No. 22 JUNE 1998

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REDUCING NITROGEN POLLUTION FROM PIGS - THE ROLE OF FISH MEAL IN LOW PROTEIN DIETS

SUMMARY

In areas where pollution threatens waterways - for example, where nitrate levels in drinking water are regarded as unacceptably high, limits are in place or being set to control the excreta (manure) from animals spread on the land. These limits could result in a contraction of pig farming in these areas.

One of the more effective ways of reducing nitrogen and phosphorus output from pigs is to reduce their level in the diet. This can only be done without jeopardising growth if the dietary protein and phosphorus sources are highly digestible. In the case of protein, the essential amino acid supply should equal requirements and avoid the use of excessive levels, that is, closely match the ideal protein.

Fish meal is rich in protein and phosphorus in a highly available form. It also has an amino acid content rich in essential amino acids which approaches that of the ideal protein, making it a valuable component of low protein low phosphorus pig diets.

A trial with fish meal has been conducted at Wye College, University of London with 64 individually fed finishing pigs. A low protein (13%) diet with fish meal was compared with "normal" protein diets (17%) without and with fish meal. Because reducing protein in the diet reduces energy required to metabolise and excrete excess nitrogen, savings in energy should be possible. This was tested by including a low protein low energy diet.

The results of the trial showed that in the presence of fish meal a marked reduction of dietary protein could be made from 17% to 13%, without affecting growth. A daily gain of over 1 kg per day was achieved in each case. Lowering energy content of the diet did not reduce growth (1.069 kg/day). None of the treatments affected carcass quality.

Though the low protein diets formulated to provide adequate levels of amino acids may cost more, some of the increase can be off-set by reducing energy content. In practice, the optimum economic solution will depend on the pressure on the farm to cut nitrogen output, and may be provided by an intermediate protein level.

Nitrogen and Phosphorus Output from Pigs and Environmental Pollution

Excreta from animals containing high levels of nitrogen and phosphorus has been identified as a major pollutant of waterways. This can lead to excessive vegetative growth, particularly algal growth, leading to stagnation. Some algae are toxic, threatening farm livestock and other animals. From the waterways, high levels of nitrogen can get into drinking water in the form of harmful nitrates.

Intensive pig production and spreading large amounts of pig slurry (manure) have been identified as a significant source of polluting nitrogen and phosphorus. Legislation has been introduced in some countries to reduce waste nitrogen and phosphorus from farm animals, e.g. in Holland and Taiwan. An EU Directive (91/676 'Council Directive of 12 December 1991 Concerning Protection of Waters against Pollution caused by Nitrates from Agricultural Sources) which comes into effect in December 1998 will limit the amount of nitrogen from manure that can be spread on land. This limit could threaten pig farming, resulting in its contraction in pollution sensitive areas.

Reducing Output of Nitrogen and Phosphorus by Reducing Dietary Levels - The Role of Fish Meal

One of the most cost effective ways of cutting nitrogen output in the excreta from pigs is to reduce dietary protein. In doing so, it is important that the diet is formulated to meet the requirement of essential amino acids in a form available to the animal. Phosphorus too should be provided in an available form to allow the amount in the diet to meet requirement without feeding excessive levels.

Fish meal is rich in amino acids likely to be limiting in pig diets. These are in a highly digestible form (Partridge *et al*, 1987). This makes it a protein which closely approaches the ideal, enabling protein to be used more efficiently. In turn, this allows dietary protein to be reduced. It is also rich in phosphorus. Coming mainly from the bones of fish, this natural source has a high availability to the pig. This will allow dietary phosphorus to be reduced, whilst still meeting the pig's requirements. Reducing dietary nitrogen and phosphorus will lead to reductions in their output in pig manure (slurry).

Other Possible Advantages of Reducing Dietary Nitrogen

By reducing surplus nitrogen in the diet, less energy is required to metabolise and excrete it. The extra energy made available may result either in increased body fat deposition or extra lean growth depending on the genetic predisposition of the pigs and the scale of feeding adopted.

Other possible advantages of low protein diets and reduced nitrogen excretion are a smaller requirement for water, less slurry production, less ammonia in the pig house environment and consequent improvements to health.

Trial with Finishing Pigs

To investigate if diets including fish meal could be formulated with a considerably reduced protein level without jeopardising pig growth a trial was undertaken at Wye College, Ashford, UK, part of the University of London. It was undertaken with finishing pigs (45 to 91 kg liveweight) as this is the stage of production where most nitrogen is excreted.

Dietary Treatments

Pig diets with 13% protein have been shown to support good growth if the limiting amino acids were provided in adequate amounts (Lenis, 1992). For this purpose the ileal protein concept of Wang and Fuller (1989) has been used. Although the diets were formulated using total amino acids, the content of the more limiting amino acids (lysine, threonine, methionine and tryptophan) were also calculated on an ileal digestible basis to ensure the amounts indicated by Wang and Fuller were provided.

Control diets without and with fish meal (diets 2 and 3) were formulated with 17% protein, this representing the lower end of the protein range in commercial pig finisher diets (17% to 20%). These supplied more than the minimum requirement of essential amino acids. The normal protein diet with fish meal (3) required no supplementary amino acids. The normal protein diet without fish meal (2) was supplemented with lysine and methionine to give the same total levels as in diet 3. (Details of diets see later)

To check if energy requirement was reduced with reduced dietary protein a fourth treatment (4) was included with low protein and reduced energy, but maintaining the same amount of fish meal and digestible amino acids as in the low protein diet. In case carcass quality was affected in any of the diets, all pigs were subjected to carcass measurements at slaughter following the end of the trial.

Trial Facilities

The trial was carried out in the Pig Research Unit at Wye College, a breeding-fattening unit with 190 Landrace sows. Their facility for individual feeding of 112 pigs in a Danish style pig house for finishing pigs (growing typically from 45 kg to 90 kg) was used. The house contained seven pens on either side of a central passage with a capacity of up to eight pigs in each pen. Each pig had access to an individual feeder.

Animals

A total of 64 female Landrace pigs, initial weight approximately 45 kg, were used. In order to obtain pigs of similar weight there were four blocks of 16 pigs starting at four dates over a period of two months. The four diets were allocated to four pigs within each block, giving 16 replicates grouped in fours by start date. Pigs were individually fed but were grouped in pens such that all diets were represented in each pen.

Pigs were fed individually twice a day to a feeding scale (see Appendix Table 2), except Sunday when they received their day's allocation in one feed. They were weighed fortnightly. On reaching bacon weight (91 kg or over) they were sent for slaughter. The slaughter house provided carcass weight, carcass fat and grading measurements on a scale 1 to 5 with 1 as best for each pig.

Diets

The diets for each of the four treatments are shown in Appendix Tables 1a (ingredient composition), and 1b (calculated analysis and determined analysis on samples collected during the trial).

They were formulated with nutrient levels typical of those in commercial pig feeds except for protein and amino acids. In all cases the nutrient content was sufficient to meet requirements. They were formulated to a minimum total content of lysine, methionine, threonine and tryptophan which were calculated to satisfy the requirements of finishing pigs. The digestible amino acid content was also calculated using literature values.

Ingredients and inclusion levels were selected to reflect as far as possible those used in typical commercial pig finisher diets.

A mixture of cereals, wheat and barley were used as well as tapioca which is widely used in Europe and enables a low protein diet to be produced even though supplementary proteins are used. High protein (48%) soyabean meal, rapeseed meal low toxin (00) and beans were the proteins used, these being typical of those used in Europe. The fish meal was UK produced, mainly from trimmings including white-fish. Sugar beet pulp which is widely used in pig finisher feeds in the UK, was used in the low energy diet (4) to reduce energy content. All four were fed according to the same feeding scale, details of which are given in Appendix Table 2.

Results - Statistical Analysis

Pigs were started on trial in replicated blocks at different times, all treatments being represented within a block and in pen. Consequently the data were statistically analysed removing the effects of start date, pens and start date x diet interaction (not significant) so that variation caused by diet could be tested against the variation between pigs on the same diet within each start time period pooled for all pigs.

Liveweight Gain

Excellent growth was achieved by all pigs (see Tables 1 and 2). With the exception of the control diet without fish meal (2) all pigs grew at a rate of more than 1 kg per day. The dietary treatment effect was not significant. The pigs that received the low protein diet with fish meal (1) grew faster than those on the control "normal" protein diet (3) with fish meal (1.066 v 1.021 kg/day) and the normal protein diet (2) without fish meal (1.066 v 0.982 kg/day) though the differences were not significant. Even the pigs on the low protein and low energy diet with "minimum" amino acid content (4) grew as fast as the pigs on the control "normal" protein diet with fish meal (1.069 v 1.021 kg per day) and faster than those on the control diet without fish meal (1.069 v 0.982 kg per day) though these differences too were non-significant.

Some response in growth was seen to the fish meal inclusion in the normal protein diets (1.021 v 0.982) though the difference was not significant.

Table 1

PIG PERFORMANCE DATA FROM 45 KG TO BACON WEIGHT BY DIET						
Observation	**Diet**					**Probability**
	1	**2**	**3**	**4**	**SE Mean**	
Start wt.(kg)	45.72	45.52	45.91	45.58	0.254	NS
Final wt.(kg)	93.60	91.79	93.30	93.23	0.517	NS
Liveweight gain (kg)	47.88	46.27	47.38	47.65	0.628	NS
Days on trial	47.37	48.37	47.94	46.49	1.508	NS
Average DLWG (kg/d)	1.066	0.982	1.021	1.069	0.033	NS
Food Intake (kg)	108.7	109.0	109.0	106.9	3.568	NS
Feed Conversion	2.256	2.350	2.290	2.238	0.066	NS

Feed Conversion

Feed conversion was better with low protein diets, that with low energy giving the best value, but differences were not significant.

Table 2

COMPARISON OF DIFFERENCES IN AVERAGE DAILY LIVEWEIGHT GAIN			
EFFECT	DIETS COMPARED	SIGNIFICANCE	
		DIFFERENCE	
Fish meal 13% CP normal energy v no fish meal, 17% CP normal energy	1 v 2	+0.084	NS
Fish meal 13% CP normal energy v fish meal, 17% CP normal energy	1 v 3	+0.045	NS
Fish meal 13% CP low energy v fish meal, 17% CP normal energy	4 v 3	+0.048	NS
Fish meal 13% CP low energy v no fish meal, 17% CP normal energy	4 v 2	+0.087	NS
Fish meal 17% CP normal energy v no fish meal, 17% CP normal energy	3 v 2	+0.040	NS
Fish meal 13% CP low energy v fish meal, 13% CP normal energy	4 v 1	+0.003	NS
For each comparison the Standard Error of the difference = 0.0467 and the difference required to be significant at a probability of 5% = 0.0929			

Carcass Grading

There were no differences in carcass grading, carcass weight, dressing percentage or carcass fat (see Table 3).

There was no indication that the low protein diets had any adverse effect on carcass grading.

Table 3

PIG CARCASS DATA BY DIET						
Observation	**Diet**					**Probability**
	1	**2**	**3**	**4**	**SE mean**	**Sig.**
Carcass weight (kg)	65.66	63.86	63.64	64.17	0.630	NS
Dressing (%)	70.13	69.57	68.22	68.83	0.567	NS
Carcass fat (mm)	10.94	11.11	11.67	11.56	0.511	NS
Carcass grade	1.19	1.16	1.54	1.31	0.152	NS

Ammonia Levels in Pig House

It was not possible to measure ammonia levels in the pig house. However people working there noted a less "acrid" smell which may have indicated less ammonia compared with similar adjacent houses.

Conclusions

The results of this trial show that marked reductions in protein content of the diet of finishing pigs can be made (from 17% to 13%) with no adverse effect on either growth or feed conversion, where it contained fish meal. Carcass measurements indicated that lowering dietary protein did not affect grading. Reducing protein to the levels in this trial increased diet cost partly because of the need to supplement with amino acids and the cost of including fish meal. However, in lowering protein it was shown that energy could be lower. This would off-set some of the cost of lowering protein. In practice the optimum economic solution, dependent on the pressure on the farm to cut nitrogen output, may be provided by an intermediate protein level in the diet and a correspondingly smaller reduction in its energy content.

REFERENCES

Lenis, N.P. (1992). Digestible amino acids for pigs : assessment of requirements on ileal digestible basis. Pig News and Information. **13**, No. 1, 31N-39N.

Partridge, I.G., Low, A.G. and Matte, J.J. (1987). Double-low rapeseed meal for pigs; ileal apparent digestibility of amino acids in diets containing various proportions of rapeseed meal, fish meal and soyabean meal. Animal Production, **44**, 415-420.

Wang, T.C. & Fuller, M.F. (1989). The optimum dietary amino acid pattern for growing pigs. Brit. J. Nutr., **62**, 77-89.

Appendix 1 a

DIETS FOR THE PIG POLLUTION STUDY AT WYE COLLEGE				
	Dietary Treatments			
	1	**2**	**3**	**4**
Protein	low	normal	normal	low
Amino Acids	low	high	high	low
Energy	normal	normal	normal	low
Fish Meal	+	-	+	+
Ingredients				
Wheat	36.69	25.28	19.35	33.24
Barley	10.00	10.00	10.00	10.00
Tapioca	20.00	10.00	15.00	17.00
Wheat Middlings	15.00	20.00	22.00	18.50
Soyabean Meal Dehulled	-	11.0	5.0	-
Rapeseed Meal	3.00	7.50	7.50	2.00
Beans	3.00	5.50	7.50	2.00
UK Fish Meal	4.00	-	4.00	4.00
Sugar Beet Pulp	-	-	-	6.00
Beet/Molasses	4.00	4.00	4.00	4.00
Fat	1.50	4.29	3.80	0.50
Dical	0.80	0.80	0.30	0.80
Limestone	1.00	1.00	1.00	1.00
Salt	0.30	0.35	0.30	0.25
Lysine	0.28	0.05	-	0.28
Methionine	0.08	0.03	-	0.08
Threonine	0.08	-	-	0.08
Tryptophan	0.02	-	-	0.02
Supplement	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**

Appendix 1 b

DIETS FOR THE PIG POLLUTION STUDY AT WYE COLLEGE				
	Dietary Treatments			
	1	**2**	**3**	**4**
Calculated Composition				
Protein	13.09	16.97	16.95	13.13
Oil	3.37	6.02	5.86	2.45
Fibre	4.16	5.08	5.23	5.22
DE (MJ/KG)	13.27	13.25	13.25	12.64
Lysine	0.80	0.88	0.88	0.80
Methionine	0.29	0.27	0.28	0.30
Methionine + Cystine	0.50	0.56	0.56	0.50
Dig Lysine	0.70	0.73	0.74	0.70
Dig Methionine	0.27	0.24	0.24	0.27
Dig Methionine + Cystine	0.44	0.49	0.48	0.44
Dig Threonine	0.43	0.49	0.50	0.43
Dig Tryptophan	0.12	0.15	0.14	0.12
Calcium	0.83	0.72	0.74	0.87
Total Phosphorus	0.61	0.63	0.60	0.61
Sodium	0.20	0.19	0.21	0.20
Acid Base	23.08	29.60	28.78	24.87
Determined Composition				
Protein	13.1	17.0	16.7	13.4
Oil (ether extract)	2.4	5.8	5.5	2.2
Fibre (neutral detergent)	4.2	5.6	5.5	5.0
DE[1]	16.05	16.83	16.70	15.59

[1]DE calculated as = 17.49 + 0.079 x protein + 0.158 x oil - 0.331 x ash - 0.140 x fibre

Appendix Table 2

WEEKLY FEED ALLOWANCE PER PIG ACCORDING TO LIVEWEIGHT	
Liveweight (kg)	**Feed allowance/pig/week (kg)**
45	12.4
50	13.4
55	14.4
60	15.3
65	16.2
70	17.1
75	18.0
80	18.9
85	19.7
90	20.8

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