The effect of protein inclusion level in diets formulated to contain an ideal amino acid composition for growing pigs

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Abstract

The aim of the study was to determine the optimum protein inclusion level in diets containing an ideal amino acid balance for growing pigs. The performance of commercial crossbred grower-pigs was studied in two trials in which the experimental animals were housed either in commercial-type group housing (experiment1) or in individual pens (experiment 2). Treatments consisted of diets containing 14%, 16%, 18% or 20% crude protein. Lysine, tryptophan, threonine and total sulphur-containing amino acids were included in all diets at levels equivalent to that supplied by the 18% crude protein diet. In experiment one, 144 pigs (72 boars and 72 gilts) of initial mass 30 kg were fed until slaughter at 70 kg. In experiment two, 80 pigs (40 boars and 40 gilts) of live masses ranging from 17.5 to 31.1 kg were fed until slaughter at masses between 64 and 105.5 kg. There were no differences between treatments ($p > 0,05$) for daily gain, feed conversion ratio, daily intake or carcass classification, but feed conversion ratio differed between sexes in experiment two ($p < 0.05$). It was concluded that protein inclusion levels in pig growth diets could be decreased from 18% to 14% without any detrimental effect on performance, provided that the digestible essential amino acid composition is adjusted to meet requirements. This practice is however not economically viable for South African pig producers at the prevailing price of synthetic amino acids.

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Introduction

The efficiency of protein utilisation by pigs is critical, not only from an economic perspective, but also because poorly metabolised nitrogenous feed components are ultimately recycled to the environment where they may contribute to nitrate pollution of soil and water. In order to avoid unnecessary wastage of dietary protein, it is important to feed pigs according to requirements. Requirements can be described in terms of the ideal amino acid composition of protein, which is an approximation of the ratio of amino acids in the body of the animal. A number of different amino acid combinations have been proposed for the ideal amino acid profile (ARC, 1981; Wang, 1988; Fuller *et al*., 1989; Wang & Fuller, 1989; Kemm *et al*., 1990). Differences between these profiles are small, with the exception of that of ARC (1981) which contains comparatively low levels of tryptophan, phenylalanine and tyrosine.

Improvement of the efficiency of protein utilisation by pigs can be achieved in two ways: by supplying amino acids according to growth potential and physiological status (phase feeding; Lenis, 1989) or by improving dietary amino acid balance and concomitantly reducing dietary protein content (Henry, 1993). As phase feeding is expensive and difficult to implement, the latter strategy may represent an easier and more cost-effective alternative. The use of synthetic amino acids to balance dietary amino acids enables the level of intact dietary protein to be reduced, and significantly reduces nitrogen excretion (Sutton *et al*., 1999). Thus, the optimum combination of synthetic amino acids and locally available South African feedstuffs in low-protein diets for pigs may help to overcome protein shortages and reduce nitrate pollution. The aim of this experiment was to quantify the effects of reduced protein inclusion levels in diets formulated to contain an ideal amino acid balance, and to determine the economic implications of these diets.

Materials and methods

Two experiments were conducted. In experiment one, 144 (72 boars and 72 gilts) commercial-type crossbred grower-pigs were used. The pigs entered into the trial at an average live mass of 30 kg and were slaughtered at an average live mass of 70 kg. Animals were kept in a temperature-controlled commercial grower facility consisting of 12 pens with 12 animals per pen (six boars and six gilts). Pens were equipped with self-feeders and automated water nipples. In experiment two, 80 (40 gilts and 40 boars) commercial-type crossbred grower-pigs were used. The pigs were housed individually and entered into the trial at live masses ranging from 17.5 to 31.1 kg and completed the trial at live masses ranging from 64 to 105.5 kg. Animals were kept in a temperature-controlled grower facility in individual flat deck cages with perforated metal floors equipped with self-feeders and automatic water nipples.

Two summit diets containing either 14% or 20% crude protein were formulated according to the ideal amino acid pattern described by Kemm *et al*. (1990) for all amino acids except tryptophan, for which the value listed by Wang & Fuller (1989) was used. These two diets were then blended in order to yield diets containing 16% and 18% crude protein, respectively. The levels of lysine, tryptophan, threonine, and total sulphur-containing amino acids in these two diets corresponded to that supplied by the 18% CP diet. Feed was available *ad libitum*. The ingredient and nutrient composition of the diets are given in Tables 1 and 2.

Table 1 Ingredient composition of experimental diets containing different levels of crude protein (%)

Ingredient (kg)	Experiment 1				Experiment 2			
	14%	16%	18%	20%	14%	16%	18%	20%
Maize	83.9	79.00	74.38	69.48	78.58	72.07	65.76	59.44
Soya oil-cake meal	7.49	9.50	11.40	13.41	0	0.67	1.32	1.97
Fishmeal	4.20	5.66	7.04	8.50	4.40	2.90	1.45	0
Sunflower oil-cake meal	0	2.01	3.90	5.91	0	0	0	0
Wheaten bran	0	0	0	0	10.35	12.95	15.48	18.00
Gluten 60	0	0	0	0	2.03	6.77	11.36	15.95
Monocalcium phosphate	2.16	1.78	1.43	1.05	1.42	1.44	1.46	1.48
Feed lime	0.75	0.74	0.72	0.71	0.83	0.94	1.04	1.15
Salt	0.75	0.74	0.72	0.75	0.75	0.75	0.75	0.75
L-Lysine HCL	0.47	0.31	0.16	0	0.65	0.66	0.66	0.67
D/L-Methionine	0.08	0.05	0.03	0	0.45	0.38	0.32	0.25
Threonine	0	0	0	0	0.22	0.16	0.10	0.04
Tryptophan	0	0	0	0	0.12	0.11	0.10	0.09
Vitamin and mineral premix *	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40

*Commercial non-medicated vitamin and mineral premix conforming to the standards of the ARC (1981).

Table 2 Estimated nutrient composition (as is basis) of experimental diets containing different percentages of crude protein

		Experiment 1				Experiment 2			
Nutrient	Unit	14%	16%	18%	20%	14%	16%	18%	20%
Crude fibre	(%)	3.3	3.4	3.6	3.7	3.2	3.4	3.6	3.8
DE pig	(MJ/kg)	14.0	14.0	14.0	14.0	13.8	13.8	13.8	13.8
Crude protein	(%)	14.0	16.0	18.0	20.0	13.5	15.6	17.6	19.6
Lysine	(%)	1.00	1.02	1.03	1.05	1.00	1.00	1.01	1.01
TSSA	(%)	0.61	0.66	0.70	0.75	0.84	0.87	0.91	0.95
Threonine	(%)	0.51	0.58	0.65	0.72	0.63	0.65	0.67	0.69
Tryptophan	(%)	0.16	0.19	0.22	0.25	0.20	0.20	0.21	0.21
Calcium	(%)	0.9	0.9	0.9	0.9	1.0	0.9	0.9	0.9
Phosphorous	(%)	2.8	2.6	2.5	2.3	2.8	2.6	2.5	2.3
Moisture	(%)	94.2	93.8	94.3	94.6	93.6	93.9	94.3	94.4

Feed residues from self-feeders were weighed every four days in experiment 1, and weekly in experiment 2. Average daily gain and feed conversion ratio were estimated using a linear model for experiment 1, and an autoregressive, allometric model (Siebrits, 1986) for experiment 2. Carcass mass and classification were noted at slaughter. Animals were weighed every four days in experiment 1 and weekly in experiment 2, corresponding with the intervals at which feed residues were weighed. Analysis of variance was performed on data from experiment 1 (Genstat 5, 1993). Because of the large variation in initial mass in experiment 2, an autoregressive allometric model (Siebrits, 1986) was used for data description, and the parameters estimated from the autoregressive allometric model were subject to analysis of variance (Genstat 5, 1993).

Results and discussion

Results for animals fed under group-housing conditions (experiment 1) are shown in Table 3, and those for animals fed in individual pens (experiment 2) are shown in Tables 4 and 5.

Table 3 Average daily intake, average daily gain (ADG), carcass classification and feed conversion ratio (FCR) (± standard deviation) of animals kept under group housing conditions and fed different levels of crude protein (CP) from 30-70 kg live mass (experiment 1)

Treatment	Average daily intake (kg)	ADG (g/day)	Carcass classification*	FCR (kg feed/kg gain)
14% CP	1.8 ± 0.29	604 ± 120	P	2.69 ± 0.11
16% CP	1.9 ± 0.18	683 ± 73	P	2.46 ± 0.07
18% CP	1.8 ± 0.14	677 ± 75	P	2.40 ± 0.08
20% CP	1.8 ± 0.18	602 ± 98	P	2.52 ± 0.17

No significant differences ($p > 0.05$) were observed for any of the parameters measured; * P = Calculated percentage carcass meat ≥ 70.1 %, based on electronic measurement of the hanging carcass between the second and third-last ribs 45 mm laterally from the carcass midline (Government gazette, 1992).

Table 4 Parameters (± standard deviation) derived from the autoregressive allometric model (Siebrits, 1986) for animals fed in individual pens (experiment 2).

Treatment	Sex	α_I ln (MJ)	ρ	μ_i ln (MJ)	ln a	b
14%	Boar	8.645 ± 0.252	0.893 ± 0.018	6.371 ± 0.197	1.650 ± 0.259[a]	0.771 ± 0.037[a]
	Gilt	8.729 ± 0.401	0.904 ± 0.019	6.395 ± 0.201	1.532 ± 0.154[b]	0.754 ± 0.022[b]
16%	Boar	8.737 ± 0.274	0.898 ± 0.021	6.382 ± 0.199	1.577 ± 0.216[a]	0.766 ± 0.034[a]
	Gilt	8.525 ± 0.145	0.888 ± 0.013	6.368 ± 0.166	1.591 ± 0.177[b]	0.765 ± 0.026[b]
18%	Boar	9.158 ± 0.845	0.913 ± 0.030	6.360 ± 0.151	1.726 ± 0.213[a]	0.793 ± 0.030[a]
	Gilt	8.855 ± 0.428	0.909 ± 0.019	6.323 ± 0.162	1.413 ± 0.161[b]	0.741 ± 0.022[b]
20%	Boar	8.651 ± 0.316	0.894 ± 0.029	6.370±0.176	1.760 ± 0.374[a]	0.796 ± 0.062[a]
	Gilt	8.682 ± 0.579	0.899 ± 0.027	6.382±0.190	1.423 ± 0.233[b]	0.743 ± 0.034[b]

[a] Means within columns with different superscripts differ significantly ($p < 0.05$); α_I: Asymptote of ln(cumulative DE intake); ρ: Slope of the autoregression; μ_I: ln(cumulative DE intake) at the start of the experiment; a, b: Intercept and slope of the regression equation; ln(live mass) = ln a + b ln(cumulative DE intake)

Table 5 Average daily gain (ADG), feed conversion ratio (FCR), grams crude protein (CP) per kilogram gain and cost per kilogram gain (± standard deviation) between 20 kg and 70 kg live mass for pigs fed diets containing various percentages of crude protein on an individual basis (experiment 2)

Treatment	Sex	ADG (g/day)	FCR (kg feed/kg gain)	Protein efficiency (g CP/kg gain)	Cost efficiency (R/ kg gain)
14%	Boar	832 ± 113	2.9 ± 0.3	406 ± 36	4.14
	Gilt	752 ± 105	3.0 ± 0.2	421 ± 22	4.28
16%	Boar	891 ± 115	2.8 ± 0.3	387 ± 35	3.61
	Gilt	790 ± 100	2.9 ± 0.2	405 ± 31	3.74
18%	Boar	1001 ± 144	2.5 ± 0.3	352 ± 40	2.83
	Gilt	797 ± 122	2.9 ± 0.2	418 ± 25	3.28
20%	Boar	938 ± 236	2.6 ± 0.4	364 ± 62	2.94
	Gilt	723 ± 194	2.9 ± 0.3	416 ± 44	3.28

No significant differences ($p > 0.05$) were observed for any of the parameters measured

No differences ($p > 0.05$) were found between treatments for any of the performance parameters measured in either experiment. For the group-housed animals there was, however, a tendency ($p < 0.10$) for better ADG and FCR in the 16% CP and 18% CP groups (Table 3). FCR differed ($p < 0.05$) between sexes in the individually housed group. No differences in carcass classification were observed in either experiment; all the carcasses were classified as P, the leanest class of a six-class scale. Despite a higher essential amino acid intake, the pigs fed the 20% CP diet in both experiments performed no better than those fed the other diets. This was probably due to an oversupply of amino acids and the associated energy-cost of deamination. This is in agreement with the results of Henry *et al*. (1992) and D'Mello (1994) who reported that excess amino acid supply resulted in reduced protein utilization or reduced feed conversion efficiency and reduced mass gain. The results of this experiment, which are in agreement with those of Tuitoek *et al*. (1997), Lenis (1989) and Valaja *et al*. (1993), show that the efficiency of protein utilisation can be improved under South African conditions by formulating low-protein diets containing with an optimal combination of synthetic amino acids and locally available South African feedstuffs.

Table 6 depicts economic scenarios for different synthetic amino acid prices when all other feed ingredient prices are kept constant. Due to the current (high) price of synthetic amino acids, the most economical diet was that containing 18% CP. It is also evident that the cost of the 16% CP diet would be the lowest if the price of tryptophan were to decrease to that of methionine, (scenario 2). If the cost of all amino acids should, however, decrease to the current lysine price, the 14% CP diet (scenario 3) would have the lowest cost per ton of feed.

Table 6 Different scenarios depicting the influence of synthetic amino acid price on feed cost for diets containing different levels of crude protein (CP)

Diet CP content	*Scenario 1 (R/ton)	*Scenario 2 (R/ton)	*Scenario 3 (R/ton)
14% CP	1477	1138	1077
16% CP	1288	1113	1082
18% CP	1131	1114	1097
20% CP	1132	1132	1120

*Scenario 1: Tryptophan R 41/kg; Threonine and methionine R 23/kg; Lysine R 11/kg
*Scenario 2: Tryptophan, threonine and methionine R 23/kg; Lysine R 11/kg
*Scenario 3: Tryptophan, threonine, methionine and lysine R 11/kg

Conclusion

It was concluded that the protein inclusion levels in pig growth diets could be reduced from 18% to 14% without any significant detrimental effect on performance provided that the essential amino acid composition is adjusted. If the price of synthetic amino acids were to decrease, it would be possible to formulate diets containing less protein without adversely affecting production. The 20% CP diet was not biologically or economically viable under any circumstances and is therefore not recommended.

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