine supplementation of a 12 % protein, lysine supplemented, corn-soybean meal diet for growing pigs. J. Anim. Sci. 56, 1115—1123.

Salo, M-L., Tuori, M. & Kiiskinen, T. 1982. Rehutaulukot ja ruokintanormit. 70 p. Helsinki.

Shiemann, R., Nehring, K., Hoffmann, L., Jentsch, W. & Chudy, A. 1971. Energetische Futterbewertung und Energienormen. VEB Deutscher Lantwirtschaftsverlag, Berlin. 344 pp.

Ms received

SELOSTUS

Teollisesti tuotetut aminohapot porsaiden ja sikojen rehuissa

Inborr, J.[1] and Suomi, K.[2]

[1] *Suomen Sokeri Oy, Finnfeeds Ltd Forum House, Brighton Road, Redhill, Surrey RH1 6YS, England*

[2] *Maatalouden tutkimuskeskus, Sikatalouden tutkimusasema 05840 Hyvinkää*

Kolmessa tuotantokokeessa, kaksi pikkuporsailla ja yksi kasvavilla sioilla, tutkittiin rehun raakavalkuaistason alentamisen vaikutusta kasvuun, rehun hyväksikäyttöön ja ripulin esiintymiseen. Vähemmän valkuaista sisältävien rehujen (koerehujen) lysiinin, metioniinin ja treoniinin määriä nostettiin samaan tasoon kuin kontrollirehun lisäämällä niitä puhtaina aminohappoina.

Ensimmäisessä porsaskokeessa rehun valkuaistasoa alennettiin 20 %:sta 18,3 %:iin ja toisessa 18,3 %:sta 16,7 %:iin. Kasvavilla sioilla tehdyssä kokeessa rehun raakavalkuaistasoa alennettiin 17,0 %:sta 15,5 %:iin. Teollista L-lysiiniä, DL-metioniinia ja L-treoniinia lisättiin koerehuihin, jotta niiden määrä olisi sama kuin kontrollirehussa.

Porsaiden kasvussa ja rehun hyväksikäytössä ei ryhmien välillä ollut eroja. Tulokset viittaavat siihen, että lisättyjen aminohappojen ja rehuvalkuaisen aminohappojen käyttökelpoisuus oli yhtä hyvä. Vähemmän valkuaista sisältäviä rehuja saaneiden porsaiden terveydentila oli huomattavasti parempi kuin kontrolliryhmän (vähemmän vieroitusripulia), mikä viittaa siihen, että ripulialttius oli pienempi.

Koeryhmän siat kasvoivat 6 % nopeammin (788 vs. 743 g/pv; $p<0,07$) ja käyttivät rehua 4 % tehokkaammin hyväkseen kuin kontrolliryhmän. Myös koeryhmän teuraslaatu oli parempi. Erot eivät olleet tilastollisesti merkitseviä.