Feeding A Single Diet Versus Phase Feeding To Pigs In The Growing-Finishing Phase.

PROJECT A3A-104

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Executive Summary

Feed is responsible for greater than 60% of the total cost of pig production, therefore minor changes in diet formulation can have large impacts on profitability. The phase feeding strategy is used to strengthen the relationship between animal nutritional requirement, according to live weight, to the levels of nutrients in the feed. Thus, it is expected that phase-feeding pigs according to their necessity either maximises weight gain or feed conversion efficiency and reduces nutrient wastage. A single diet, on the other hand, simplifies the process of feed manufacture, storage, delivery and may be more economical.

Previous studies have found conflicting results when production parameters, carcass quality and economics of production on a phase feeding regime were compared to a single diet regime. This present experiment aimed to compare the outcomes of a standard phase-feeding program, from 25 to 95 kg, with two single diet feeding programs differing in energy density and lysine to energy ratio.

This study showed no difference in the performance of pigs fed a single diet formulated for a 50 kg pig compared to the phase-feeding program. Pigs on the single diet formulated for a 70 kg pig had a lower average daily gain and higher FCR during the first phase of the experiment (from 25 to 50 kg live weight), resulting in a statistically significant longer time to reach market weight and a non-statistically but potentially commercially significant increase in back fat depth.

The findings from this experiment support the concept that a traditional three-phase diet feeding program can be replaced by a single diet program with comparable nutrient access, if the correct nutrient specifications are chosen. The most economical specification of the single diet will depend on the restraints and costs of varying market weight and carcass quality.

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1. Introduction

Feed is responsible for more than 60% of the total cost of pig production, therefore minor changes in diet formulation can impact on profitability. Many pig production systems around the world adopt phase feeding for the grower-finisher phase, where the energy and amino acid concentration of the diet is (theoretically) matched to the pig requirement according to its weight. The 'Single diet' approach is an alternative system which can be simpler for farmers and may provide additional benefits to the supply chain. Having a single diet from grower to finisher pigs can avoid issues with diet transition and reduce confusion when delivering diets to silos. Moreover, it is easier/simpler for storage, transport, and milling.

Previous studies suggest there may be no difference in performance and carcass characteristics, but rather an economic advantage to feeding a single diet formulated to a specific standardised ileal digestible lysine (SID Lys) to digestible energy (DE) ratio throughout the grow-finisher period, compared to a traditional phase-feeding approach. O'Connell *et al.* (2005) found that pigs on a single diet performed similarly to pigs on phase feeding, although phase feeding reduced daily lysine intake and improved lysine feed conversion (FCR), with no differences in carcasses. Additionally, Moore *et al.* (2013) suggested there was no difference in performance and carcass characteristics, but an economic advantage, to feeding a single diet formulated to a specific SID Lys/DE ratio throughout the grow-finisher period, compared to a traditional phase-feeding approach. In another experiment, Lei *et al.* (2018) concluded that two-phase feeding programs did not differ from three-phase feeding programs when applied to grow-finisher pigs.

Conversely, Moore *et al.* (2016) found that despite there being no differences in growth performance of pigs on a single diet regimen compared to phase feeding and weekly blend feeding, the single diet had a negative impact on carcass quality. Dressing percentage was reduced for single diet pigs and fat deposition was increased. These results may significantly impact the profit gained from each carcass. More recently, in a project supported by APRIL, Moore et al. (2019) found that in order to reduce diet costs in the grower-finisher phase, pigs could be fed the same diet (targeted to their lysine requirements at either 60 or 70 kg LW) with no effect on growth performance or carcass quality. Compared to phase feeding it was cheaper to feed the 'Single 60' and 'Single 70' diet by 0.14 and 0.32 c/kg LW gain, respectively.

Nonetheless, previous experimental outcomes have been conflicting in terms of production parameters. Moreover, they were derived under the conditions of a particular genotype using their estimated Lys and energy requirements, and under the farm's specific management and feeding conditions. Responses may therefore be different, or of a different magnitude, using other genotypes that might have different Lys and energy requirements and/or be kept under different management and feeding conditions.

Therefore, the present experiment hypothesised that single diet feeding programs would not change the growth and carcass characteristics of grow-finisher pigs compared to traditional phase feeding.

2. Methodology

Two hundred and sixty-four (132 males and 132 females) grower pigs (~70 d) were allocated to the grower shed across two weeks of entry in late summer. Upon entry, pigs were separated by sex, individually weighed and groups of 11 were assigned to a pen (24 pens). Pens were allocated to one of three treatments using a randomised block design with entry week as a blocking factor. Pigs had access to *ad libitum* feed and water throughout the experiment.

Pigs were individually weighed when there was a diet change for the control, phase fed group. The second weight was measured when control diet changed from grower to porker (28 d after the start of the trial). The third weight was measured when control diet changed from porker to finisher diet (d49, 21 d after previous diet change), and the final weight was measured at d69 (20 d post previous diet change). The last day of the experiment fell in late autumn. Feed delivery was recorded by the FeedPro Intelligent Feeding system (FeedLogic by ComDel Innovation, Wahpeton, ND, USA) with feed residues measured at the end of the study. Pigs were harvested on a weight, rather than time basis, with the first cut marketed at d70. Individual data for carcass weight (HSCW), back fat (P2) and age (days to slaughter) were collected at the abattoir.

The temperatures during this experiment fluctuated between 21.5^{o} C maximum and 5.7^{o} C minimum with an average of 15^{o} C.

Diet treatments reflected the commercial diets used on the research farm, varying in DE and SID Lys as follows:

1. **Control:** standard phase feeding diets fed from 25 to 95 kg.

   Grower (25-50 kg), 14.0 MJ DE/kg, 0.76 g SID Lys/MJ DE
   Porker (50-70 kg), 13.75 MJ DE/kg, 0.70 g SID Lys/MJ DE
   Finisher (70+ kg), 13.5 MJ DE/kg, 0.64 g SID Lys/MJ DE

2. **Single 50:** single diet fed from 25 to 95 kg formulated to meet requirements of a 50 kg pig, 13.75 MJ DE/kg, 0.70 g SID Lys/MJ DE.

3. **Single 70:** single diet fed from 25 to 95 kg formulated to meet requirements of a 70 kg pig, 13.5 MJ DE/kg, 0.64 g SID Lys/MJ DE.

The finisher facility consisted of 24 pens of identical configuration (2.6 m x 3.3 m). Penning was open galvanised steel paneling with partially slatted concrete floors. Water was supplied *ad libitum* via three nipple drinkers per pen. Feed was offered to each individual pen via a multi-space adjustable plastic feeder. Diets were offered *ad libitum* throughout the experimental period. Feed disappearance was calculated from feed deliveries and weighed refusal on the transition day. Medications used in all treatments were administered in feed. Male pigs were administered the first dose of Improvac® (2 ml, Zoetis Australia Pty Ltd, Rhodes, NSW) at approximately 90 days of age and the second dose at approximately 120 days of age.

Data were analysed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp, Armonk, NY, USA). A GLM Univariate analyses was applied to the data with week of entry as a blocking factor and pen as the experimental unit. Differences between treatments were determined by LSD ($P<0.05$). There were no treatment by sex interactions observed, and including entry weight as a covariate did not alter the statistical significance of results. Removals were tested for significance via Chi-square analysis ($P<0.05$).

3. Outcomes

Live weight

There was no significant difference between treatments at the start of the experiment (d0). Numerical differences were observed during all three phases, with differences in phase two being statistically different ($P<0.05$). Pigs on the Single 70 treatment weighed significantly less than both the Control and Single 50 treatments (Table 1).

Average daily gain

Pigs on the Single 70 treatment grew significantly ($P<0.05$) slower than both the Control and Single 50 treatments during phase 1 (Table 1). No differences were observed in either phase 2 or 3.

On a cumulative basis (Table 2), that is, an assessment from each weigh event back to the start of the experiment, the impact of slower growth in the initial phase resulted in the Single 70 treatment growing significantly ($P<0.05$) slower across the first two phases. However, across the whole experimental period there was no difference in growth rate between treatments.

Average daily feed intake

The Single 70 treatment pigs ate significantly ($P<0.05$) less in phase 2 than other treatments (Table 1), with no statistical differences observed in other phases. On a cumulative basis no differences were observed between treatments (Table 2).

Feed conversion

Feed conversion was significantly ($P<0.05$) worse in the initial phase in pigs receiving the Single 70 treatment compared to both the Control and Single 50 treatments, with no differences observed in other phases (Table 1). This difference was not conserved when examined over a cumulative basis (Table 2).

Observed differences between treatments would appear to be a result of the Single 70 diet containing levels of energy and amino acids that were below the requirements of the pig in the initial phase, which may be supported by the numerically higher feed intake observed in phase 1. There is limited evidence of compensatory growth during the third stage, although the Single 70 treatment pigs grew numerically faster. Differences observed in feed intake in phase 2 may reflect the lighter weight of Single 70 pigs, with feed intake being a factor of the live weight of the pig.

Table 1. Growth characteristics of grow-finisher pigs offered a standard phase-feeding program (Control) compared with those offered a single diet formulated to meet the requirements of either a 50 kg (Single 50) or a 70 kg (Single 70) pig.

	Control	Single 50	Single 70	SED	*P* value Treat	Batch	T x B
Liveweight (kg)							
Entry (d0)	26.5	25.9	25.9	0.53	0.613	0.358	0.807
Phase 1 (d28)	50.4	49.3	46.9	0.96	0.058	0.444	0.921
Phase 2 (d49)	71.5[a]	70.6[a]	67.5[b]	1.03	0.034	0.126	0.959
Exit (d69)	93.7	93.3	90.8	1.19	0.202	0.002	0.730
Average daily gain (kg/d)							
Phase 1 (d0-28)	0.852[a]	0.836[a]	0.753[b]	0.020	0.006	0.041	0.996
Phase 2 (d29-49)	1.005	1.014	0.979	0.025	0.598	0.001	0.950
Phase 3 (d50-69)	1.108	1.135	1.163	0.043	0.675	0.009	0.738
Average daily feed intake (kg/d)							
Phase 1 (d0-28)	1.74	1.78	1.83	0.052	0.491	0.554	0.755
Phase 2 (d29-49)	2.30[a]	2.23[a]	2.06[b]	0.042	0.003	0.001	0.333
Phase 3 (d50-69)	2.74	2.62	2.69	0.078	0.542	0.001	0.320
Feed conversion ratio (kg/kg)							
Phase 1 (d0-28)	2.03[a]	2.12[a]	2.43[b]	0.053	0.001	0.105	0.639
Phase 2 (d29-49)	2.30	2.20	2.11	0.077	0.268	0.230	0.748
Phase 3 (d50-69)	2.48	2.32	2.32	0.054	0.077	0.925	0.168

[a,b]Means in a row with different superscripts differ significantly ($P<0.05$).

Table 2. Cumulative growth characteristics of grow-finisher pigs offered a standard phase-feeding program (Control) compared with those offered a single diet formulated to meet the requirements of either a 50 kg (Single 50) or a 70 kg (Single 70) pig.

	Control	Single 50	Single 70	SED	*P* value Treat	Batch	T x B
Average daily gain (kg/d)							
Phase 1 (d0-28)	0.852^{a}	0.836^{a}	0.753^{b}	0.020	0.006	0.041	0.996
Phase 1,2 (d0-49)	0.918^{a}	0.912^{a}	0.850^{b}	0.015	0.009	0.138	0.987
Phase 1,2,3 (d0-69)	0.973	0.977	0.941	0.017	0.269	0.005	0.874
Average daily feed intake (kg/d)							
Phase 1 (d0-28)	1.74	1.78	1.83	0.052	0.491	0.554	0.755
Phase 1,2 (d0-49)	1.97	1.97	1.92	0.042	0.686	0.252	0.955
Phase 1,2,3 (d0-69)	2.20	2.16	2.15	0.036	0.627	0.003	0.576
Feed conversion ratio (kg/kg)							
Phase 1 (d0-28)	2.03^{a}	2.12^{a}	2.43^{b}	0.053	0.001	0.105	0.639
Phase 1,2 (d0-49)	2.15	2.15	2.26	0.042	0.113	0.967	0.868
Phase 1,2,3 (d0-69)	2.25	2.21	2.28	0.040	0.425	0.923	0.663

^{a,b}Means in a row with different superscripts differ significantly (P<0.05).

Digestible energy (DE) and standardised ileal digestible lysine (SID Lys) daily intake

Given the variation in DE and SID Lys concentrations of the dietary treatments, looking at feed intake from a purely volume aspect does not potentially tell the complete story. By using the diet formulations and feed intake levels, average daily energy and lysine intakes can be determined.

In the initial phase, there was no difference in DE intake between treatments (Table 3), which helps explain the numerically higher feed intake that was observed in the Single 70 treatment (Table 1). However, the reduced growth rate observed in the Single 70 treatment pigs in this initial phase may be as a result of the significantly reduced (P<0.05) Lys intake observed (Table 3).

Significant differences (P<0.05) in both energy and Lys intakes were observed in the second phase with the pigs receiving the Single 70 treatment consuming less energy and Lys, although this is more likely to be a reflection of reduced voluntary feed intake of the smaller pig. No differences were observed in phase 3.

Table 3. Average daily energy and SID lysine intake of grow-finisher pigs offered a standard phase-feeding program (Control) compared with those offered a single diet formulated to meet the requirements of either a 50 kg (Single 50) or a 70 kg (Single 70) pig.

	Control	Single 50	Single 70	SED	*P* value
Digestible energy (MJ DE/d)					
Phase 1 (d0-28)	24.3	24.4	24.6	0.68	0.937
Phase 2 (d29-49)	31.6^{a}	30.6^{a}	27.9^{b}	0.74	0.005
Phase 3 (d50-69)	37.0	36.0	36.3	1.38	0.867
SID lysine (g/d)					
Phase 1 (d0-28)	18.5^{a}	17.1^{b}	15.9^{b}	0.47	0.003
Phase 2 (d29-49)	22.1^{a}	21.4^{a}	17.9^{b}	0.51	0.001
Phase 3 (d50-69)	23.9	25.2	23.4	0.92	0.399

^{a,b}Means in a row with different superscripts differ significantly (P<0.05).

Carcass characteristics and days-to-slaughter

With pigs sold on a pen weight basis there was no significant difference observed in carcass weight at slaughter (Table 4), and no impact on coefficient of variation was observed. Whilst there was no statistically significant difference observed in depth of subcutaneous back fat (P2) of pigs on the different treatments, a numerically higher P2 in the Single 70 pigs (0.7 to 0.8 mm) is likely to be commercially significant. The lower growth rate observed cumulatively across the first two phases led to an increase in the number of days the pigs took to reach slaughter weight.

The distribution of pigs by slaughter weight shows the impact of treatment on carcass quality (Table 5). Although not significant, Single 50 pigs were observed to be leaner across categories, with both light and heavy pigs in the Single 70 treatment tending to be fatter.

Table 4. Carcass characteristics and days-to-slaughter of grow-finisher pigs offered a standard phase-feeding program (Control) compared with those offered a single diet formulated to meet the requirements of either a 50 kg (Single 50) or a 70 kg (Single 70) pig.

	Control	Single 50	Single 70	SED	*P* value
Carcass weight					
Weight (kg)	83.5	82.9	83.4	0.79	0.814
CV (%)	4.3	5.7	4.8	0.01	0.296
Fat depth at the P2 site (65 mm from the midline at the head of the last rib)					
Thickness (mm)	11.7	11.6	12.4	0.40	0.308
CV (%)	22.0	20.0	24.0	0.03	0.696
Days-to-slaughter (d)	82.1^{a}	82.5^{ab}	84.2^{b}	0.60	0.045

^{a,b}Means in a row with different superscripts differ significantly (P<0.05); CV, coefficient of variation.

Table 5. Carcass weight distribution and corresponding average back fat depth of grow-finisher pigs offered a standard phase-feeding program (Control) compared with those offered a single diet formulated to meet the requirements of either a 50 kg (Single 50) or a 70 kg (Single 70) pig.

	Control		Single 50		Single 70	
Carcass weight (kg)	No pigs (%)	Back fat (mm)	No pigs (%)	Back fat (mm)	No pigs (%)	Back fat (mm)
<69.9			1	8.2		
70 – 79.9	20	11.3	18	10.6	19	13.3
80 – 89.9	70	11.3	73	11.8	76	12.1
90 – 99.9	10	15.4	6	12.3	5	14.5
>100			1	13.2		

4. Application of Research

Our results support the findings of Moore *et al.* (2013) and more recently Moore *et al.* (2019; APRIL project A3A-103) in showing that a single diet strategy, in this case a diet formulated to meet the pigs' energy and nutrient requirements at ~50 kg LW, is comparable to a phase-feeding strategy in terms of growth performance and carcass quality.

Therefore, under optimal conditions, a single diet approach can be adopted by farmers which may simplify feed order and production at the mill as well as storage and distribution of feed to silos at the farm. One single diet for the grower and finisher phases reduces potential mistakes that a phase-feeding system may incur in terms of feed production and delivery. Additionally, a single diet with one level of DE and SID Lys to energy ratio used to feed grow-finisher pigs may reduce formulation and diet costs when compared to a system that uses multiple diets.

In this experiment, the use of a single diet reduced the cost per kg of LW gain by $0.021 (Single 50) and $0.030 (Single 70) when compared to the control treatment. However, on a fixed sale time basis (all-in all-out production), the savings involved from using the Single 70 diet would be more than offset by the reduced carcass weight marketed due to the slower rate of gain observed.

5. Conclusion

Overall, the results of this experiment showed that the phase feeding strategy can be replaced by the Single 50 diet strategy without compromising performance and carcass quality.

6. Limitations/Risks

This experiment was conducted in a relatively high standard, well managed farm, with pigs kept at optimal feed spacing capacity and conducted during autumn months when the weather is conducive to good growth outcomes. These factors had an important contribution to the outcomes.

However, these conditions are not always encountered on farms. Temperatures will vary according to season and location and it is well-known that high temperatures and/or humidity reduce available feeding time and have a negative impact on feed intake. Under conditions of heat stress, when feeder access may be limited, it is possible that a single diet approach may exacerbate issues associated with variable feed intake. The same may be true for other events or practices that may impact feeder space and/or management.

Therefore, a single diet approach must be carefully evaluated and discussed between farmer and nutritionist for each individual herd prior to implementation.

7. Recommendations

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

The use of a single diet program with comparable nutrient access to a phase feeding program is viable and can be adopted by farmers. However, factors such as feeder space availability, overall farm management and climatic conditions should be considered before implementation.

8. References

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9. Appendix 1. Diet formulations

	Grower	Porker	Finisher
Ingredients			
Barley	150.0	250.0	606.0
Wheat	553.7	434.5	200.0
Millrun		77.0	
Canola meal	136.0	87.0	65.5
Soybean meal	45.0	39.0	27.0
Blood meal	20.0	20.0	10.0
Meat meal	57.5	56.5	58.5
Vegetable oil	26.5	25.5	22.0
Salt	2.50	2.5	2.5
DL-Methionine	0.50	0.45	0.40
Lysine HCl	3.95	3.30	3.65
L-Threonine	0.55	0.50	0.60
L-Tryptophan	0.25	0.15	0.25
NSPase	0.50	0.50	0.50
Phytase	0.08	0.08	0.08
Deodorase	1.00	1.00	1.00
Vitamin/Mineral Premix	2.00	2.00	2.00
Analysis			
Digestible energy (MJ DE/kg)	14.00	13.75	13.50
Crude Protein	20.0	18.8	16.8
SID Lys/MJ DE	0.76	0.70	0.64