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Effect of Pre-and Post-weaning Nutrition and Management on Performance of Weaned Pigs to circa 35 kg.

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Summary

The objective of this project was to examine the factors affecting performance (growth rate, appetite, feed conversion efficiency) of pigs in the stage from weaning to 35 kg liveweight. The study involved three stages, creep feeding during the suckling period, management during the first weaner stage (c. 4 weeks from weaning or 6 kg to 15 kg liveweight) and management during the second weaner stage (c. 15 kg to 35 kg liveweight.

Creep feed intake before weaning was low c. 2.5 to 3.0 kg per litter but where it was consumed the response in terms of feed conversion efficiency was good with litter weight increasing in weight by about 1.1 kg for each 1 kg creep consumed. Milk replacer in liquid form was very readily consumed but its preparation and feeding is very laborious. Weaning weight was poorly related to post weaning performance and weaning age seemed to be more critical which is probably a reflection of the greater maturity of older animals.

In the first weaner stage, feeding of cooked cereal containing diets was found to have little benefit in pig performance. Acidification of feeds is likely to have only a minor influence on pig performance. An experiment on choice feeding of starter and link feeds did not confirm that smaller pigs require a higher quality diet and, in a choice situation will eat a greater proportion of the more nutrient dense diet.

In the second weaner stage, comparison of three commercial weaner feeds with a cereal based control diet showed good performance on all four diets. Pigs fed a high lysine weaner diet grew better in the weaner stage but by slaughter those pigs fed the low lysine weaner diet, after all pigs were fed a common finisher diet, had overtaken them. The high lysine group did, however, have leaner carcasses.

Residual effects of early nutrition need to be investigated in more detail including the effect of pregnancy feeding on prenatal development and the relationship between prenatal growth and postnatal growth, in particular development of muscle.

Introduction

The practice of creep feeding of suckling pigs was initiated when piglets were weaned at 6-8 weeks of age. The benefits of creep feeding in a 3 - 4 week weaning system is uncertain since intakes, at least up to 21 days of age, are low and variable. Sow milk yield peaks at 3 - 4 weeks post-partum and the need for supplementary feed is less though creep feeding may allow the pig to adjust more easily to dry feed after weaning.

Creep feed intake is affected by the milk supply of the sow, age of the pig, diet formulation, diet form and management.

It has been reported by Tokach et al. (1992) that each additional 0.5 kg advantage at weaning translated into approximately 1 kg by day 56 postweaning and 2 kg at market weight. It is not clear if this represents the inherent growth potential of the heavier pig or whether similar advantages accrue from management systems which will affect weaning weight. An increase in weaning weight is generally associated with increased age at weaning and a more mature digestive system. This may lead producers to assume that weight at weaning is a good indicator of maturity and the ability to cope with the stresses encountered post-weaning such as change of diet, housing and the environment. An earlier study conducted at Moorepark reported that pigs which were older at weaning (28 days) grew significantly faster than pigs of the same weight but younger (21 days old).

While there is little information in the literature on the effect of freshness on acceptability, feeds containing oxidised or rancid fats are thought to be unpalatable. Both free fatty acid (FFA) and peroxide levels have been used as measures of fat quality and suitability for feeding especially to young animals but neither is a reliable predictor of animal performance (Carpenter, 1968). Connolly et al. (1970) found that pig performance was unaffected by high levels of peroxide in the diet or prolonged storage and concluded that it is doubtful if toxicity from lipid peroxides would arise in practical feeding.

3. Creep feeding of suckling pigs

3.1 Creep feed intake

The objective of this study was to determine the level of creep feed intake by suckling piglets in a minimal disease herd while considering the factors affecting intake.

In the first experiment (Expt. 3.1.1), 64 litters of suckling pigs were blocked on the basis of age, and within block, randomly assigned to the following treatments:

A Control (no creep),
B Acidified calf milk replacer reconstituted to 20% dry matter,
C High density creep diet (Startrite 100 - SCA Feeds, Naas, Co. Kildare) offered with peat primer (Piglet Primer - Inroads International, Whitchurch, Shropshire, UK),
D High density creep diet (Startrite 100).

Creep feed was introduced at 7-12 days of age. Litters on Treatment C were offered peat primer from 5 days prior to introduction of creep feed and for the next 3 days were fed a mixture of creep and peat. Pigs were weaned at 25.3 (s.e. 2.9) days of age and litter size was 10.1 (s.e. 1.3) pigs.

The second experiment (Expt. 3.1.2) involved 40 litters of suckling pigs. Pigs were randomly assigned to one of 4 treatments:

A Control (no creep),
B High density creep feed (Startrite 100),
C Medium density creep feed (Thrive, SCA Feeds),
D Pelleted cooked cereal.

Pigs were weaned at 24.8 days of age (s.e. 1.1) with a litter size of 10.4 (s.e. 0.44)

The trial diets: Startrite 100 (25.5% protein, 11.0% oil, 1.5% fibre, 1.75% lysine), Thrive (21.5% protein, 7.5% oil, 2.7% fibre, 1.5% lysine) and cooked cereal (9.0% protein, 2.0% oil, 2.0% fibre, 0.40% lysine) were manufactured by SCA Feeds and the first two were proprietary compound creep feeds. The acidified calf milk replacer (20% protein, 20% oil, 0.2% fibre, 7.2% ash) was manufactured by Kerry Group Plc., Tralee, Co. Kerry.

Results from Experiments 3.1.1 and 3.1.2 are shown in Tables 3.1.1 and Table 3.1.2. In Experiment 3.1.1 creep feed intake was significantly greater (P<0.01) in the liquid form and these pigs were significantly heavier than control pigs at weaning (P<0.05). The peat primer tended to cause a small but not significant increase in creep feed intake. In Experiment 3.1.2 intake was higher on the high density creep feed, but growth rate was not significantly affected.

Table 3.1.1: Creep feed intakes and performance to weaning - Expt. 3.1.1

	A	B	C	D	s.e.	F-test
Treatment	Control	Milk R	Peat primer	HD Creep		
No. Litters	16	16	15	16		
Pig weight (kg)						
10 days of age	3.7^{ab}	3.8^{a}	3.3^{b}	3.6^{ab}	0.15	NS
Weaning	7.3^{a}	7.8^{b}	7.5^{ab}	7.6^{ab}	0.13	*
Feed consumption (g/day)						
Day 0-7 (g/day)	0^{a}	154^{b}	28^{c}	31^{c}	4	***
Day 7-14 (g/day)	0^{a}	276^{b}	143^{c}	106^{c}	20	***
Day 14-17[2](g/day)	0^{a}	323^{bc}	367^{c}	216^{b}	40	***
Total / litter (g)	0^{a}	3378^{b}	1881^{c}	1281^{c}	250	**
Daily Gain (g)						
Day O-weaning	250^{a}	277^{b}	257^{a}	263^{ab}	9	P=0.10

[1] Means having different superscripts are significantly different (P<0.05)
[2] Includes only 45 litters of pigs

Table 3.1.2: Creep feed intakes and pig performance to weaning - Expt. 3.1.2

	A	B	C	D.	e.	F-test
Treatment	Control	HD Creep	MD Creep	Cereal		
No. Litters	0	10	10	10		
Litter size	10.2^{a}	10.9^{a}	10.7^{a}	9.8^{a}	0.3	NS
Pig weight (kg)						
10 days	3.6^{a}	3.5^{a}	3.6^{a}	3.6^{a}	0.20	NS
Weaning	7.3^{a}	7.3^{a}	7.0^{a}	7.3^{a}	0.26	NS
Litter wean wt.	72.7^{a}	77.5^{a}	75.4^{a}	71.4^{a}	2.7	NS
Feed consumption (g/day)						
Day 0-7 (g/day)	0^{a}	45^{b}	35^{b}	32^{b}	5	***
Day 7-14 (g/day)	0^{a}	246^{b}	201^{b}	128^{c}	30	***
Day 14-17* (g/day)	0^{a}	898^{b}	823^{bc}	354^{c}	123	**
Total/litter (g)	0^{a}	3287^{b}	2266^{b}	1624^{a}	582	**
Daily Gain (g)						
Day 0-weaning	271^{a}	254^{a}	267^{a}	263^{a}	10.8	NS

* Includes only 25 litters of pigs

It is concluded that pigs will consume more of a high quality creep feed but growth was not consistently improved. Use of reconstituted milk as creep resulted in greater intake and heavier weaning weights than pigs on a dry diet but has a high labour requirement and for this reason is unlikely to have commercial application.

3.2 An assessment of the effect of feed freshness on intake and performance of sucking and weaned pigs

The aim of this study was to examine the effect of feed freshness on intake and growth of suckling and weaned pigs, using free fatty acid and peroxide levels as indicators of freshness.

In experiment 3.2.1, 54 litters of suckling pigs of size greater than 7 pigs (mean = 10.3, s.e. 0.3) were used. Litters were blocked on the basis of number of pigs and age and within each block assigned at random to one of three treatments:

A Fresh commercial starter feed,
B 30 day old commercial starter feed,
C 60 day old commercial starter.

Litters were offered feed from 10-11 days of age up to weaning at 26.0 (s.e. 0.6) days of age.

In Experiment 3.2.2, 87 individually fed pigs (29 per treatment) were weaned at 24-28 days of age, blocked on the basis of weight and sex and within each block assigned to one of three dietary treatments:

A 5 kg fresh starter followed by fresh link feed;
B 5 kg 30 day old starter followed by 30 day old link feed;
C 5 kg 60 day old starter followed by 60 day old link feed.

The duration of the trial was 21 days from weaning. The starter and link feeds contained 10.0% and 7.5% fat respectively. Age of feed refers to the number of days from manufacture to the time of commencement of feeding to pigs. Feed was delivered fresh from the manufacturers and stored, in sealed paper sacks, at ambient temperature in the Moorepark feed mill until feeding. Free fatty acid content and peroxide values were measured using the FADM 08 (extraction and titration) method on samples which were taken on delivery, after 30 days and after 60 days and stored at -20°C pending analysis.

In experiment 3.2.1, creep feed intake per litter was 2533, 2742 and 2683g (s.e. 266g: P>0.10) on treatments A, B and C, respectively up to weaning. Growth rate for the creep feeding period (10-11 days of age to weaning) was 253, 242 and 257 (s.e. 9.0)g / day for treatments A, B and C, respectively (P>0.10). Creep feed intake and growth rate of suckling pigs was unaffected by feed freshness.

In experiment 3.2.2, feed intake was 422, 421 and 438 (s.e. 13g) g/day (P>0.10), average daily gain was 415, 418 and 422 (s.e. 11g) g/day (P>0.10) and feed conversion efficiency was 1.10, 1.03 and 1.01 (s.e. 0.02) for treatments A, B and C, respectively.

Performance of weaned pigs was also unaffected by feed freshness. Feed intake and growth rates were similar on all three treatments.

Free fatty acid content and peroxide values of the feeds used are shown in Table 3.2.1.

Table 3.2.1: Free fatty acid content (%) and peroxide value (meq/kg) of fresh and stored feeds (Expt 3.2.2).

	Fresh		30 day old		60 day old	
Diet	free fatty acid	peroxid	free fatty acid	peroxide	free fatty acid	peroxide
Starter	8.1	48.2	11.2	47.1	11.8	46.1
Link	6.0	45.3	9.3	44.5	10.8	48.4

It is concluded that the storage of starter and link diets, under good conditions, for periods of up to 2 months after manufacture has no adverse effect on its acceptability to pigs and on pig performance. The values for free fatty acid content of the feed samples can be taken as a measure of deterioration of fat in feed during storage. No such trend was found in the peroxide values.

3.3 Effect of creep feed intake on weaning weight of piglets

The objective of this study was to quantify creep feed intake by suckling pigs and to assess the effect of creep feeding on piglet growth and weight at weaning when weaned at 26.0 (s.e. 0.6) days of age.

The results reported here were obtained by combining data from 296 litters of suckling pigs on 5 creep feeding trials. The five trials involved comparison of diets and management systems as follows:

A Effect of quality of creep feed (high quality starter diet vs medium quality starter diet vs a pelleted cooked cereal),
B Comparison of meal and pelleted diets,
C The effect of form (reconstituted calf milk replacer - 20% dry matter vs solid pellet vs peat primer offered with a solid pellet - Experiment 3.1.1 above)
D Effect of feed freshness (fresh creep vs 30 day old creep vs 60 day old creep feed - Experiment 3.2.1 above)
E Effect of creep feeding piglets on pre-weaning performance.

Litter size ranged from 7 to 13 pigs in the five trials. Litters were blocked on the basis of number of pigs in the litter and age and within each block assigned at random to treatments within each of the five trials. Pigs were offered creep feed from 10 - 11 days of age and fed creep up to weaning at c. 26.0 days of age. Creep feed was fed ad libutum from shallow circular plastic creep feeders (22 cm diameter; AGRA Comercial, Agramunt, Spain) with five feeding spaces. Diets fed were commercial feeds (SCA Feeds, Naas, Co. Kildare) and where pelleted were fed at 2.5 mm pellets. Feed was changed daily to avoid a build up of stale feed. Data from the five creep feeding trials was combined and analysed by the Regression procedure (PROC REG) of SAS Inc., Cary, N. Carolina using (1) age at weaning and (2) number of pigs in the litter as independent variables. The effect of each trial was included as a dummy variable.

Average weaning age was 25.9, 27.2, 25.9, 26.7 and 27.5 days of age, average number of pigs in the litter at weaning was 10.4, 10.7, 10.0, 10.3 and 10.8 and average weaning weight was 7.3, 8.1, 7.6, 7.7 and 8.1 kg for trials A, B, C, D and E, respectively.

Creep feed consumption was low and variable, average litter intake over a 17 day creep feeding period was 2.5 - 3.0 kg and average pig intake was 200 - 300 g. Overall creep feed consumption per litter increased by 327 ± 44 g per day of age at weaning ($P<0.01$) and by 142 ± 81 g per pig in the litter ($P=0.08$). However, weaning age, number of pigs in the litter and treatment / trial effects accounted for only 27% of the variation in creep feed consumption per litter. Inclusion of the quadratic effects of weaning age and number of pigs did not improve the proportion of variation accounted for.

Creep feed intake per pig increased by 32 ± 4.4 g per day of age at weaning ($P<0.01$) and decreased by 13 ± 8.1 g ($P<0.01$) per extra pig in the litter. Weaning age, number of pigs and treatment/trial effects accounted for only 26% of the variation in creep feed intake per pig. Total litter weight at weaning increased by 1.14 ± 0.39 kg per kg creep feed consumed ($P<0.01$) and average pig weight at weaning increased by 1.20 ±0.37 kg per kg creep feed consumed on a per pig basis ($P<0.01$).

For pigs not offered creep feed (n = 60 litters), average weaning weight increased by 0.19 ± 0.04 kg for each extra day of weaning age ($P<0.01$) and decreased by 0.23 ± 0.08 kg for each extra pig in the litter ($P<0.01$). Pigs fed creep feed (n = 236 litters) showed an increase of 0.13 ± 0.03 kg in weaning weight per day of age at weaning ($P<0.01$) and a decrease of 0.14 ± 0.04 kg per extra pig in the litter at weaning ($P<0.01$).

It is concluded that a minimal proportion of the variation in creep feed consumption amongst suckling pigs is explained by age at weaning and number of pigs in the litter. As litter size increased the amount of creep consumed per litter increased while that consumed per pig decreased. The smaller decline in weaning weight per extra pig in creep - fed litters suggests that the benefits of creep feeding may be greater in larger litters.

3.4 The effect of weaning weight on post-weaning performance and carcass traits

The objective of this study was to examine the effect of weaning weight on post-weaning feed intake, performance up to slaughter and carcass traits.

In this study (Experiment 3.4.1), 96 crossbred pigs from 24 litters were weaned at 24 - 28 days of age. Four pigs were taken from each litter, two heavy and two light, two male and two female. Individual feed intake was recorded for each animal from weaning to slaughter. Pigs were weighed at regular intervals over the course of the study: birth, weaning, 14 days post-weaning, 26 days post-weaning, 56 days post-weaning and at slaughter. Pigs were penned individually for 56 days from weaning and from there to slaughter in groups of 12 - 14 with feed intake of each pig being recorded using the Hunday FIRE feeding system (Hunday Electronics, Newcastle upon Tyne, UK). Pigs were fed a starter diet (Startrite 90, SCA Feeds) for 3 weeks followed by a weaner diet (barley, wheat, fishmeat, soyabean meal) to 39 kg liveweight and finisher diet (barley, wheat, soyabean meal) to slaughter at approximately 85 kg liveweight. Carcasses were assessed on the basis of backfat depth, muscle depth and carcass lean meat content by the Hennessy Grading Probe. Kill out percentage was also recorded.

The effect of weaning weight on post-weaning pig performance and carcass traits is shown in Table 3.4.1. Pigs which were heavier at weaning had also been heavier than their littermates at birth but not significantly so ($P>0.10$). For the period from weaning to slaughter, heavier pigs (weaning wt. = 8.9 kg) consumed 4% more feed per day than lighter weight pigs (weaning wt. = 7.5 kg) ($P > 0.10$). Heavy pigs tended to grow faster than lighter weight pigs from weaning to slaughter (750 vs 726 g / day, $P > 0.10$), however this difference was significant only from day 26 to day 56 (806 vs 764 g / day, $P < 0.05$). Feed conversion efficiency (FCE) was unaffected by weaning weight ($P > 0.10$). Lean meat content, kill out percentage, muscle depth and fat content of the carcass was unaffected by weight at weaning ($P > 0.10$).

Regression analysis was used to examine the effect of weaning weight and age on post-weaning performance. The results showed that weaning weight was poorly related to post-weaning-performance, explaining only a small proportion of the variation in each trait and the effect of weaning weight could almost equally be accounted for by weaning age. Weaning weight explained 42%, 8% and 8% of the variation in pig weight recorded at 26 days, 56 days post-weaning and at slaughter. Weaning weight advantage (difference between pig weaning weight and average weaning weight of that litter) was even more poorly related to post-weaning performance with 20%, 4% and 2% of the variation in pig weight 26 days, 56 days post-weaning and at slaughter respectively being explained by weaning weight advantage. Examination of partial regression coefficients shows that an extra day of age at weaning had as great effect on performance from weaning to 26 days post-weaning as did 1 kg in weaning weight.

Table 4.1: Effect of weaning weight on pig performance post-weaning and carcass traits (Expt 3.4.1).

	Heavy	Light	s.e.	F - test
No. of pigs	48	48		
Pig weight kg				
Birth	1.7	1.5	0.05	NS
Weaning	8.9	7.5	0.12	**
Day 14	12.9	11.2	0.21	**
Day 26	22.1	19.9	0.38	**
Day 56	41.3	38.0	0.49	**
Slaughter	88.4	85.9	0.98	P = 0.09
Weaning to slaughter				
Daily gain g	750	726	10	P=0.12
Daily feed intake g	1385	1334	19	P=0.09
FCE	1.85	1.84	0.02	NS
Carcass traits				
Carcass weight kg	68.2	66.3	0.8	P = 0.12
Kill out %	77.2	77.3	0.31	NS
Muscle depth mm	50.5	49.1	0.9	NS
HGP Fat mm	13.7	13.5	0.4	NS
Carcass lean %	55.4	55.4	0.4	NS

It is concluded that weaning weight is a poor predictor of postweaning pig performance. Age at weaning explained almost as much of the variation in post-weaning performance as did weaning weight suggesting that the emphasis placed by producers on achieving high weaning weights may be misplaced.

4.0 Effect of heat processing of feed, feed acidification and choice feeding on performance of newly weaned pigs (6-15 kg)

4.1 Effect of age and weight on response of weaned pigs to cooked cereals in the diet

Inclusion of cooked cereals in diets for starter pigs is common practice among feed manufacturers. Gelatinisation of starch occurs on cooking and may improve the availability of cereal starch for enzymatic digestion. This is desirable for weaned pigs which have a limited capacity to digest starch.

However feeding trials have shown no consistent benefit from inclusion of cooked cereals in the diet. This may be because gelatinisation of starch has no effect on its digestion but could also be due to heat damage to protein (especially lysine) or to the starch. The objective in this work was to determine if younger, lighter pigs responded differently from older and heavier animals to the inclusion of cooked cereal in the diet.

In the first experiment (experiment 4.1.1) pigs were weaned at 17-28 days of age (mean = 22.2) and varied in weight from 4 to 8 kg. One hundred and twenty eight pigs were paired on the basis of sex, age and weight and one of each pair was assigned at random to a regime of cooked or uncooked cereal based diets. Cooked cereals had been heat treated by steaming and flaking.

Pigs were individually fed the trial diets for 28 days after which they were penned in groups of 14-16, fed a common weaner diet (barley, wheat, fishmeal, soyabean meal) to 30 kg (day 60 approx.) followed by a common finisher diet (barley, wheat, soyabean meal) to slaughter at about 82 kg liveweight.

In the second experiment (experiment 4.1.2) pigs weaned at 20-28 days of age (mean = 25) were formed into single sex groups of 18. Six such groups were formed each week 2 light weight, 2 medium weight and 2 heavy weight. From each pair of pens of similar weight one was assigned at random to each treatment.

The trial diets were commercial formulations of SCA Feeds, Naas, Co. Kildare and contained wheat, maize, fishmeal, milk powder and soyabean meal. Variable amounts of starter diet were fed (Startrite 90; 2.0, 1.5, 1 and 0.5 kg for pigs of weaning weights <5, 5-6, 6-7 and >7 kg, respectively). This was followed by a lower specification link feed (Thrive) to day 26 post-weaning. The weaner diet fed from day 26 to 30 kg liveweight contained uncooked wheat, barley, soyabean meal and fishmeal and was formulated to contain 14.4 MJ DE/kg and 1.4% total lysine.

The level of gelatinised starch as a percentage of total starch was 26.5%, 83.8%, 20.3% and 74.6 for maize, flaked maize, raw wheat and flaked wheat, respectively.

Results of Experiments 4.1.1 and 4.1.2 are shown in Table 4.1.1. In experiment 4.1.1 performance of pigs fed cooked cereals to day 28 was not significantly different to those fed uncooked cereal. Carcass quality was not affected by feeding of cooked cereal post-weaning.

The group fed pigs in Experiment 4.1.2 showed a similar trend to that in Experiment 4.1.1. There was no evidence of a treatment * weaning weight interaction effect on pig performance. It was observed that individually fed pigs (Experiment 4.1.1) ate more and grew faster but had poorer FCE than group fed pigs in the 4 week weaning period (Experiment 4.1.2).

Weight and age at weaning were poor predictors of post-weaning performance and together accounted for less than 30% of the variation in feed intake from weaning to day 14 or day 26 on cooked diets and 35-38% on uncooked diets in Experiment 4.1.1. Age and weight explained only 11% (uncooked) and 15% (cooked) of variation in growth rate in the first 14 days after weaning, and 23% (cooked) and 27% (uncooked) of the variation in growth rate from weaning to day 28.

Table 4.1.1: Effect of cooking of cereal on post-weaning pig performance (Experiments 4.1.1 and 4.1.2).

	Experiment 1				Experiment 2			
	Uncooked	Cooked	s.e.	F Test[1]	Uncooked	Cooked	s.e.	F-test
No. pigs/group	64	64			16	16		
Pig weights (kg)								
Weaning	6.2	6.2	0	NS	6.4	6.5	0.08	NS
Day 14	9.3	9.4	0.12	NS	9.6	9.7	0.09	NS
Day 28[2]	16.9	17.2	0.26	NS	16.0	16.3	0.20	NS
Day 60	34.9	35.6	0.65	NS	32.9	33.5	0.80	NS
Slaughter	81.5	84.3	1.1	+				
Slaughter Age	154.5	155.4	1.78	NS				
Feed Intake (gm/day)								
Day 1-14	235	241	5.8	NS	250	256	7.6	NS
Day 1-28	461	461	9.2	NS	415	413	11.3	NS
Day 28-60					951	976	24.4	NS
Daily gain (gm/day)								
Day 1-14	212	222	8.2	NS	228	228	7.4	NS
Day 1-28	382	392	9.2	NS	363	370	7.8	NS
Day 28-60	588	601	17.6	NS	558	581	13.1	NS
Day 1-Slau.	574	593	12.3	NS				
FCE								
Day 1-14	1.18	1.17	0.04	NS	1.10	1.12	0.02	NS
Day 1-28	1.23	1.19	0.02	NS	1.14	1.12	0.02	NS
Day 28-60					1.71	1.69	0.03	NS

[1]+ P<0.10, [2]Day 26 in experiment 2.

It was concluded that steaming and flaking of wheat and maize was effective in the gelatinisation of the starch component but there was no significant improvement in pig performance from the inclusion of cooked cereal in the diet.

4.2 Measurements of the acid binding capacity of ingredients used in diets for starter pigs

Suckling pigs have poorly developed HCl secretion in the stomach and the low stomach pH is primarily a result of bacterial fermentation of lactose to lactic acid.

Starter diets of low acid binding capacity (ABC) are sometimes recommended to ensure an acidic environment in the stomach of newly weaned pigs. A low stomach pH aids protein digestion and provides a barrier against the passage of bacteria into the small intestine. A diet of low ABC can be formulated through careful selection of ingredients (Jasaitis et al., 1987). The present study was undertaken to measure the ABC of feed ingredients commonly used in starter feeds and to determine if diet ABC can be predicted from the ABC of the ingredients.

Ingredients were ground through a 2 mm screen and stored in air tight jars until analysis. Feeds were categorised as follows:

1. Milk products (dried sows milk, milk replacer, spray dried skim, rennet casein, acid casein, dried whey, provilacta),
2. Cereals (pinhead oats, cooked flaked wheat, wheat, barley screenings, feed barley, oat flour, flaked maize, fatty maize, maize, maize starch),
3. Root products (cassava, beet pulp, Chinese sweet potato chips),
4. Synthetic amino acids (methionine, threonine, lysine),
5. Vegetable proteins (beans, canola, rape seed meal, soyabean meal, full fat soya bean meal, soycomil, peas, maize gluten, milo distillers meal),
6. Animal by-product meals (meat and bone meal, fishmeal),
7. Minerals (limestone flour, defluorinated phosphate, mono dicalcium phosphate, mono-ammonium phosphate, monophosphate, dicalcium phosphate),
8. Organic acids (fumaric, citric, propionic, DL-malic, sorbic, acetic, DL-lactic, formic),
9. Acid salts (mould curb, calcium formate).

ABC values were also measured on 34 samples of pig starter feeds manufactured at Moorepark and values recorded were compared with those predicted from the ingredient composition.

A modification of the procedure of Jasaitis et al. (1987) was used to determine pH and ABC. All pH measurements were made on a RADIOMETER pH METER 26 which had been standardised with a certified pH 4 buffer solution. A 0.5 g sample of feed was suspended in 50 ml of distilled de-ionised water and continuously stirred with a magnetic stirrer. This was then titrated with 0.1N HCl or 0.1N NaOH (depending on whether pH was to be raised or lowered) so that approximatley 10 additions of titrant was required to reach pH 3. Initial pH and further pH readings were recorded after equilibration for three minutes. ABC was calculated as the amount of acid in milliequivalents (meq) required to lower the pH of 1 kg of feed to a) pH 4 (ABC-4) and b) pH 3 (ABC-3).

Significant differences ($p < 0.01$) were found in ABC values of the different feed categories (Table 4.2.1). Minerals had the highest ABC values and acids, with negative ABC values, the lowest.

The ABC values of organic feeds are positively correlated with their ash and protein contents (Bolduan et al., 1988). This was also found to be the case here with cereals and root products having the lowest ABC values and protein feeds having the highest values.

In the literature ABC-3 values are used by some researchers (Prohaszka and Baron, 1980) while ABC-4 values are used by others (Bolduan et al., 1988). The present study found that ABC-3 and ABC-4 values are highly correlated in all feed categories examined (Table 4.2.1).

Observed and predicted ABC values for complete diets are well correlated (Table 4.2.2) as reported previously by Jasaitis et al. (1987). Lawlor et al. (1993) have shown that excluding Ca and P sources from starter diets for a short period post-weaning or feeding 2 g/kg fumaric acid in the diet both reduced diet ABC and improved pig performance.

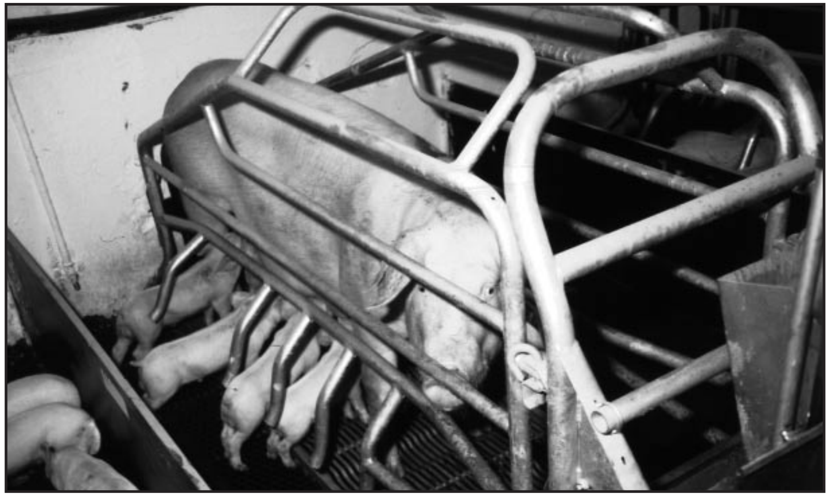
It is concluded that the final pH to which ABC is measured should matter little as ABC-3 and ABC-4 are well correlated and that it is possible to predict the ABC of pig feeds from the ingredient composition.

Table 4.2.1: ABC values for each feed category (mean and standard deviation) and their adjusted R^2 values.

Feed Category	N	ABC-4		ABC-3		Adjusted R^2
Milk products	7	644	(384)	840	(508)	0.99
Cereals	10	87	(58)	217	(80)	0.95
Root products	3	145	(31)	383	(100)	0.76
Amino acids	3	101	(33)	747	(244)	0.92
Vegetable proteins	11	389	(191)	652	(247)	0.91
Meat and fish meals	2	866	(0)	1839	(262)	-
Minerals	8	2919	(4408)	5568	(4733)	0.91
Acids	8	-5978	(4851)	-1732	(1557)	0.86
Acid salts	2	3100	(707)	7530	(5756)	-
F-Test		**		**		

Table 4.2.2: Correlation between observed and predicted ABC values of complete diets.

	N	Observed	Predicted	Adjusted R^2
ABC-4	34	259	294	0.82
ABC-3	34	609	640	0.70



Weaning weight was poorly related to post-weaning performance.

4.3 Response of weaned pigs to choice feeding of a complete diet

Choice feeding of complete feeds offers the potential for a more gradual transition to feeds of lower specification as the pig grows. This may result in more efficient production provided the pig consumes a blend of nutrients which provides the optimum match to its nutrient requirement for growth. The objective of this study was to compare performance of weaned pigs fed a sequence of commercial feeds with pigs allowed consume these diets free choice.

Two experiments were carried out using pigs weaned at 22-26 days of age, penned in groups of 16 and fed the test diets for a 26 day period from weaning. The test diets were commercial starter and link feeds (Startrite 90 and Thrive, products of SCA Feeds, Naas, Co. Kildare) marketed as suitable for pigs of 3-8 kg, 8-15 kg and 15-30 kg, respectively, and a weaner feed of undisclosed composition (14.0 MJ DE/kg; 1.4% total lysine) from the same firm. Each group (including the control) had two self feeders, 0.75m long with one diet in each. After the 26 day trial period all pigs received a common Moorepark weaner diet (barley, wheat, soyabean meal, fishmeal; 14.4 MJ DE/kg, 1.35% lysine) to about 36 kg liveweight.

In the first experiment (Experiment 4.3.1) 24 groups of pigs (average weight = 6.8 kg) were fed one of three test treatments:

A. Starter diet (Startrite 90) for 10 days followed by link diet (Thrive) to day 26,
B. Starter (Startrite 90) and link diets (Thrive) fed free choice for 26 days,
C. Starter (Startrite 90) and weaner (described above) diets fed free choice for 26 days.

Pigs on treatments B and C had the diets in the feeder rotated twice weekly.

In the second experiment (Experiment 4.3.2) 24 groups of pigs (average weight = 7.8 kg) were fed one of three treatments:

A. Starter diet (Startrite 90) for 10 days followed by link diet (Thrive) to day 26,
B. Starter(Startrite 90) and link diets (Thrive) fed free choice for 26 days,
C. As B with feeder position rotated twice weekly.

Results are shown in Tables 4.3.1 and 4.3.2. Daily feed intake and growth rate in the 26-day test period were not affected by feeding system in either experiment. While there were significant treatment differences in FCE in both trials, these did not consistently favour either feeding system. Growth rate, feed intake and FCE in the period from day 26 post-weaning to 36 kg liveweight, or overall from weaning to 36 kg liveweight were not affected by the post-weaning feeding system. In both trials the proportion of starter feed consumed fell rapidly to about 50% of total intake and remained close to this level.

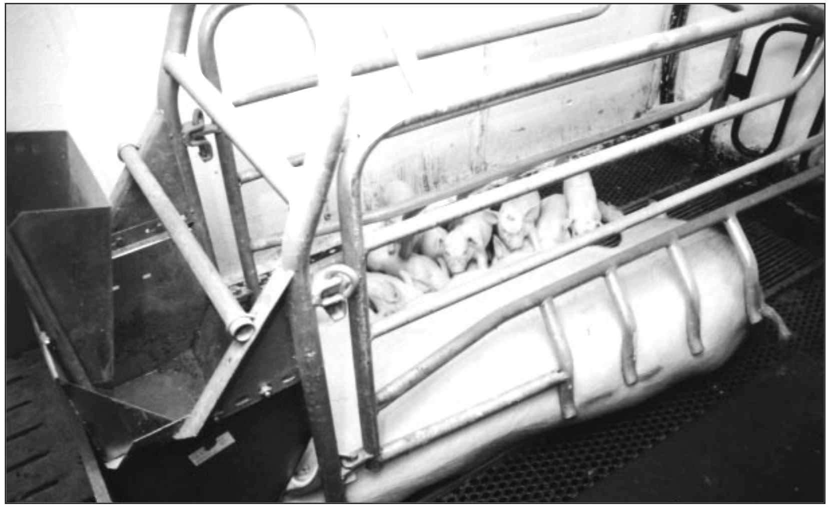
It is concluded that choice feeding of weaned pigs offers no advantage over conventional feeding of a sequence of diets.

Table 4.3.1: Response of weaned pigs to choice feeding (Experiment 4.3.1).

	A	B	C	s.e.	F-test
Daily feed g					
Day 0-14	272	261	254	9	NS
Day 0-26	506	496	506	9	NS
Day 26-end	1153	1147	1147	25	NS
Daily gain g					
Day 0-14	299	292	295	8	NS
Day 0-26	406	410	397	8	NS
Day 26-end	631	620	621	18	NS
FCE					
Day 0-14	1.10	1.12	1.17	0.02	*
Day 0-26	1.25	1.21	1.28	0.01	**
Day 26-end	1.83	1.86	1.85	0.03	NS
High specification diet as % of total feed					
Day 0-4	100	63	60	2.6	**
Day 0-7	100	60	57	2.5	**
Day 0-14	65	52	47	2.7	**
Day 0-26	20	50	47	2.3	**

Table 4.3.2: Response of weaned pigs to choice feeding (Experiment 4.3.2).

	A	B	C	s.e.	F-test
Daily feed g					
Day 0-14	325	320	312	7	NS
Day 0-26	531	537	521	11	NS
Day 26-end	1133	1151	1144	16	NS
Daily gain g					
Day 0-14	329	322	323	10	NS
Day 0-26	465	486	488	11	NS
Day 26-end	740	732	734	16	NS
FCE					
Day 0-14	0.99	1.00	0.98	0.02	NS
Day 0-26	1.14	1.10	1.07	0.02	*
Day 26-end	1.53	1.58	1.56	0.03	NS
High specification diet as % of total feed					
Day 0-4	100	75	73	4.7	**
Day 0-7	100	64	69	4.3	**
Day 0-14	64	52	63	3.6	*
Day 0-26	21	49	55	2.2	**



Milk replacer in liquid form was very readily consumed.

4.4 Effect of weaning weight on post weaning growth of pigs fed high density and medium density diets

Performance of weaned pigs in terms of feed intake and growth rate is frequently disappointing. Higher nutrient density (high energy, high protein, high amino acids) diets are fed to lighter pigs on the basis of a perceived higher nutrient requirement and limited ability to consume a bulky lower density diet. Provision of two diets in separate feeders, with the pig choosing between the diets, has been proposed as a means of allowing the pigs of various weights within a group to each satisfy their own nutritional requirements.

The objective of this study was to assess the effect of weaning weight on the response of pigs to the feeding of high and medium density diets for a four week period from weaning and the effect of weaning weight on proportions of feed consumed in a free choice situation.

In the first experiment (Experiment 4.4.1) four pigs, two heavy and two light, were taken at weaning (21-24 days, mean = 21.6 days) from each of 32 litters and two pigs, one heavy and one light assigned at random to each of two commercial piglet diets. Pigs had received no creep feed while suckling. The diets fed were:

A. A high quality starter feed (Startrite 100) designed for pigs of 4-6 kg (11% oil, 25% crude protein, 1.7% lysine, 1.5% crude fibre) and,
B. A lower specification diet (Thrive) designed for feeding after diet A to pigs of 6-10 kg (7.5% oil, 21% crude protein, 1.5% lysine, 2.7% crude fibre).

In the second trial (Experiment 4.4.2) sixty four pigs weaned at 18 to 26 days of age (mean = 21.7) and weight 4.1 to 8.5 kg (mean = 6.3 kg) were randomly assigned to three treatments:

A. High density diet as in Experiment 4.4.1.
B. High density (Startrite 100) and medium density diet (Thrive) above free choice,
C. High density diet above and a weaner diet (7% oil, 20% crude protein, 1.3% lysine, 3.1% crude fibre) fed free choice.

All three diets were manufactured by Nutec and fed as 2.5 mm pellets. Pigs were penned individually and the diets were fed ad libitum for a 26 day period.

Results of Experiment 4.4.1 are shown in Table 4.4.1. There was a significant effect of weaning weight category on feed intake and growth rate but not feed conversion efficiency. Diet did not affect feed intake but growth rate and feed conversion efficiency were better on the high density diet from day 14 to 26 and overall from weaning. There was no significant diet by weight category interaction effect but there was a trend towards a numerically greater response to the high density diet by the heavier pigs.

In the second trial (Experiment 4.4.2) growth rates from weaning to day 26 post-weaning were 403, 436 and 394 g/day (s.e. 13, P=0.07) for treatments A, B and C respectively. Corresponding values for daily feed intake were 472, 497 and 475 g/day 9s.e. 15, P = 0.45) and for feed conversion efficiency, 1.20, 1.26, 1.24 (s.e. 0.02, P<0.02). On both treatments B and C the proportion of the high density diet consumed was similar and fell from 65% in days 1-4 post-weaning to 50-55% during the remainder of the trial period. There was a tendency (not significant) for heavier pigs and older pigs to eat less of the high density diet and more of the lower density feed.

Table 4.4.1: Effect of diet on post weaning performance of heavy and light pigs (Experiment 4.4.1).

Wt category	Heavy		Light		s.e.	F-test,	P-value[1]	
Diet	High	Medium	High	Medium		Diet	Wt. group	Diet* wt
No pigs[2]	32 (30)	32 (28)	32 (28)	32 (31)				
Pig weight kg								
Weaning wt.	7.1	7.0	5.8	5.9	0.12	NS	**	NS
Wt day 14	10.4	9.8	8.6	8.5	0.21	P=0.12	**	P=0.14
Wt day 26	18.1	16.8	15.5	15.1	0.32	*	**	P=0.07
Daily feed g								
Days 0-14	245	242	217	227	6	NS	*	NS
Days 14-26	666	638	582	594	16	NS	**	NS
Days 0-26	448	431	390	402	11	NS	**	NS
Daily gain g								
Days 0-14	235	199	196	196	11	P=0.15	P=0.09	P=0.14
Days 14-26	604	551	534	524	13	*	**	P=0.11
Days 0-26	412	367	357	353	11	*	**	P=0.08
FCE								
Days 0-14	1.20	1.28	1.11	1.24	0.06	0.11	NS	NS
Days 14-26	1.11	1.16	1.10	1.14	0.02	0.03*	NS	NS
Days 0-26	1.10	1.17	1.11	1.15	0.02	**	NS	NS

[1] * = P<0.05, ** = P<0.01; [2]No. pigs completed trial in brackets

There is no evidence from this study that light-weight pigs at weaning respond better to the feeding of high nutrient density diets than do heavier pigs.

5. Nutrition of pigs from 15 to 30 kg liveweight

Performance of weaned pigs on commercial farms is often disappointing with slow growth rates, poor feed intakes and feed conversion efficiency. Diet quality is frequently blamed. Modern leaner genotypes of pigs may respond in terms of growth rate and feed conversion efficiency to higher levels of amino acids than have been fed until now.

5.1 Response of weaned pigs to dietary lysine

The objectives of this trial (Experiment 5.1.1) were:
(1) To compare performance, from 10-38 kg, of pigs fed diets varying in level of lysine and other amino acids, and
(2) To assess the effect of lysine level in the weaner diet on subsequent performance to slaughter, a period during which all pigs were fed a common diet.

This trial involved 39 pigs, weaned at 24-28 days of age, blocked on sex and weight and fed individually in an RCB design. The three diets were:

A Low (1.20%) lysine weaner diet,
B Medium (1.35%) lysine weaner diet, and
C High (1.50%) lysine weaner diet.

All pigs were fed 1 kg/pig commercial starter feed (Startrite 90, SCA Feeds, Naas) and 4 kg/pig Moorepark link fed (uncooked cereal, fish meal, dried whey, full fat soya), after weaning followed from c.13 days later by the test diets to c. 38 kg liveweight, after which all pigs were fed a common finisher diet (barley, wheat, soyabean meal, meat and bone meal: 13.6 MJ DE/kg and 1.10% lysine) to slaughter.

Composition of the test and finisher diets fed is shown in Table 5.1.1. The diets were formulated to contain 14.4 MJ DE/kg and levels of total methionine, methionine plus cystine, threonine and tryptophan were at least 30%, 60% 66% and 18% of total lysine content. All diets were fed dry as 5 mm pellets. Weaned pigs were individually penned in fully slatted (plastic) pens 0.7m x1.0m in a controlled environment facility. From 38 kg to slaughter pigs were housed in groups of 12 in fully slatted (concrete) pens, 4.2 m x 3.0 m, with individual monitoring of feed intake by computer controlled feeders (Hunday FIRE system). Feeding was ad libitum in all stages. Pigs were slaughtered at c.90 kg liveweight and carcasses assessed by the Hennessy Grading Probe. Statistical analysis was by the GLM procedure of SAS Inc.

Results are shown in Table 5.1.2. There were significant linear effects ($P<0.01$) of dietary lysine on pig weight at the end of the test period, daily weight gain and FCE. Pigs fed the low lysine weaner diet tended to grow faster and more efficiently in the finisher stage when all pigs were fed a common diet but this effect was not significant ($P>0.10$). There was a significant linear effect of dietary lysine on carcass leanness ($P<0.05$).

Table 5.1.1: Composition of test and finisher diets, kg/tonne (Experiment 5.1.1).

Diet	Low	Medium	High	Finisher
Barley	250	250	250	450
Wheat	526	472.3	415.1	283.5
Fish meal Killybegs	100	100	100	0
Soya Hi-Pro	75	130	185	200
Meat and Bone	0	0	0	50
Fat (Tallow)	30	28	30	10
Lysine (synthetic)	2.0	2.0	2.0	1.5
Methionine (synthetic)	0	0.5	0.7	0.5
Threonine (synthetic)	1.0	1.2	1.2	0.5
Minerals/vitamins	16	16	16	4

While high lysine weaner diets support better performence the pig has the potential to compensate during subsequent feeding.

Table 5.1.2: Effect of dietary lysine level in weaner stage on pig performance.

	Low	Med	High	s.e.	F-test[1]
Pig weight kg					
Day 14	12.4	12.8	11.7	0.4	NS
Day 26	19.8	20.6	20.5	0.3	L:P=0.12
Day 48	36.8	39.1	39.5	0.7	L: **
Slaughter	91.2	88.7	91.0	2.6	NS
Test period (day 14-48)					
Daily feed g	1232	1225	1192	33.2	NS
Daily Gain g	711	782	806	20.3	L:**
FCE	1.75	1.56	1.48	0.03	L: **
Finishing period					
Daily feed	1881	1767	1864	52	NS
Daily gain g	750	699	702	29	NS
FCE	2.53	2.59	2.67	0.1	NS
Kill out %	75.0	75.5	76.2	0.5	L: P=0.14
Carcass lean %	55.7	56.8	58.3	0.7	L:*

[1] F-test; L = linear effect; * = P<0.05; ** = P<0.01.

It is concluded that while high protein/lysine weaner diets support better pig performance, the pig has the potential to compensate for moderate “stunting”if subsequently fed an adequate diet for a sufficient period of time.

5.2 Comparison of commercial diets for weaned pigs

The objective of this trial (Experiment. 5.2.1) was to compare performance, in the weight range 12-36 kg liveweight, of pigs fed the standard Moorepark diet based on cereals, fishmeal and soyabean meal with that on three of the top-selling commercial weaner feeds. Feeds were purchased from the manufacturers who were not aware of the objective of the trial.

Thirty three groups of pigs (16 pigs/group) were weaned at 24 - 28 days of age, formed into single sex groups and assigned at random to one of 4 treatments in an RCB design. Treatments were the Moorepark weaner diet (barley, wheat, fishmeal, soyabean meal; 14.4 MJ DE/kg, 1.35% lysine) as control and three commercial feeds (A,B,C).

After weaning pigs received 1.5 kg commercial starter feed per pig (Startrite 90, SCA, Naas) followed by 5 kg Moorepark link feed per pig (uncooked cereal, fish meal, dried whey, full fat soya) and then (from c. 17 days after weaning) the test diet was fed ad libitum to 37 kg. Pigs were housed in fully slatted pens in a controlled environment facility and were weighed at weaning, day 14, day 26 and at the end of the trial.

Digestibility of nutrients in the feeds was determined, using acid insoluble ash as a marker (McCarthy et al., 1973), when pigs were 60-70 days old, by collecting fresh manure samples from c. 8 pigs from each of four pens/treatment. Statistical analysis was by the GLM procedure of SAS Inc., Cary, North Carolina.

Performance on all four diets was good and growth rate on the control diet similar to the mean of the three commercial diets (Table 5.2.1). At the end of the trial period there was a significant difference (P<0.05) in pig weights, with those pigs fed commercial diet B being lighter than the others.

Pigs showed good performance on all four diets offered at the weaner stage.

Table 5.2.1: Performance of pigs fed control and three commercial feeds (Expt 5.2).

	Control	Diet A	Diet B	Diet C	s.e.	F- test
Pig weight kg						
Weaning	8.3	8.2	8.2	8.2	0.05	NS
Day 14	11.5	11.5	11.4	11.5	0.19	NS
Day 26	17.1	17.8	17.1	17.7	0.38	NS
Final (day 53)	36.7[a]	37.4[a]	35.0[b]	36.9[a]	0.58	P=0.05
Trial period (Day 17-53)						
Days	35.6	36.0	34.7	35.4	0.49	NS
Feed / day g	941[a]	999[b]	962[ab]	993[b]	16.4	P=0.10
Daily gain g	635	638	616	649	11.7	NS
FCE	1.48[a]	1.57[b]	1.56[b]	1.53	0.01	**
Overall period, weaning to end of trial						
Feed / day g	764[a]	812[b]	776[ab]	802[ab]	12.5	P=0.07
Daily gain g	520[ab]	525[ab]	508[b]	531[a]	6.9	P=0.18
FCE	1.47[a]	1.55[b]	1.53[bc]	1.51[c]	0.01	1**
Digestibility of nutrients						
Gross energy %	86.0[ab]	85.6[b]	84.5[c]	86.8[a]	0.3	**
Crude protein %	85.0	85.6[ab]	84.4[b]	86.8[a]	0.5	**
Crude fibre %	30.1[a]	44.5[b]	37.3[b]	42.1[b]	2.3	**
DE MJ / kg	14.6	14.6	14.3	14.7	0.3	NS
DE / kg gain MJ	21.5	22.6	21.9	22.2	-	-

During the trial period (day 17-53) pigs fed the control diet ate less per day than those fed diets A and diet C (P<0.05). FCE on the control diet was significantly better than on the three commercial diets which did not differ from one another. While there were significant differences between diets in digestibility of energy, crude protein and crude fibre (P<0.01), the diets did not differ significantly in DE content. It is concluded that all three commercial diets were capable of supporting good pig performance.

CONCLUSIONS

1. Creep feed intake before weaning was low c. 2.5 to 3.0 kg per litter but where it was consumed the response in terms of feed conversion efficiency was good with litter weight increasing in weight by about 1.1 kg for each 1 kg creep consumed.

2. Milk replacer in liquid form was very readily consumed but its preparation and feeding is very laborious.

3. Weaning weight was poorly related to post weaning performance and weaning age seemed to be more critical which is probably a reflection of the greater maturity of older animals.

4. In the first weaner stage, feeding of cooked cereal containing diets was found to have little benefit on pig performance.

5. Acidification of feeds is likely to have only a minor influence on pig performance.

6. An experiment on choice feeding of starter and link feeds did not confirm that smaller pigs require a higher quality diet and, in a choice situation will eat a greater proportion of the more nutrient dense diet.

7. In the second weaner stage, comparison of three commercial weaner feeds with a cereal based control diet showed good performance on all four diets.

8. Pigs fed a high lysine weaner diet grew better in the weaner stage but by slaughter those pigs fed the low lysine weaner diet, after all pigs were fed a common finisher diet, had overtaken them. The high lysine group did, however, have leaner carcasses.

9. Residual effects of early nutrition need to be investigated in more detail including the effect of pregnancy feeding on prenatal development and the relationship between prenatal growth and postnatal growth, in particular development of muscle.

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