International Fishmeal & Oil Manufacturers Association

TESTING FISH MEAL TO REDUCE POLLUTION FROM FINISHING PIGS

USE OF FISH MEAL IN LOW PROTEIN DIETS TO REDUCE NITROGEN OUTPUT IN FINISHING PIGS

Report of a Trial at Wye College

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EXECUTIVE SUMMARY AND CONCLUSIONS

A trial with 96 individually fed finishing pigs (45 to 91 kg liveweight) has been carried out at the University of London, Wye College to test the use of fish meal in low protein diets designed to reduce nitrogen output. Four diets, numbers 1 and 2 with low (13%) protein fortified with amino acids to meet requirement, and numbers 3 and 4 with normal (17%) protein, with and without fish meal, were fed. A further low protein fish meal diet (5) was fed with low energy to check whether it would be necessary to feed less energy in conjunction with low protein in order to maintain a desirable lean carcass composition. Another low protein fish meal diet (6) was formulated with raised levels of the limiting amino acids, equating them to those in the high protein diets to test whether the requirements had been fully met at the low protein level. Weight gain, feed conversion and carcass measurements were taken.

The following conclusions were drawn from the results:-

i) Dropping the dietary protein from 17% to 13% whilst still supplying the calculated requirement for the most important amino acids (lysine, threonine and methionine plus cystine) by supplementation (diets 3 and 4 v 1 and 2) increased growth rate ($P<0.05$). Feed conversion and carcass quality of the pigs were not affected. A reduction in protein intake of this magnitude should lead to a considerable drop in nitrogen output in urine and faeces. However, the low protein diets were more expensive. Taking into account pig performance, pollution reduction and diet cost, the feed formulator may opt for an intermediate protein level which would depend on feed ingredient costs. Clearly, present protein levels in pig finisher diets, often over 17%, can be reduced.

ii) For finishing pigs receiving low protein diets supplemented with amino acids (see above), including fish meal did not give improved growth. As its inclusion in these diets increases their cost, this experiment has given results that would not justify the use of fish meal. This result was unexpected. The higher digestibilities of the amino acids in fish meal compared with those of amino acids in the vegetable proteins it replaced in the low protein diets was expected to increase growth. A low protein diet with a higher level of amino acids (treatment 6) did give a growth response (P=0.07 in a one-tail test) compared with the similar diet with amino acid levels calculated to meet requirements (treatment 2), yet the fish meal treatment in low protein diets with low amino acids did not give a response.

iii) Because of the limited number of treatments possible in this type of experiment, and the number of questions to be answered, only two treatments (1 and 2) were available to compare low protein diets with (4%) and without fish meal. These were formulated to equate nutrients. To do so, fish meal was replaced with rapeseed meal plus beans, and wheat middlings were increased and fat addition reduced in the fish meal diet. The substitution of fish meal inevitably involves several dietary changes. These were formulated using feed industry data, and done in a way a formulator might do in practice. Analysis of diets revealed no discrepancies in actual versus calculated dietary nutrient content. Nevertheless, the possibility that nutrients were not equated in the substitution, or that a fortuitous result was obtained for treatments 1 or 2 cannot be ruled out.

iv) Because a drop in dietary protein should make more energy available for growth, possibly giving surplus energy and increased carcass fat, a treatment was included to investigate the effect of lowering dietary energy (treatment 5). There was no reduction in carcass fat with the reduced energy diet (diet 5 versus diet 2) and no indication that the low protein diets (1 and 2) with normal energy content increased carcass fat. It can be concluded that when dietary protein was lowered in these fast growing lean pigs, energy savings from not needing to synthesise urea to excrete the excess nitrogen are directed towards increased growth. Alternatively, dietary energy may be reduced with consequent reduction in dietary costs.

BACKGROUND - OBJECTIVES OF THE TRIAL

The nitrogen output of pigs can be reduced by feeding proteins which are more digestible, and supplementing with synthetic amino acids. This improves the amino acid profile (digestible), enabling the amount of nitrogen fed to be reduced, and the amount excreted in urine and faeces to be reduced also. A further advantage of reducing dietary protein is that because the surplus nitrogen is reduced, 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. Further advantages of reduced N excretion are a smaller requirement for water, less slurry production, less ammonia in the pig house environment with consequent improvements to health.

From computer exercises, it has been found that whilst the value of fish meal in such diets increases, the fish meal may still not come in on a least-cost basis. Reducing the protein in the diet can increase its cost, and a further increase to include fish meal would probably prevent fish meal being used for this purpose, unless it can be shown that performance improves.

The trial was designed to compare growth, feed conversion and carcass quality of pigs fed normal and low protein diets formulated with the four most limiting amino acids - lysine, threonine and methionine plus cystine meeting calculated requirements. At each protein level diets either had 0 or 4% fish meal. An additional low protein diet with fish meal, formulated to a reduced energy content was included. Because in practice diets with higher contents of the above limiting amino acids are used, a treatment was included with low protein content and amino acids (see above) equated to those in the high protein diets.

It has been shown that provided limiting amino acids are adequately supplemented, a finishing diet with only 13% protein has given good growth (Lenis, 1992). For this purpose the ideal protein concept of Fuller and Wang (1989) has been used, along with data from ARC 1981, to calculate the requirements for all the essential amino acids.

TRIAL FACILITIES

The trial was carried out at the Pig Research Unit of Wye College (University of London), a breeding-fattening unit with 190 Landrace sows.

Their facility for individual feeding of up to 112 pigs in a Danish style pig house for finishing pigs (fattening 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 having access to an individual feeder.

Animals

A total of 96 female Landrace pigs of approximately 45 kg liveweight went onto the trial. There were four start dates, 24 pigs starting each time - three pens of eight pigs. A total of 12 pens were used. This was to allow for sufficient numbers of pigs of similar weight to become available from the herd to start the trial at the same time, where each batch of 24 pigs was made up of 12 sibling (related) pairs. Pigs were randomly allocated to one of three pens, no single pen containing a sibling pair. Each pen accommodated eight pigs in which there was one replicate of 4 diets and two replicates of the other 2 diets, so that within each start date diet was replicated four times.

Pigs were fed individually twice a day to a feeding scale (see Appendix Table 1), 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 for each pig.

Dietary Treatments

There were six treatments, comprising of a main part of four treatments and a subsidiary part with two further treatments aimed at aiding interpretation of the responses of the main part. The four main treatments (Tables 1a and b, diets 1-4) examined the efforts of two levels of crude protein (13% and 17%) each without or with 4% inclusion of fish meal. Diets 1 and 2 (13% CP) were formulated to supply 0.8% lysine, 0.5% methionine plus cystine, 0.5% threonine and 0.15% tryptophan which were calculated to satisfy the requirements of finishing pigs. The digestible amino acids content of the diets was also calculated using literature values. Inclusion of fish meal in diet 2 marginally increased the digestible lysine and methionine but decreased digestible threonine and tryptophan compared with diet 1 (Table 1b).

One subsidiary treatment was a further low protein fish meal diet (5) with reduced energy concentration to be compared with diet 2 to check whether it would be necessary to feed less energy in conjunction with low protein in order to maintain a desirable lean carcass composition. The second subsidiary treatment was also a low protein fish meal diet (6) formulated with raised levels of lysine, methionine, threonine and tryptophan equating these to levels provided in the high protein diet (4) to test whether the provision of these critical amino acids was adequate in diet 2.

The diets were based on wheat as the main cereal with tapioca and wheat middlings as other major ingredients (see Table 1a). The tapioca, widely used in Europe, enables a low protein diet to be produced even though supplementary proteins are used - high protein soyabean meal (48%), rapeseed (low toxin -00) and beans being used in these diets, as representing typical ingredients of European pig feeds. Sugar beet pulp, which is widely used in pig feeds in finisher pig diets in the UK, was used to reduce the energy content of diet number 5. Feeding was according to a scale, details of which are given in Appendix Table 1.

RESULTS AND DISCUSSION

Liveweight Gain, Feed Intake and Feed Conversion

There were marked and significant differences in growth rate of pigs according to the start date, irrespective of diet (Table 2). Consequently the data were re-analysed, removing effects of pens, start date and start date x diet interaction (not significant) (see Table 3 and Appendix 1) so that variation caused by diet could be tested against the variation between pigs within replicates in each start time period.

Appropriate dietary contrasts for liveweight gain are shown in Table 4. Decreasing dietary protein from 17% to 13% increased growth rate ($P<0.05$). Inclusion of 4% fish meal had no significance, neither averaged over the two protein levels nor at each protein level separately.

With most pigs averaging a daily liveweight gain of around 1 kg per day or more, these were considered very good.

The fact that for the low protein diet with fish meal and with amino acid levels to meet requirements (2) growth was around 3% less than that for the diet without fish meal (1.066 v 1.095 kg/day) was surprising. It was the opposite of what was expected and also opposite to the trend at the high protein (3 and 4). Checks were made to confirm diets were satisfactorily mixed. These so far have included protein and oil content and the presence of long chain omega-3 fatty acids to indicate the presence of fish meal. Results of the checks (results not yet available for this report) appear to confirm that diets were mixed satisfactorily and fish meal correctly added. As the diets were formulated on the basis of total amino acids, higher digestibility of amino acids especially lysine in fish meal, which have not necessarily been reflected in calculated digestibility values because of the 'book' values used, might have resulted in better growth. This was not the case. In contrast, pigs receiving the high protein diet with fish meal grew faster than those on the diet without it (1.021 v 0.982 kg/day). As neither of the differences 1 v 2 nor 3 v 4 was significant, it can only be assumed that these results are due to chance. An unexpected failure to equate nutrients in the substitution of fish meal might also account for the unexpected results (1 v 2) for example the decrease in calculated digestible threonine.

Adding extra amino acids to the low protein diet with fish meal (6) boosted growth compared with diet 2. The increase did not achieve statistical significance in the conventional two-tail test but the probability of the expected <u>increase</u> occurring by chance was only 7% ($P=0.07$) in a one-tail test. This response indicates that diet 2 (and by analogy also diet 1) was borderline in meeting the requirement for one or more amino acids and, therefore, the comparison of diets 1 and 2 should have been sensitive to any improvement in availability of amino acids contributed by the inclusion of fish meal.

Although diet 6 (low protein) was formulated to supply the same amount of the major essential amino acids as diet 4 (high protein) it supported significantly ($P<0.05$) better growth rate (1.135 kg/day v 1.021 kg/day). The better growth rate at equal amino acid supply indicates the penalty of feeding excess protein and consequent reduced net energy supply in pigs given rationed amounts of feed.

Finally, the diet in which energy was reduced (5) compared with the equivalent diet with normal energy content (2) gave similar growth (1.069 v 1.066 kg/day).

Feed intake did not differ between treatments, though it tended to be lower for diets 6 and 1. Feed conversion differences were also not significantly different though the diets 1 and 6 gave the lowest (best) values.

Carcass Data

There were no significant differences in carcass data though the heaviest carcasses were recorded for the pigs on low protein diets with fish meal (Table 5).

Dressing percentage, carcass fat and grade were not affected by treatment. Dropping protein content did not have a detrimental effect on carcass quality. Put another way, because when protein is reduced energy is spared, there was no indication this energy was used to produce more fat, but in these pigs the saved energy was used to promote increased lean growth. Since pigs fed low protein diets did not get fat, it is not surprising that the reduced energy diet (5) did not reduce carcass fat. However, in a situation where pigs respond to net energy supply by change in lean growth rate the lack of effect of reduced energy on liveweight gain is more difficult to explain. A partial explanation is an increased gut fill through the use of sugar beet pulp, resulting in a non-significant 1.5 kg less carcass weight and 1.3% less dressing percentage (Table 5).

RECOMMENDATION

It is recommended that the Association should not actively promote the use of fish meal in low protein diets for finishing pigs until more trial work can be undertaken. Before returning to work with finishing pigs, it is recommended that a growth trial on similar lines to the present one should be undertaken using younger pigs in the growth stage from 20kg to 45kg.

REFERENCES

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Table 1 a DIETS FOR THE PIG POLLUTION STUDY AT WYE COLLEGE						
Dietary Treatments	DIET NO.					
	1	2	3	4	5	6
Protein	low	low	high	high	low	low
Amino Acids	low	low	high	high	low	high
Energy	normal	normal	normal	normal	low	normal
Fish Meal	-	+	-	+	+	+
Ingredients						
Wheat	29.91	36.69	25.28	19.35	33.24	37.42
Barley	10.00	10.00	10.00	10.00	10.00	10.00
Tapioca	19.99	20.00	10.00	15.00	17.00	20.00
Wheat Middlings	10.00	15.00	20.00	22.00	18.50	15.00
Soyabean Meal Dehulled	-	-	11.0	5.0	-	-
Rapeseed Meal	10.00	3.00	7.50	7.50	2.00	2.30
Beans	9.50	3.00	5.50	7.50	2.00	3.00
UK Fish Meal	-	4.00	-	4.00	4.00	4.00
Sugar Beet Pulp	-	-	-	-	6.00	-
Beet/Molasses	4.00	4.00	4.00	4.00	4.00	4.00
Fat	3.50	1.50	4.29	3.80	.50	1.20
Dical	1.00	0.80	0.80	0.30	.80	0.80
Limestone	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.35	0.30	0.35	0.30	0.25	0.30
Lysine	0.28	0.28	0.05	-	0.28	0.40
Methionine	0.10	0.08	0.03	-	0.08	0.14
Threonine	0.10	0.08	-	-	0.08	0.14
Tryptophan	0.03	0.02	-	-	0.02	0.05
Supplement	0.25	0.25	0.25	0.25	0.25	0.25
	100	**100**	**100**	**100**	**100**	**100**
Diet ingredient cost (£/tonne) based on UK prices March 1995	129.69	132.33	122.37	125.66	127.93	138.60

Table 1 b DIETS FOR THE PIG POLLUTION STUDY AT WYE COLLEGE						
Dietary Treatments	DIET NO.					
	1	2	3	4	5	6
Calculated Composition						
Protein	13.09	13.09	16.97	16.95	13.13	13.09
Oil	4.92	3.37	6.02	5.86	2.45	3.07
Fibre	4.69	4.16	5.08	5.23	5.22	4.10
DE (MJ/KG)	13.28	13.27	13.25	13.25	12.64	13.26
Lysine	0.79	0.80	0.88	0.88	0.80	0.88
Methionine	0.27	0.29	0.27	0.28	0.30	0.35
Methionine + Cystine	0.50	0.50	0.56	0.56	0.50	0.55
Dig Lysine	0.67	0.70	0.73	0.74	0.70	0.78
Dig Methionine	0.25	0.27	0.24	0.24	0.27	0.32
Dig Methionine + Cystine	0.44	0.44	0.49	0.48	0.44	0.50
Dig Threonine	0.45	0.43	0.49	0.50	0.43	0.49
Dig Tryptophan	0.13	0.12	0.15	0.14	0.12	0.15
Calcium	0.77	0.83	0.72	0.74	0.87	0.82
Total Phosphorus	0.59	0.61	0.63	0.60	0.61	0.61
Sodium	0.19	0.20	0.19	0.21	0.20	0.20
Acid Base	24.73	23.08	29.60	28.78	24.87	22.92

Table 2

PIG PERFORMANCE DATE FROM 45 KG TO BACON WEIGHT BY START DATE

Observation	Start Date				SE Mean	Probability	
	1	2	3	4		p	Sig
Start wt.(kg)	45.54	45.79	45.42	45.82	0.185	0.415	NS
Final wt.(kg)	94.75	92.82	93.00	92.06	0.214	0.001	***
Live wt gain (kg)	49.21	47.03	47.58	46.24	0.277	0.001	***
Days on trial	54.83	48.71	46.96	35.58	2.145	0.004	**
Avg.DLWG* (kg/d)	0.907	0.982	1.029	1.327	0.046	0.003	**
Food intake (kg)	127.4	109.9	108.5	79.4	4.971	0.003	*
Feed conv. Eff.	2.592	2.337	2.277	1.716	0.094	0.003	**

*daily liveweight gain

Table 3

PIG PERFORMANCE DATA FROM 45 KG TO BACON WEIGHT BY DIET

Observation	Diet							Probability
	1	2	3	4	5	6	SE Mean	
Start wt.(kg)	45.59	45.72	45.52	45.91	45.58	45.51	0.254	0.868 NS
Final wt.(kg)	93.33	93.60	91.79	93.30	93.23	93.68	0.517	0.127 NS
Liveweight gain (kg)	47.73	47.88	46.27	47.38	47.65	48.17	0.628	0.370 NS
Days on trial	45.14	47.37	48.37	47.94	46.49	43.82	1.508	0.274 NS
Average DLWG(kg/d)	1.095	1.066	0.982	1.021	1.069	1.135	0.033	0.036 *
Food Intake (kg)	103.5	108.7	109.0	109.0	106.9	100.9	3.568	0.505 NS
FCE	2.160	2.256	2.350	2.290	2.238	2.089	0.066	0.105 NS

Table 4

COMPARISON OF DIFFERENCES IN AVERAGE DAILY LIVEWEIGHT GAIN

EFFECT	DIETS COMPARED	DIFFERENCE OF MEANS	SED	SIGNIFI -CANCE
Low v high protein	(1+2) v (3+4)	+0.079	0.0330	<0.05
Fish meal v no fish meal	(2+4) v (1+3)	+0.005	0.0330	NS
Protein x fish meal interaction	(1+4) v (2+3)	-0.034	0.0330	NS
Fish meal v no fish meal at 13% CP	2 v 1	-0.029	0.0467	NS
Fish meal v no fish meal at 17% CP	4 v 3	+0.040	0.0467	NS
Increased amino acids at 13% CP	6 v 2	+0.069	0.0467	0.07 (one tail)
Amino acids equated to 17% CP	6 v 4	+0.114	0.0467	<0.05
Reduced energy	5 v 2	+0.003	0.0467	NS

SED - standard error of difference

Table 5

PIG CARCASS DATA BY DIET

Observation	Diet							Probability	
	1	2	3	4	5	6	SE mean	p	Sig.
Carcass weight (kg)	64.91	65.66	63.86	63.64	64.17	65.19	0.630	0.178	NS
Dressing (%)	69.57	70.13	69.57	68.22	68.83	69.57	0.567	0.224	NS
Carcass fat (mm)	11.96	10.94	11.11	11.67	11.56	11.21	0.511	0.715	NS
Carcass grade	1.59	1.19	1.16	1.54	1.31	1.21	0.152	0.198	NS

Appendix Table 1

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

Appendix 1

STATISTICAL ANALYSIS OF RESULTS

For the purpose of statistical analysis the experimental design could be broken down as follows:-

SOURCE	**df**		
12 pens*	11	*shown as its three components	
6 diets	5	start date	3 df
start date x diet	15	'pencode'	2 df
residual	64	start date x 'pencode'	6 df
	95		

Diet was again removed in the analyses together with the effects of pen which include start date, the hypothetical parameter of 'pencode' (1, 2 or 3 for each start date) and the interaction between them. This was carried out both to eliminate the effect pen might have on pig performance and to enable the interaction between start date and diet to be tested. In addition, the main effect of start date was tested using the pencode x start date term (6 df) as the residual.

Having removed the effect of start date on the performance of pigs on the trial fed the various diets, the effect of diet on average daily liveweight gain moved from non-significance ($p = 0.289$) in the preliminary analysis to significance ($p = 0.036$) in the second analysis.

Start date had significant effects on all measurements, except start weight which remained non-significant. Having removed this source of variation in the second analysis, the probability values achieved for diet became smaller compared to those in the preliminary analysis.