FINAL REPORT

EVALUATION OF FEEDING STRATEGIES AND MEASUREMENT OF FEED CONSUMPTION USING THE FEEDLOGIC SYSTEM

Report prepared for the Co-operative Research Centre for an Internationally Competitive Pork Industry

By

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Executive Summary

The majority of feed used in commercial piggeries is fed to grower-finisher pigs (20 to 105kg LW), and hence even small savings in feed costs during this period can have a large impact on the overall cost of production. It was common for producers to feed 2 to 3 diets during this phase of growth, but because amino acid and energy requirements are constantly changing as the pig increases in LW there are frequently periods when the diet being fed is supplying excess nutrients. Therefore if we can feed a greater number of diets during this phase of growth, each being slightly lower in nutrient specifications and hence cost than the one fed previously, then there is potential to reduce the cost of production without any adverse impact on growth or carcass quality.

This experiment utilized the ability to blend feeds using the Feedlogic feed system that has recently been installed at the Medina Research Centre in Western Australia. This meant that by blending two diets, it was possible to alter the nutrient concentration of the diet being fed on a weekly basis. The results showed that there was no significant different in growth rate, feed conversion efficiency or carcass quality when pigs were fed diets as a blend (i.e. changed weekly) as compared to the conventional feeding system, and the savings in feed costs were approximately 3 cents/kg LW gain.

The other alternative approach is to feed the same diet from 20 to 105 kg, the theory being that while the diet in the early stages of growth is supplying insufficient nutrients for pigs to grow to their potential, during the later stages there is compensatory growth such that there is no overall impact on pig performance. The results from this experiment indicate that under certain circumstances feeding a single diet has merit because there was no significant impact on performance in this experiment yet there was a small saving in feed costs. However, this may not work if the variation in LW in pens at the start of the feeding period is greater than that used in the current research.

There are options available for producers to reduce feed costs, and these are largely associated with feeding pigs diets where the nutrient concentration closely matches the pig's requirements. Two of those options have been explored in this experiment and have shown that cost of production can be decreased, and these results will allow producers and industry to do the necessary economic evaluation to determine if these strategies can be put into practice. The successful implementation of these strategies relies on knowing the nutrient requirements of particular genotypes and the conditions in which those animals are reared.

Table of Contents

Executive Summary i

1. Introduction 1
2. Methodology 2
3. Outcomes 5
4. Application of Research 12
5. Conclusion 13
6. Limitations/Risks 13
7. Recommendations 14
8. References 14

1. Introduction

It is common practice in commercial piggeries for pigs to be fed 2 or 3 diets during the grower-finisher period (20 to 105 kg live weight (LW)). However, since the amino acid and energy requirements are constantly changing as the pig increases in LW there are frequently periods when the diet being fed is supplying excess nutrients. This not only means an increase in the amount of waste products (nitrogen) that are excreted in effluent but also an increase in diet costs. The ideal situation would be for pigs to be fed a greater number of diets during this period, with each diet being slightly lower in nutrient specifications and costing less than the previous one. However, it would be impractical for a commercial piggery to have the 10 or more different diets that might be required for such a feeding program.

Blend feeding, in which two diets are mixed together in varying ratios, allows an increased number of diets to be fed while only having to have two base diets. In theory this would allow a different diet to be fed every day, or at least weekly. A study with pigs in individual pens found no difference in pig performance but a reduction in feed costs of approximately $3/pig when blend feeding was used as compared to the current feeding system (Mullan *et al*., 1997). However, the study by Mullan *et al.* (1997) was labour intensive and did not take into account the potential impact of blend feeding on the variation in pig performance when pigs are fed in groups. If the range in LW within a pen is relatively large, then if diet specifications are based on or just above the weight of the average then variation in growth rate may increase because a proportion of animals will always be receiving a diet that is less than optimal.

While there are financial benefits in adopting a blend feeding system, only those piggeries that have installed liquid feeding equipment currently have the capacity to undertake such a feeding program. However, a new feeding system (Feedlogic) has been developed in the United States that has the capacity to deliver any number of blends of dry feed to pigs in group pens. Feedlogic is a fully integrated feed dispensing and management system. The system has the ability to automatically deliver multiple diets to specific feeders and provide real-time data on feed disappearance.

The complete opposite to blend feeding would be to feed the same diet throughout the grower-finisher period. The theory with this strategy is that while feeding a single diet provides less than the required level of nutrients during the early period of growth, during the later stages there is an excess supply of energy and amino acids and that compensatory growth occurs such that there is no overall difference in average daily gain (ADG). Gill (1998) found no significant difference in growth rate when boars and gilts were fed a single diet containing 0.70g Av. Lys/MJ DE between 33 and 88kg LW as compared to pigs that were fed three diets over this period (0.88, 0.70 and 0.53 g Av lysine/MJ DE for 30 to 50, 50 to 70, and 70 to 88 kg LW, respectively) (783 vs 761 g/d, respectively). However, when pigs were fed a single diet containing 0.53g Av. Lys/MJ DE over this same period there was a significant decrease in ADG (736 g/d). The conclusion from this study was that while a single diet could be an alternative to more traditional feeding strategies, continuous adjustment of dietary lysine supply would be more cost-effective, especially if growing pigs to over 100 kg LW.

Another study conducted in the United Kingdom (BPEX, 2004) found a significant ($P<0.05$) increase in ADG between 35 and 102 kg LW when pigs were fed a single diet containing 0.60g Av. Lysine/MJ DE as compared to pigs where the diet was changed daily on a phase feeding system. There was no significant difference in FCR (2.36 vs 2.36), but pigs on the single diet had a significantly higher voluntary feed intake (VFI) (2.06 vs 1.99kg/day, $P<0.05$). The two sets of results from the UK do suggest that the concept of feeding a single diet has some merit, and there would be clear advantages to the manufacture, transport and storage of feeds if a single diet could be fed during the grower-finisher phase. However, whether it can be used when feeding pigs over a larger LW range as would be typical in Australia (e.g. 20 to 105kg LW) is unknown.

The hypothesis for this experiment was that blend feeding or feeding a single diet would reduce the cost of production compared to the conventional system, by minimising the over-supply of nutrients without adversely affecting pig growth performance or carcass quality. The aim of this study was to measure ADG, VFI, FCR and carcass quality of pigs that had been fed the same base diets using different feeding strategies.

2. Methodology

This experiment was conducted at the Department of Agriculture and Food Western Australia's (DAFWA) Medina Research Centre, and the experimental protocol used in this study was approved by the DAFWA Animal Research Committee and by the Animal Ethics Committee, and animals were handled according to the Australian code of practice for the care and use of animals for scientific purposes (NHMRC, 2004).

Treatments and diets

A total of 216 female pigs (Large White x Landrace) were allocated to three treatments, with pigs housed in groups of 6 and there being 12 pens (reps.) per treatment. The treatments were:

1. **Conventional**: diets changed when the average LW of pigs in the pen reached 20, 50 or 80kg;
2. **Blend**: diets changed weekly to meet the nutrient requirements of the average LW of pigs in the pen, and
3. **Single**: the same diet fed throughout the experiment.

The nutrient specifications were determined using the AUSPIG simulation model (Black *et al.* 1986) based on the performance of pigs of a similar genotype and health status that have been used in previous experiments at Medina. These specifications were then used to determine the level of available lysine for pigs from 20 to 100kg LW and hence the levels used for the three treatments as described above (Table 1, Figure 1). These values were subsequently used to set the nutrient specifications and hence formed the basis for formulating the base diets (Table 2). The energy content of diets was set according to standard industry practice and in consultation with nutritionists on the Pork CRC grower-finisher nutrition panel. The objective was to set the energy content of diets sufficiently high so that energy intake would not limit animals to grow to their genetic potential. Diets were formulated to contain the same range of ingredients wherever possible, and milled and pelleted in a commercial mill. The diet for the Single treatment was a mix of 40% of the LW20 diet and 60% of the LW110 diet.

Table 1: The predicted lysine requirement (g Av. lysine/MJ DE) for pigs of different LW, and the ratios then used for each treatment, and the ratio of the two diets used to create the Blend treatment.

LW (kg)	Requirement	Conventional	Single	Blend	LW20	LW110
					%	%
20	0.74	0.74	0.57	0.74	100	0
25	0.74	0.74	0.57	0.74	100	0
30	0.71	0.74	0.57	0.71	90	10
35	0.68	0.74	0.57	0.68	80	20
40	0.65	0.74	0.57	0.65	70	30
45	0.62	0.74	0.57	0.62	60	40
50	0.59	0.60	0.57	0.59	50	50
55	0.58	0.60	0.57	0.58	45	55
60	0.57	0.60	0.57	0.57	40	60
65	0.54	0.60	0.57	0.54	30	70
70	0.52	0.60	0.57	0.52	25	75
75	0.51	0.60	0.57	0.51	20	80
80	0.49	0.50	0.57	0.49	15	85
85	0.49	0.50	0.57	0.49	15	85
90	0.48	0.50	0.57	0.48	10	90
95	0.45	0.50	0.57	0.45	10	90
100	0.45	0.50	0.57	0.45	0	100

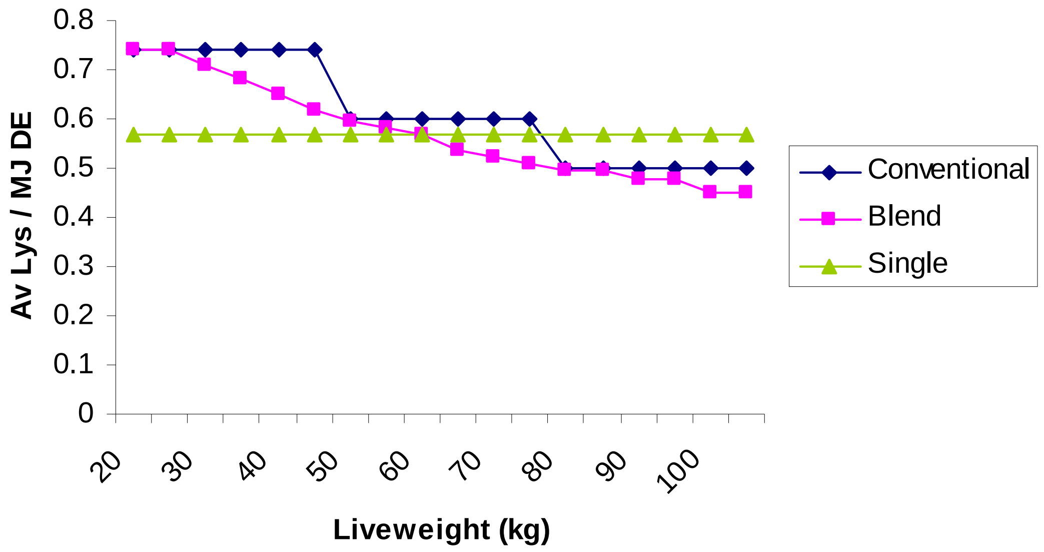

Figure 1: The change in the lysine to energy ratio with LW for each of the experimental treatments.

Table 2: The nutrient specifications and ingredient composition of the base diets.

Diet code	LW20	LW50	LW80	LW110
Target specifications:				
LW (kg)	20	50	80	110
DE (MJ/kg)	14.5	14.0	13.7	13.2
Av. lysine (g/MJ DE)	0.74	0.60	0.50	0.45
Ingredients (g/kg):				
Wheat	302.3	307.7	259.9	287.8
Triticale	250.0	150.0	150.0	150.0
Oats	-	100.0	200.0	200.0
Lupins	150.0	250.0	242.9	100.0
Dehulled lupins	100.0	48.0	14.2	-
Millmix	-	-	-	145.0
Canola meal	70.0	70.0	70.0	62.5
Blood meal	25.0	-	-	-
Meat meal	55.0	38.0	26.0	25.0
Fishmeal	20.7	-	-	-
Tallow	19.6	25.0	25.0	15.0
Lysine	1.33	1.17	-	0.74
Methionine	0.67	0.59	0.22	-
Limestone	2.42	6.48	8.65	10.86
Salt	1.50	1.50	1.50	1.50
Phyzyme	-	0.10	0.10	0.10
Mineral-Vitamin premix	1.50	1.50	1.50	1.50
Nutrient composition[b]				
DE (MJ/kg)	14.5	14.0	13.7	13.2
Crude protein (%)	23.8	21.4	19.6	16.7
Avail. Lysine (%)	1.07	0.84	0.69	0.61

[a] Each kilogram of vitamin and mineral premix contains 7 MIU Vitamin A, 1.4 MIU Vitamin D_3, 20 g Vitamin E, 1 g Vitamin K, 1 g Vitamin B_1, 3 g Vitamin B_2, 1.5 g Vitamin B_6, 15 mg Vitamin B_{12} 12 g niacin, 10 mg pantothentic acid, 0.19 g folic acid, 30 mg biotin, 10.6 g Calcium pantothenatic, 60 g iron, 100 g zinc, 40 g manganese, 10 g copper, 0.2 g cobalt, 0.5 g iodine, 0.3 g selenium, and 20 g antioxidant.

[b] Calculated composition.

Animals and measurements
Pigs were sourced at weaning (21 days, approx 7kg LW) from a high health status commercial herd whose bloodlines were sourced from the Pig Improvement Company. In order to obtain the required number of piglets of the same sex it was necessary to bring the pigs to the Medina Research Centre in two groups, two weeks apart. All pigs were housed in weaner accommodation and fed the same creep and weaner pelleted diets that were formulated to standard industry specifications. All pigs had *ad libitum* access to feed and water for the entire period of the experiment.

Upon arrival at Medina piglets were identified individually with ear tags, inoculated with Enterisol for protection against ileitis and weighed. Piglets were then weighed fortnightly thereafter, and when the pigs reached 8 weeks of age (or approximately 20 kg LW) pigs were stratified on a weight basis. The heaviest 18 pigs were randomly allocated to treatment and this process repeated until all pigs had been allocated to their treatment groups. At selection pigs were moved into a conventional shed where pigs were housed in groups of 6 on partially slatted concrete flooring (3.6 x 1.8 m), equipped with a single space feeder and a swing drinker with two nipple drinkers. The shed was naturally ventilated.

Individual pig weight was recorded on the same day and approximately the same time each week, and feed disappearance was recorded daily using the Feedlogic system. When pigs were 99kg LW or above they were individually tattooed, removed from feed overnight and transported to a commercial abattoir (approx. 90 minute transport time). The pigs were stunned using a carbon dioxide, dip-lift stunner set at 85% CO_2 for 1.8 minutes (Butina, Denmark). Exsanguination, scalding, dehairing and evisceration were performed using standard commercial procedures. Hot carcass weight (AUSMEAT Trim 13; head off, fore trotters off, hind trotters on; AUS-MEAT Ltd, South Brisbane, Qld, Australia) and P2 backfat depth, 65 mm from the dorsal midline at the point of the last rib (PorkScan) were measured approximately 35 minutes after exsanguination, prior to chiller entry (2^{o}C, airspeed 4 m/second).

Carcass value was calculated using a typical price schedule for Western Australian producers in December 2008. Cost of diets was determined based on the average cost of ingredients in September 2008 and included a charge for milling and freight which was the same for all diets regardless of composition.

Statistics
The results were analyzed using analysis of variance with the pen as the experimental unit. The carcass data was analyzed with the pig as the experimented unit. Pigs were blocked on their initial weight. All analyses were conducted using Genstat 11th Edition.

3. Outcomes

Pigs were an average of 22.6 kg LW and 63 days of age at the start of the experiment and there was no significant difference (P=0.471) in start weight between treatments (Table 3). The results have been analyzed for the first 35 days (63 to 98 days of age) corresponding to the typical grower phase, the next

35-day period (98 to 133 days of age) and then overall. Pigs ended the experiment when they reached the target slaughter weight, and as a consequence towards the end the number of pigs in the pen was reduced over one or more weeks. Despite aiming to slaughter pigs at the same LW, pigs on the Blend treatment were significantly heavier at the end then those on the Conventional treatment (P=0.040). There was no significant difference between the final LW of the Blend and Single treatments, nor between the Single and Conventional treatments. There was also no significant difference between treatment in the number of days on the experiment (P=0.143).

There was no significant difference in either ADG (P=0.701), VFI (P=0.817) or FCR (P=0.393) between the Conventional, Single and Blend treatments, although the FCR when calculated in terms of energy per kg LW gain was significantly lower on the Blend and Single treatments than compared to the Conventional treatment, a decrease of 1.2 MJ DE/kg (Table 3) or approximately 4%. The lack of difference in ADG is also depicted in Figure 1 which shows the weight for age of pigs on the three treatments, up until week 19 when the first pigs started to be selected for slaughter. These results indicate, therefore, that despite there being quite different feeding strategies used in this experiment the overall performance of pigs on this experiment was not affected. This would indicate that in each case, the supply of nutrients was sufficient to meet the genetic potential of pigs. The results support the concept of blend feeding as a way of reducing the over-supply of nutrients while not affecting growth performance. The results also are an indication that the base specifications set using the Auspig model were reasonably accurate, because had they been set to low then we could have expected ADG to have been lower on the Blend treatment than on the Conventional treatment.

During the early phase of the experiment pigs on the Single treatment had a significantly lower ADG (Figure 2) and higher FCR (Figure 3) than those on either of the other two treatments, indicating that the diet fed during this phase was not supplying sufficient nutrients for pigs to grow to their potential. The Single diet contained 0.57g Av lysine/MJ DE which was somewhat lower than the predicted requirement value of 0.74 for pigs at 20kg LW, and it was also lower in energy (13.72 vs 14.5 MJ DE/kg, respectively) than the diet fed to pigs on the other two treatments. It is therefore not surprising that we recorded this result.

From 98 to 133 days of age, the FCR for the pigs on the Single treatment was significantly lower than that for either the Conventional or Blend treatments (Table 3), which concurs with the principle of compensatory growth. This difference in FCR appears to be primarily due to a sharp increase in FCR for the Conventional and Blend treatments during weeks 17 and 18 of the experiment which requires further investigation. However, there was no significant difference in ADG or VFI between treatments during the second phase of the experiment. There does appear to be some merit in the use of a Single diet to feed grower-finisher pigs, especially since it has several advantages for feed manufacture, storage and delivery. However, its success will depend on the specifications that are chosen, which will vary depending on genetic potential of the herd, and over what weight range pigs are to be fed. The range in LW within a pen was relatively low in this experiment because of the way pigs were allocated to treatment, but this range would be far greater in a commercial production system and this would put a higher proportion of pigs at a disadvantage if the Single diet strategy was adopted.

There was a steady increase in VFI over the period of the experiment (Figure 4) until 133 days of age with no indication that feed intake had reached a maximum. Pigs were at no stage over-stocked and there was ample opportunity for them to display their potential for both feed intake and growth. An indication of the variation in daily feed intake for a pen of pigs for each treatment is shown in Figure 5, together with ambient temperature for the same time period. These results suggest average VFI fluctuates by approximately 0.3kg/d for pigs at around 70 to 80kg LW but it is difficult to see any clear decrease in intake corresponding to the change in diet for the Conventional treatment. A more detailed analysis of every pen of pigs, over different periods of growth would be needed to see if a change in diet resulted in a decrease in intake. Feed intake would certainly not have been influenced by ambient temperature which was close to the thermal comfort zone for pigs on this LW. The single-space feeders used in this experiment were relatively new and while there was some feed wastage because of poor pellet quality with the LW110 diet, it was still considered to be relatively low.

The overall performance of pigs on this experiment was excellent by industry standards. Of the 215 pigs that started on the experiment one was removed for health reasons and the mortality rate for the experiment was zero.

Table 3: Live weight (LW), average daily gain (ADG), voluntary feed intake (VFI), feed conversion ratio (FCR) and days on experiment for female pigs fed using three different feeding strategies.

Treatment	Conventional	Blend	Single	SED	p-value
N =	12	12	12		
No. of pigs/treatment	72	72	71		
Days on experiment	82.3	83.5	84.5	1.10	0.143
LW (kg):					
63d of age (start)	22.7	22.6	22.4	0.267	0.471
98d of age	54.5[a]	54.5[a]	51.3[b]	0.621	<0.001
133d of age	89.4	88.6	87.0	1.04	0.086
End	101.0[a]	102.3[b]	101.6[ab]	0.505	0.040
VFI (kg/d):					
63 to 98d age	1.73	1.73	1.70	0.034	0.698
98 to 133d age	2.33	2.34	2.21	0.062	0.100
63d age to slaughter	2.14	2.12	2.11	0.040	0.817
ADG (g):					
63 to 98d age	908[a]	910[a]	839[b]	14	<0.001
98 to 133d age	995	974	1005	21	0.354
63d age to slaughter	954	961	951	12	0.701
CV (%)	4.60	4.25	4.40		
FCR (kg feed/kg LW gain):					
63 to 98d age	1.90[a]	1.89[a]	2.03[b]	0.022	<0.001
98 to 133d age	2.34[a]	2.40[a]	2.20[b]	0.107	0.003
63d age to slaughter	2.24	2.21	2.22	0.025	0.393
FCR (MJ DE/kg LW gain):					
63 to 98d age	27.6[ab]	27.0[a]	27.9[b]	0.317	0.025
98 to 133d age	27.3	27.3	26.1	0.567	0.062
63d age to slaughter	31.5[a]	30.3[b]	30.3[b]	0.342	0.006

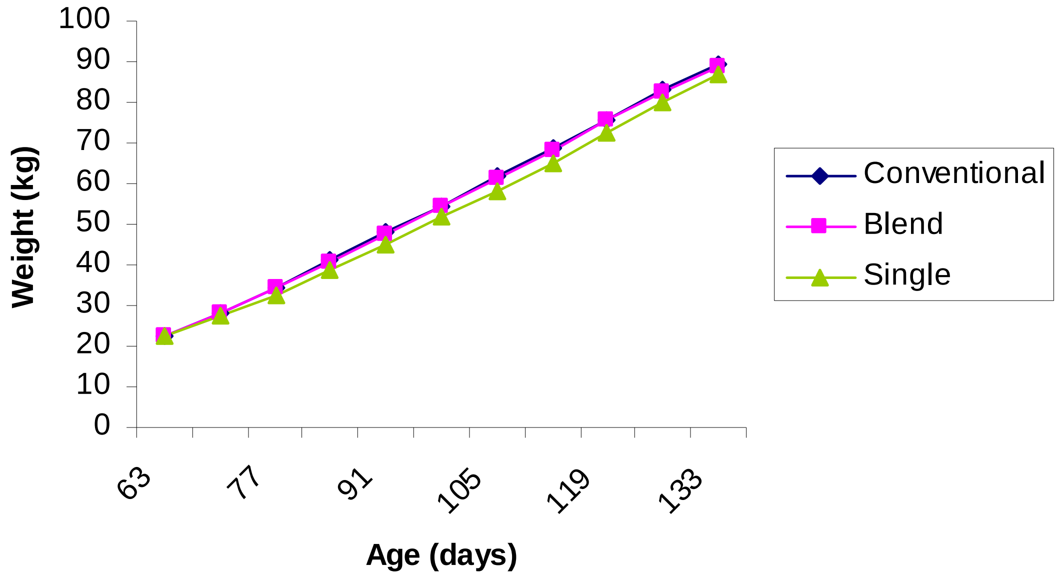

Figure 1: Live weight vs age for female pigs from 63 to 133d of age that were fed using three different feeding strategies

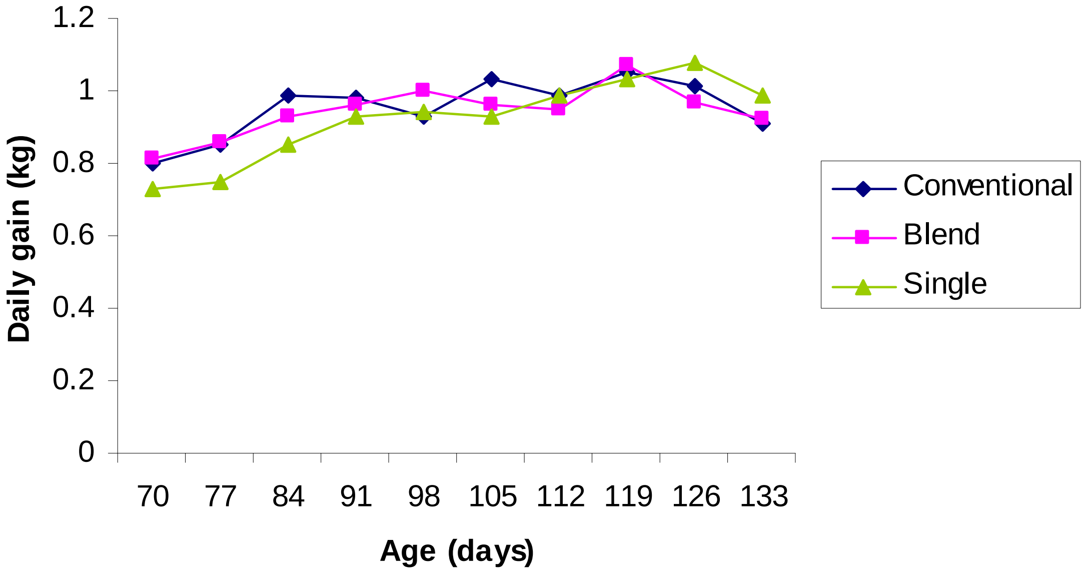

Figure 2: Average daily gain for female pigs from 63 to 133d of age that were fed using three different feeding strategies.

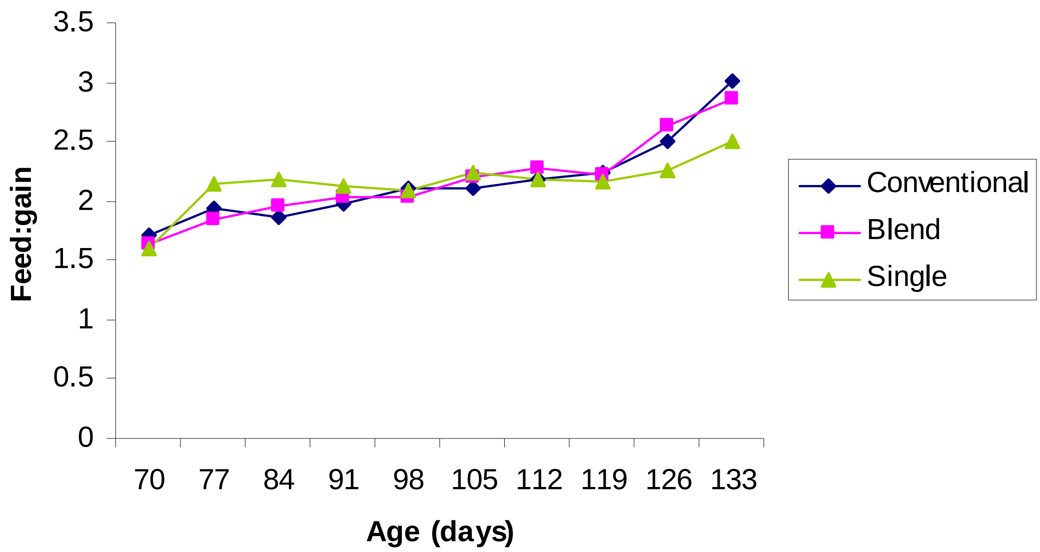

Figure 3: Feed conversion ratio for female pigs from 63 to 133d of age that were fed using three different feeding strategies.

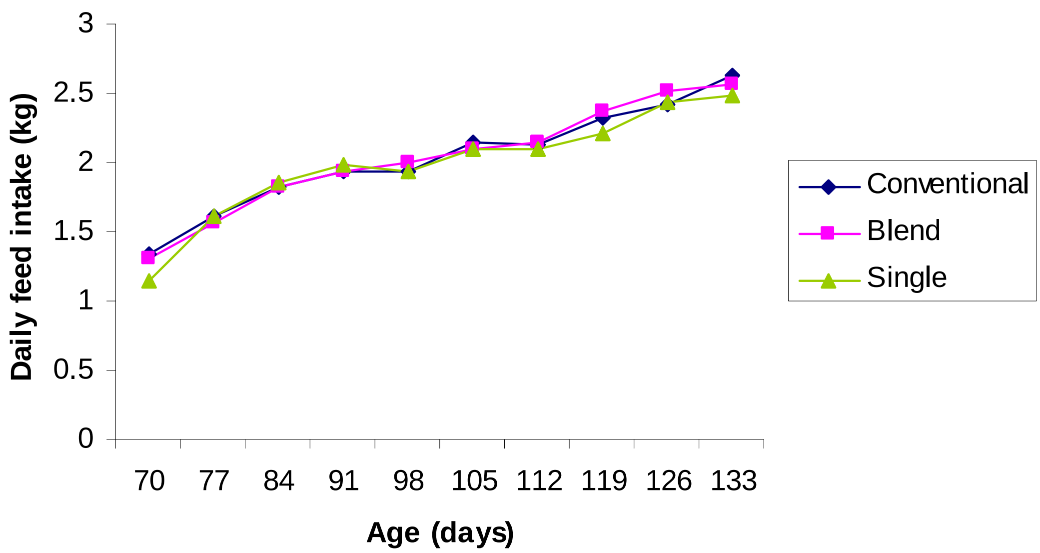

Figure 4: Voluntary feed intake for female pigs from 63 to 133d of age that were fed using three different feeding strategies.

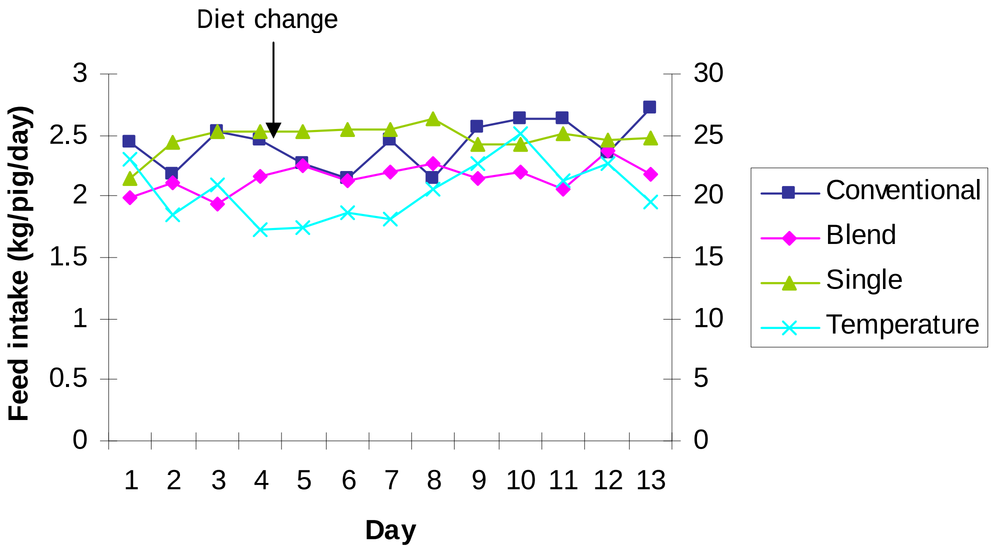

Figure 5: The daily feed intake for a representative pen of pigs and corresponding temperature for a Conventional, Blend and Single treatments of similar average LW.

There was no significant difference in either carcass weight, dressing percentage or depth of subcutaneous backfat (P2) (Table 4). As a measure of whether treatments had an effect on variation, the proportion of carcasses in each of the main P2 categories was determined. .

The cost of feed per kilogram of LW gain for pigs on the Blend and Single treatments was 3.3 and 3.1 cents less, respectively, than for pigs on the Conventional treatment ($P<0.05$) for the period of this experiment. This reduction does not take into account the cost of installing the necessary equipment to allow blend feeding to occur, nor does it account for the many advantages that this feeding strategy might have to a commercial producer. It does, however, allow producers to input their own values and to undertake their own cost benefit analysis to determine if this is a system that they should adopt.

Table 4: Carcass evaluation and economic analysis for female pigs using three different feeding strategies

Parameter	Conventional	Blend	Single	SED	p-value
Carcass weight (kg)	68.9	69.6	69.2	0.430	0.228
Dressing percentage	68.1	68.1	68.1	0.279	0.957
Backfat (P2, mm)	10.7	11.0	11.1	0.359	0.534
% distribution of carcasses:					
< 11mm	53	45	39		
11 to 12 mm	25	33	41		
> 12 mm	22	22	20		
Feed costs per pig/kg LW gain ($)	0.882[a]	0.849[b]	0.851[b]	0.009	0.002
Feed savings per pig/kg LW gain ($, vs control)	0	+ $0.033	+ $0.031		

4. Application of Research

An important part of this experiment was testing the use of the Feedlogic system, since this was the first large scale study undertaken with this system at Medina and the only one which incorporated a degree of blending. While there were a number of small problems with the feed system, most of these were related to fine-tuning the operation of the system to suiting the requirements at Medina, coping with feed that would not flow from storage silos, overcoming problems with build up of static electricity and computer software problems. The project was very successful in improving our knowledge of how to use the system and make it a very successful and important experimental tool.

While there is a general understanding in the pig industry of the potential to reduce the cost of production by increasing the number of diets fed to grower-finisher pigs, up until now it would have meant using a liquid feeding system. The development of the Feedlogic system makes it possible for those feeding dry diets to now use blend feeding as a way to reduce the cost of production, and the results from this experiment can be used as a basis for industry to work from. On the other extreme, there appears to be merit in using a single diet during the grower-finisher period, at least in some circumstances, although this may require further review and study before being adopted with confidence by industry. The major constraint will be the anticipated greater variation in start weight that would be expected in a commercial piggery as compared to what was found in this experiment.

The economic value of using any of the feeding strategies tested in this experiment will vary depending on the cost of ingredients, the target slaughter weight and the price grid that producers are paid on. The cost of modifying existing feed systems or the additional cost of installing the Feedlogic system into a new facility would also need to be taken into account. The results from this experiment also highlight the importance of knowing the nutrient requirements of pigs of a particular genotype, and then feeding pigs accordingly. The data has also set a benchmark for what is possible in terms of growth performance and carcass quality that could be used by industry and other research projects. This study has not taken into account the possible benefits to reducing the load on effluent systems by adopting the blend feeding strategy and its consequent benefits to the environment.

5. Conclusion

Blend feeding is not a new strategy. It is relatively easy to calculate that if you better match the supply of nutrients to the pig as it increases in LW then you have the potential to reduce the cost of feed and hence the cost of production. This experiment has demonstrated on a relatively large scale that the potential savings in cost of production are approximately 3 cents/kg LW gain and that there is no decrease in any parameter of pig performance that was measured. The economic benefit will obviously change depending on the cost of ingredients. The use of a single diet to feed pigs from 20 to 100 kg LW is a novel approach, and there was not the decrease in performance that might have been anticipated. This is a strategy that might have appeal for certain circumstances.

6. Limitations/Risks

The major limitation for producers adopting this research is having the capital to invest in these feed systems, nor facilities that they can adapt to accommodate this feed system. However, at least they are now in a better position to do the calculations using data derived under Australian conditions.

There is no doubt that the Feedlogic system has greatly improved the capacity for conducting pig research at the Medina Research Centre. A number of problems arose with the system during the course of this experiment, and were it not for the dedicated and prompt action by Roland Nicholls, Karen Moore and Richard Seaward then this may have had an impact on the results of this experiment. We can certainly now be far more confident about using the system for subsequent experiments.

7. Recommendations

As a result of the outcomes in this study the following recommendations have been made:

- that producers are made aware of the findings of this research, in particular the potential to reduce their cost of production by using blend feeding
- that we investigate how other research groups are using the Feedlogic system, to ensure that the most appropriate experiments are conducted for the Australian industry

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