FEEDING A SINGLE DIET TO PIGS IN THE GROWER/FINISHER STAGE TO REDUCE FEED COSTS AND IMPROVE FEED EFFICIENCY

A3A-103

Final Report prepared for the Australasian Pork Research Institute Limited (APRIL)

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February2020

Executive Summary

Feeding the same diet through the grower-finisher period (single diet) is a possible alternative to the widely used phase feeding strategy where approximately three to four diets are fed. Moore *et al.* (2012, 2016) found that feeding a single diet targeted to meet lysine requirements at 60 kg live weight (LW) reduced digestible energy intake per kg LW gain and hence reduced feed costs by between 3.5 to 5% compared to a three-phase feeding regime with no impact on overall growth performance or carcass quality. Given the research of Moore *et al.* (2013, 2016) was conducted in a research facility with low variation there were questions from industry over the validity in a commercial facility. This project aimed to investigate the effectiveness of the single diet in a commercial facility and to determine the most appropriate weight to target the nutritional requirement of the single diet at to achieve the maximum diet cost reduction.

A completely randomised block experiment was conducted in a commercial facility using 1120 female pigs (Large White×Landrace×Duroc, 40 pigs/pen and seven replicate pens/treatment) to examine the effect of feeding strategies on performance during the grower-finisher phase. Pigs were randomly allocated to the following feeding strategies: (1) Phase: diets changed when the average LW of pigs reached 23 (0.84 g standardised ileal digestible lysine (SID Lys/MJ DE), 50 (0.67 g SID Lys/MJ DE), 70 (0.60 g SID Lys/MJ DE) or 90 kg (0.52 g SID Lys/MJ DE); (2) Single 50: the same diet fed throughout (met lysine requirements 50 kg LW; 0.67 g SID Lys/MJ DE); (3) Single 60: the same diet fed throughout (met lysine requirements at 60 kg LW; 0.65 g SID Lys/MJ DE) and; (4) Single 70: the same diet fed throughout (met lysine requirements at 70 kg LW; 0.60 g SID Lys/MJ DE). The experimental diets were fed from 23.3±0.80 to 99.0±0.91 kg LW (mean ± SE).

There was no significant effect of feeding strategy on growth performance, carcass weight or back fat (P>0.05). There was a trend for pigs who received the Single 60 or Single 70 diet to have an improved feed conversion ratio compared to those fed the Phase or Single 50 diet (P=0.062). It was cheaper to feed pigs the Single 70 diet and the Single 60 diet than the Single 50 and Phase diets (P=0.010), by approximately $6 per pig.

To reduce diet costs in the grower finisher phase pigs can 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. Feeding a single diet to pigs in the grower finisher stage has several advantages for feed manufacture, storage and delivery.

Chief Scientist's Note:
Outcomes from this project showed no significant differences in growth performance (23-99 kg LW), Trim 13 carcass weight and P2 backfat when female pigs (Large White x Landrace x Duroc) were offered diets either phase-fed (i.e., different diets fed at ~ 23 kg, 50 kg, 70 kg and 90 kg LW) or offered a single diet throughout the entire growth period, to meet the estimated lysine and energy requirements at 50 kg, 60 kg or 70 kg LW. However, feeding a single diet from ~ 23-99 kg LW that met the estimated lysine and energy requirements at 60 kg or 70 kg LW markedly reduced feed costs/kg LW gain.

It must be noted that the experimental outcomes were derived under the specific management, weight ranges and feeding conditions described in the Final Report. Responses may, therefore, be different, or of a different magnitude, using other genotypes that might have different lysine and energy requirements and (or) be kept under altered management, weight range and feeding conditions. Producers should consult their nutritionist/genetics supplier prior to adopting this strategy.

Table of Contents

Executive Summary ii

1. Introduction 1

2. Methodology 2

3. Outcomes 5

4. Application of Research 8

5. Conclusion 9

6. Limitations/Risks 10

7. Recommendations 10

8. References 10

1. Introduction

Conventional practice is for pork producers to phase-feed approximately three to four diets through the grower-finisher period. However, because the requirements of pigs are constantly changing, the diet is frequently supplying excess nutrients as the requirement for protein relative to energy decreases as weight increases (MLC Technical Division 1998). Feeding the same diet through the grower-finisher period is a possible alternative to phase feeding. While the diet is deficient in nutrients initially, during the later stages there is an excess supply of energy and amino acids and the compensatory growth phenomenon should occur (Fabian *et al.* 2002). The compensatory growth phenomenon occurs when there is a period of increased growth induced by a prior period of, for example, nutrient restriction which has resulted in slower growth (McMeekan, 1940). Moore *et al.* (2013a, 2016) found that feeding a single diet reduced digestible energy intake per kg LW gain and hence reduced feed costs by between 3.5 to 5% compared to the conventional three-phase feeding regime with no impact on overall growth performance or conventional measures of carcass quality.

The previous experiments looking at the single diet focused on pigs fed from around 25-30 kg liveweight (LW) until slaughter at 100 kg LW, with the diet meeting their requirements at approximately 60 kg LW. At producer meetings around Australia there has been interest expressed in the single diet concept, but further information has been requested before adoption. This project will provide this information and will also determine the most appropriate weight to target the nutritional requirement of the single diet at to achieve the maximum diet cost reduction and improvement in feed to gain in terms of MJ DE/kg live weight gain.

Feeding a single diet to pigs may also alter the mobilisation of body fat and increase the level of intramuscular fat due to protein restriction in the early growing period (de Greef *et al.* 1992). Moore *et al.* (2016) found that carcass fatness was increased in pigs fed a single diet compared to a phase diet; however, this was not reflected in an increase in backfat or in intramuscular fat. It is possible that part of the increase in carcass fatness in the single diet-fed pigs was due to the restriction in the supply of lysine in the early stages. However, this may not be the whole story as the expected compensatory growth response was not observed nor was there any difference in growth performance in the period from 30 to 60 kg LW between those on the phase fed or single diet. By increasing the target nutrient requirement of the diet to a higher LW it is thought that the compensatory growth response may then occur and have a subsequent increase in the concentration of intramuscular fat.

The project aimed to develop a feeding strategy which will reduce feed costs, improve intramuscular fat, and is easy to implement and adopt by producers.

The hypotheses were:

1. Feeding a single diet will reduce the cost of feeding pigs compared to the phase system without adversely affecting pig growth performance and carcass quality.

2. Feeding a single diet targeted to meet lysine requirements at 70 kg liveweight will reduce the cost of feeding pigs compared to feeding a single diet targeted to meet lysine requirements at either 50 or 60 kg liveweight.
3. Pigs fed a single diet will have more intramuscular fat than those receiving the phase diet.

2. Methodology

This experiment was conducted in a commercial grow out facility in Western Australia. The experimental protocol used in this study was approved by the DPIRD Animal Research Committee and by the Animal Ethics Committee (AEC number 18-4-09). The animals were handled according to the Australian code of practice for the care and use of animals for scientific purposes (NHMRC, 2013).

Experimental design
One thousand, one hundred and twenty female pigs (Large White × Landrace × Duroc) were used in this experiment. The experiment was a completely randomised design with the following treatments:

1. Phase feeding: four diets fed from 25 to 100* kg LW (diet changes and formulated to meet lysine requirements at approximately 25 kg, 50 kg, 70 kg and 90 kg LW);
2. Single 50: the same diet fed throughout and formulated to meet the lysine requirements of the pig at 50 kg LW;
3. Single 60: the same diet fed throughout and formulated to meet the lysine requirements of the pig at 60 kg LW and;
4. Single 70: the same diet fed throughout and formulated to meet the lysine requirements of the pig at 70 kg LW.

*It was initially proposed to grow the pigs to 110 kg LW. However, this did not eventuate as the pigs were lighter on entry than originally anticipated. Due to pig flow it was necessary for the shed to be emptied and so the pigs finished lighter than expected at the end of the experiment.

Animals and housing
Pigs were randomly allocated to treatment when they entered the grower facility at approximately 10 weeks of age. The pigs were group housed (n=40) in a naturally ventilated fully slatted shed with 7 pens per treatment. Pigs had *ad libitum* access to water and feed via a wet-dry feeder.

Diets and feeding regime
The diets were fed from 23.3 ± 0.80 kg LW (mean ± SE) until 99.0 ± 0.91 kg LW. The concentration of standardised ileal digestible (SID) lysine required in the diets for the pigs at the target weight range were determined from the results of Moore *et al.* (2013b, 2015) and are given in Table 1. These values were then used to set the

nutrient specifications and formed the basis for formulating the high and low-lysine diets (Table 2). The energy contents of the high and low lysine diets were set according to standard industry practice (14.4 and 13.3 MJ digestible energy (DE)/kg). All diets were created by blending the high and low lysine diets in the required ratios to meet the required SID lysine:DE ratio using a Feedlogic system (automated feed delivery system, FeedPro, Feedlogic Corp., Willmar, MN, USA). The diet costs of the high and low lysine diets were $506/T and $436/T, respectively. This was exclusive of medication costs and as delivered to the farm.

Table 1: The predicted lysine requirement (g SID lysine/MJ DE) of each diet for pigs of different liveweights.

Liveweight (kg)	Requirement	Diet: Phase	Diet: Single 50	Diet: Single 60	Diet: Single 70
25	0.84	0.84	0.67	0.65	0.60
30	0.84	0.84	0.67	0.65	0.60
35	0.81	0.84	0.67	0.65	0.60
40	0.77	0.84	0.67	0.65	0.60
45	0.73	0.84	0.67	0.65	0.60
50	0.67	0.67	0.67	0.65	0.60
55	0.66	0.67	0.67	0.65	0.60
60	0.65	0.67	0.67	0.65	0.60
65	0.63	0.67	0.67	0.65	0.60
70	0.60	0.60	0.67	0.65	0.60
75	0.57	0.60	0.67	0.65	0.60
80	0.55	0.60	0.67	0.65	0.60
85	0.53	0.60	0.67	0.65	0.60
90	0.52	0.52	0.67	0.65	0.60
95	0.50	0.52	0.67	0.65	0.60
100	0.49	0.52	0.67	0.65	0.60
105	0.47	0.52	0.67	0.65	0.60
110	0.45	0.52	0.67	0.65	0.60

The composition of the experimental diets is given in Table 2. The diets were also analysed for quantitative amino acid composition (Australian Proteome Analysis Facility, Sydney, NSW, Australia) and the results are presented in Table 3.

Table 2: Composition of the experimental diets.

Diet	**High**	**Low**
Ingredients, g/kg, as-fed basis		
Barley	100	180
Wheat	372	270
Field Pea	50	80.0
Lupins, angustifolius	150	200
Oats	0	150
Soymeal	140	43.3
Canola meal	120	50.0
Tallow	26.7	0
Blood meal	10.0	0
Mono and dical phosphorus	7.00	6.67
L-Lysine HCL	3.23	0.33
Methionine[1]	1.80	0.77
L-Threonine	1.07	0
Limestone	13.0	14.0
Salt	3.93	3.93
Xylanase and Beta Glucanase[2]	0.10	0.10
Vitamin and mineral premix[5]	1.00	1.00
Nutrient composition[3]		
DE, MJ/kg	14.4	13.3
CP, g/kg	21.9	17.0
g SID Lys/MJ DE[4]	0.84	0.52

[1]Liquid MHA; [2]Axtra®XB Dupont; [3]Calculated composition; [4]SID: Standardised ileal digestible lysine/MJ digestible energy; [5]Provided per kg of final diet: 7000 IU Vitamin A, 1400 IU Vitamin D3, 20 g Vitamin E, 1 g Vitamin K, 1 g Vitamin B1, 3 g Vitamin B2, 1.5 g Vitamin B6, 15 mg Vitamin B12, 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.

Table 3: Quantitative amino acid analysis of the diets used.

Amino Acid, g/kg as-fed basis	**High**	**Low**
Histidine	5.63	4.18
Isoleucine	8.07	6.32
Leucine	14.9	11.3
Lysine	13.1	8.7
Methionine	2.00	1.48
Phenylalanine	9.27	7.10
Threonine	8.52	6.0
Valine	9.73	7.27
Serine	9.6	7.55
Arginine	13.0	11.1
Glycine	9.05	7.17
Aspartic acid	17.6	12.8
Glutamic acid	41.5	35.9
Alanine	8.18	6.05
Proline	12.6	10.6
Tyrosine	4.5	3.38

Growth performance
The pigs were weighed as a pen at the commencement of the experiment (10 weeks of age, Day 0), at 14, 17 and 20 weeks of age, and when they reached slaughter weight to determine average daily gain (ADG). Voluntary feed intake (VFI) was determined by recording feed delivered to the pen. The feed conversion ratio (FCR) was calculated on a per pen basis by dividing the total weight of feed eaten by the LW gain in the same period. Feed costs per kg LW gain were calculated by determining the delivered cost from the feed mill (at the time the experiment was conducted) to each pen and dividing by the LW gain per pen over the experimental period.

Slaughter procedure
The pigs were tattooed and transported to a commercial abattoir (approx. 90 min transport time) when they reached slaughter weight. 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 Pty Ltd., Canberra), were measured approximately 35 min after exsanguination, prior to chiller entry.

Intramuscular fat
A 40 g sample of Longissimus thoracis muscle, trimmed of visible fat and skin, was collected from 2 pigs/pen/treatment to determine the percentage of intramuscular fat using Soxhlet extraction.

Statistics
One-way analysis of variance was performed with the GENSTAT 19 program (VSN International Ltd, Hemel Hempstead, UK) to analyse the main effect of diet on growth performance, carcass quality, feed costs, price per kilo received and carcase value. Pen was used as the experimental unit for growth performance and carcass analysis. Pig was used as the experimental unit for analysis of intramuscular fat. Liveweight on Day 0 was used as a covariate in the analysis. Slaughter date was used as a block in the analysis of carcass weight, back fat and price per kilogram. A trend was defined as a level of probability of more than 0.05 but less than 0.1. Fisher's unprotected least significant differences test was used to compare the least significant difference among treatments when the treatment effect was significantly different.

3. Outcomes

There was no significant effect of feeding strategy on final liveweight (P>0.05 for all weights), days to slaughter (P>0.05), daily gain (P>0.05 for Day 0-32 and Day 0 to slaughter), feed intake (P>0.05 for all time periods) and the feed conversion ratio (P>0.05 for all time periods; Table 4). Pigs receiving the Single 70 diet grew faster than the Phase diet from Day 33-74 (P=0.038). There was no difference in growth rate between the Single 70, Single 60 and Single 50 diet or between the Phase and Single 50 and Single 60 diet.

There was a trend for pigs fed the phase and Single 60 diet to be heavier on Day 32 than those fed the Single 50 or Single 70 diet (P=0.054). There was a trend for pigs fed the phase diet to grow faster than those fed the single diets from Day 0-32 (P=0.054). From Day 0-32 there was a trend for pigs on the phase and Single 60 diets to have an improved feed conversion ratio compared to those on the Single 50 and Single 70 diets (P=0.079). From Day 0 to slaughter there was a trend for pigs who received the Single 60 or Single 70 diet to have an improved feed conversion ratio compared to those fed the Phase or Single 50 diet (P=0.062).

It was cheaper to feed pigs the Single 70 and the Single 60 diets than the Single 50 and Phase diets (P=0.010).

Table 4: Liveweight, average daily gain, feed intake and feed conversion ratio for female pigs fed one of four different feeding strategies in the grower-finisher period (n=7).

Parameter	Phase	Single 50	Single 60	Single 70	SED[1]	*P*-value
Liveweight (kg)						
Day 0	22.5	23.7	23.2	23.8	1.16	0.659
Day 32	46.2	44.5	45.6	43.7	0.92	0.054
Day 53	62.6	62.4	61.6	62.3	1.39	0.908
Day 74	77.6	78.1	77.5	81.0	1.90	0.249
Final weight	99.2	98.9	99.3	98.5	1.03	0.842
Days on experiment	99.0	98.1	98.7	98.0	1.18	0.801
Daily gain (kg/day)						
Day 0-32	0.716	0.660	0.695	0.637	0.030	0.054
Day 33-74	0.746[a]	0.802[ab]	0.761[a]	0.887[b]	0.045	0.038
Day 0 to slaughter	0.766	0.772	0.771	0.767	0.017	0.979
Feed intake (kg/day)						
Day 0-32	1.47	1.51	1.51	1.44	0.060	0.593
Day 33-74	1.99	2.01	1.97	1.98	0.059	0.912
Day 0 to slaughter	2.11	2.07	1.99	2.01	0.050	0.334
Feed conversion ratio						
Day 0-32	2.05	2.28	2.18	2.27	0.094	0.079
Day 33-74	2.68	2.51	2.61	2.27	0.166	0.109
Day 0 to slaughter	2.76	2.69	2.57	2.63	0.066	0.062
Feed costs/kg LW gain ($)[2]	1.28[a]	1.26[a]	1.20[b]	1.19[b]	0.029	0.010

[a,b,c]Means within a row with different superscripts differ significantly (P<0.05); [1]SED - standard error of difference of the means; [2]Feed costs, January 2019.

There was no significant effect of feeding strategy on carcass weight, back fat, intramuscular fat, price received per kilogram or price received per pig (all $P>0.05$; Table 5).

Table 5: Carcass weight, backfat, intramuscular fat and price received for female pigs fed one of four different feeding strategies in the grower-finisher period (n=7).

Parameter	Phase	Single 50	Single 60	Single 70	SED	*P*-value
Carcass weight (kg)	72.1	72.5	72.2	72.4	0.420	0.632
Back fat (mm)	10.1	10.1	10.1	9.78	0.211	0.352
Intramuscular fat (g/100g)	1.69	1.58	1.88	2.14	0.282	0.227
Price per kg ($)	2.90	2.88	2.91	2.90	0.018	0.414
Price per pig ($)	208	208	210	210	1.44	0.537

The coefficient of variation between treatments on a per pen basis was variable throughout the experiment (Table 6). There did not appear to be a particular trend for the coefficient of variation to increase or decrease over time for liveweight, daily gain, FCR or days to slaughter for any of the dietary strategies.

Table 6: Coefficient of variation (%) for growth performance for female pigs fed on of four different feeding strategies in the grower-finisher period (n=7).

Parameter	Phase	Single 50	Single 60	Single 70
LW Day 0	4.44	11.5	11.4	7.75
LW Day 32	3.57	6.78	9.99	5.67
LW Day 74	2.81	6.66	4.81	5.99
Daily gain Day 0-32	5.95	4.15	11.9	7.54
Daily gain Day 33-74	8.65	9.07	10.4	14.1
Daily gain Day 0 to end	2.30	5.10	5.13	3.55
FCR Day 0-32	4.62	9.66	9.13	8.34
FCR Day 33-74	12.1	4.98	14.7	13.9
FCR Day 0 to end	5.16	3.99	5.81	2.38
Days to slaughter	1.86	4.18	4.12	2.89

There did not appear to be any difference between feeding strategies for the number of pigs removed and treated for illness and the number of sudden deaths (Table 7). There was significantly less pigs on the Single 60 diet that did not reach the target slaughter weight compared to the other feeding strategies ($P=0.039$).

Table 7: A comparison of pig removals, deaths and the numbers of pigs per pen not reaching target slaughter weight

Parameter	Phase	Single 50	Single 60	Single 70	SED	*P*-value
Number removed/treated for illness[1]	0	1	3	1		
Sudden deaths[2]	6	3	3	4		
Number of pigs per pen not reaching target slaughter weight[3]	3.63[a]	4.46[a]	0.77[b]	3.56[a]	1.26	0.039

[1]Removed/treated for illness (for example, coughing) and not for physical reasons (for example lameness and tail bite); [2]Reason for deaths unknown; [3]Initial liveweight used as a covariate

4. Application of Research

The hypothesis that feeding a single diet will reduce the cost of feeding pigs compared to the phase system without adversely affecting pig growth performance and carcass quality was supported. There was no difference in growth performance and carcass quality between treatments. It was cheaper to feed the Single 70 diet and Single 60 diet, than the Single 50 and Phase diets. This is supported by Moore *et al.* (2013a, 2016) who also found that it was cheaper to feed a single diet targeted to meet requirements at 60 kg LW than to phase feed. In contrast, when feeding a single diet or a phase diet from 30 kg to slaughter (at either 88 or 107 kg), MLC Technical Division (1998) found that it was cheaper to phase feed. Moore *et al.* (2016) suggested that the differences in costs between experiments may be due to the raw ingredient costs at the time of formulation or the lysine concentrations targeted. This suggests that dietary costs may need to be assessed on a case-by-case basis.

The hypothesis that feeding a single diet targeted to meet lysine requirements at 70 kg liveweight will reduce the cost of feeding pigs compared to feeding a single diet targeted to meet lysine requirements at either 50 or 60 kg liveweight was partly supported. It was cheaper to feed the Single 70 diet compared to the Single 50 diet but there were no differences in costs between the Single 70 and Single 60 diet. This would be expected because the Single 70 diet had a lower lysine concentration than the Single 50 diet and so was cheaper to feed. The Single 70 diet had no effect no feed intake or growth performance compared to the Single 50 and Single 60 diet and so the only differences were in the specifications of the diets.

Overall daily gain, feed intake and feed conversion ratio were the same for each feed strategy. This is in agreement with Moore *et al.* (2013a; 2016) and Edwards (2011) who also found no difference between pigs fed a single diet targeted to meet requirements at 60 kg LW and pigs fed a phase-diet for a similar liveweight range.

In contrast, pigs fed a single diet from 30 to 110 kg LW were found to have an increased daily intake and gain in BPEX (2004). This may possibly be attributed to the increased slaughter weights in BPEX (2004).

The hypothesis that pigs fed a single diet will have more intramuscular fat than those receiving the phase diet was not supported. There was no difference between any treatment for the concentration of intramuscular fat. This concurs with Moore *et al.* (2016) who found no change in backfat or in intramuscular fat when pigs were fed a single diet (targeted to meet requirements at 60 kg LW) compared to a phase diet. Moore *et al.* (2016) also measured whole carcass fatness and found that this was higher in the single diet compared to the phase diet. While carcass fatness was not determined in the present experiment it is worth noting that there may be an increase in carcass fatness, particularly if producers are paid on the basis of lean meat yield rather than backfat.

It was thought that by increasing the target nutrient requirement of the diet to a higher LW such as in the Single 70 diet that the compensatory growth response may have occurred and had a subsequent increase in the concentration of intramuscular fat. In the first time period from Day 0-32, there was a trend for pigs fed the phase diet to grow faster than pigs on the single diets. In the next period (Day 33-74) the pigs on the Single 70 diet grew faster than those on the phase diet. This follows what would be expected to a certain extent but the diet specification of the Single 70 diet meant that it was still below the specifications predicted to meet the lysine requirements of the pig for the majority of the period. Therefore, although there was evidence of some compensatory growth it did not correspond with the typical pattern; however, this may also be a function of the weight points chosen.

It was also expected that pigs fed the Single 60 diet would have shown a reduction in daily gain initially and then an improvement in growth rate once the dietary requirements were meet; however, there was no difference between the pigs fed the phase diet and the Single 60 diet. The lack of a traditional compensatory growth response also occurred in Moore *et al.* (2016) and Edwards (2011). In contrast, Moore *et al.* (2013a) found that pigs on the single diet feeding strategy had a significantly better FCR from 98 days of age (approximately 54 kg LW) compared to those in the phase feeding strategies.

5. Conclusion

To reduce diet costs in the grower finisher phase, pigs can 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. Feeding a single diet to pigs in the grower finisher stage has several advantages for feed manufacture, storage and delivery.

6. Limitations/Risks

This research looked at pigs from approximately 23 to 100 kilograms liveweight. Feeding a single diet for a reduced or increased liveweight range may not produce the same cost benefits or growth performance results.

Previous research has also shown that total carcass fatness was increased when pigs were fed a single diet compared to phase feeding, and therefore this should be considered if producers were to be paid on the basis of lean meat yield rather than the current price schedule in Australia.

7. Recommendations

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

- Pigs can be fed the same diet throughout the grower finisher period (in this case 23 to 100 kg LW) to reduce diet costs when compared to phase feeding.

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