Note on different digestible energy concentrations and ratios of lysine to digestible energy in diets of piglets weaned at three weeks of age

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Sixty-two piglets weaned at three weeks of age were allotted, in pairs, to four experimental diets (14 piglets to one diet and 16 piglets to each of the other three diets), and fed until 10 weeks of age. The diets were formulated to differ in digestible energy (DE) content with lysine : DE ratios of either 0,73 or 0,94 g lysine/MJ DE. The other dietary amino acids and protein were balanced according to the ideal protein concept. The piglets performed best on the diets with a high lysine : DE ratio, resulting in better performance ($P \leq 0,01$) in all parameters. The most prominent improvement being the 42% for average daily gain (ADG), 32% for final mass and 25% for feed conversion. Feed costs per unit of gain were also lower (14%) for the piglets receiving the high lysine : DE ratio diets. Piglets receiving the high DE-level diets performed significantly better than piglets on the lower level of DE for all parameters except for feed intake and feed cost. The most prominent improvements are the 12% for ADG, 10% for final mass and 14% for feed conversion. Increasing dietary DE content above 14,5 MJ/kg for the high lysine : DE group had no significant ($P > 0,05$) effect on piglet performance or on feed cost per unit of gain. However, a significant interaction ($P \leq 0,05$) between DE level and lysine : DE level showed that both factors must be considered in determining the nutrient requirements of the early weaned piglet.

Twee-en-sestig varkies wat op drie weke gespeen is, is in pare tot op 'n ouderdom van 10 weke aan vier eksperimentele diëte onderwerp (14 varkies aan die een dieet en 16 varkies per dieet aan die ander drie diëte). Die diëte is saamgestel om verskillende verteerbare-energie(VE)-vlakke met lisien : VE-verhoudings van 0,73 of 0,94 g lisien/MJ VE te bevat. Die ander aminosure en proteïne is volgens die ideale proteïenkonsep gebalanseer. Die hoë lisien : VE-diëte het telkens tot beter prestasie van die varkies gelei met die grootste verbetering in gemiddelde daaglikse toename (GDT) (42%), eindmassa (32%) en voeromset (VO) (25%). Voerkoste per eenheid massatoename was ook die laagste (14% verlaging) vir varkies op die hoë lisien : VE-diëte. Behalwe vir voerinname en voerkoste per eenheid massatoename het die varkies op die hoë VE-diëte ook beter presteer as varkies op 'n lae VE-peil met die grootste vebetering dié van 12% in GDT, 10% in eindmassa en 14% in VO. Geen betekenisvolle ($P > 0,05$) verhoging in groeiprestasie of voerkoste per eenheid massatoename is deur die verhoging van die VE-waarde van die dieet bo 14,5 MJ/kg met die hoë lisien : VE-groep gevind nie. Daar is 'n betekenisvolle interaksie tussen VE-waarde en VE : lisien verhouding gevind wat daarop wys dat beide VE-waarde en lisien : VE-verhouding by die bepaling van die varkie se voedingbehoeftes in ag geneem moet word.

Keywords: Digestible energy, early weaning, lysine, piglet.

Campbell (1977; 1978) showed that 0,75 g of lysine per MJ digestible energy (DE) is adequate to promote maximum performance of piglets between 6,5 and 20 kg live mass. However, other authors [Zhang, Partridge, Keal &

Mitchell, 1984; Agricultural Research Council (ARC), 1981] suggested that piglets between 3 and 8 weeks of age need about 0,99 g lysine/MJ DE. ARC (1981) ascribe the lack of response of piglets to lysine levels above 0,99 g lysine/MJ DE to deficiencies in amino acids other than lysine. Campbell & Taverner (1986), balancing amino acids according to the ideal protein concept (ARC, 1981), found no additional response in piglet growth with a ratio higher than 0,75 g/MJ DE and no response in feed conversion efficiency with a ratio higher than 0,79 g/MJ DE.

Part of the discrepancies found in piglet performance on different lysine : DE ratios can be ascribed to the protein and energy sources used. According to Campbell & Taverner (1986), protein source could be an important factor in determining the dietary nutrient requirements of the piglet. A plant protein source like soybean meal in the diet, in comparison to diets containing a combination of milk, animal and plant protein sources, could result in lower digestibilities of protein and amino acids and therefore higher dietary protein and amino acid requirements. According to Zhang *et al.* (1984), there is a progressive improvement of dietary nitrogen digestibility with increasing age in the weaned piglet. This improvement reflects the immaturity of the digestive system at weaning and its rapid development thereafter. The need for sufficient protein of a high quality in the diet when weaning takes place at three weeks of age, is therefore evident.

In South Africa, satisfactory results have been obtained using combinations of plant protein (roasted full-fat soybean meal or sunflower seed meal) and animal protein (fish meal) in diets for early weaned piglets (Viljoen, Kemm & Ras, 1984; Viljoen, Ras & Coetzee, 1988). Because of the conflicting results found in the literature cited, this study was conducted to investigate the response of three-week weaned piglets to diets of two DE levels, each at a lysine : DE ratio of 0,73 or 0,94, using a combination of plant and animal protein sources.

Sixty-four Landrace × Large White crossbred piglets, weaned at three weeks of age (16 per diet), were randomly allotted to four experimental diets. The experimental diets (Table 1) were formulated to have different DE values and different lysine : DE ratios. The other amino acids and protein were balanced according to ideal protein (ARC, 1981). Before formulation of the experimental diets, the lysine content of each source included in the diets was determined using a Beckman Model 121 M amino acid analyser (Beckman, 1975).

Piglets were kept in pairs (combined at random), in flat deck-type cages (1,5 × 1,0 m) with perforated metal floors equipped with self feeders and automatic water nipples. The piglets had *ad libitum* access to their specific diets and clean water at all times. Feed intake and spillage as well as live mass were recorded once per week for seven weeks. Feed and water were not withdrawn before weighing. The performance of one pair of piglets was unrealistically poor and they were omitted, resulting in only 14 piglets receiving diet 1, whereas 16 piglets per diet received the other three diets. Analyses of variance were done to determine statistical differences between treatments as well as between DE levels and lysine ratios.

Table 1 Percentage and theoretical composition of experimental diets

Component		Experimental diets 1	2	3	4
Maize meal (8,2)[a]	(%)	61,1	65,6	57,1	61,5
Wheaten bran (15,0)	(%)	18,0	7,8	18,0	6,8
Sunflower seed meal (17,3)	(%)	10,6	15,7	9,5	14,4
Fish meal (65,0)	(%)	6,9	8,1	13,0	15,6
Feed lime	(%)	1,64	0,99	0,67	0,08
Synthetic lysine	(%)	0,48	0,49	0,52	0,47
Fine salt	(%)	1,0	1,0	1,0	1,0
Antioxidant	(ppm)	250	250	250	250
Mineral & vitamin premix	(%)	0,2	0,2	0,2	0,2
Theoretical composition[b]					
DE[c]	(MJ/kg)	14,2	14,9	14,5	15,3
Lysine/DE ratio	(g/MJ)	0,73	0,74	0,94	0,95
Lysine	(%)	1,04	1,09	1,37	1,44
Protein	(%)	16,0	16,3	19,6	20,6
Fibre	(%)	5,1	4,8	4,9	4,5
Fat	(%)	8,0	10,0	8,0	10,0

[a] Protein content of feedstuffs is indicated in inverted commas.

[b] On an air-dry basis.

[c] The DE content of the feedstuffs used was as follows: Maize meal, 14,6 MJ/kg; wheaten bran, 10,5 MJ/kg; sunflower seed meal, 18,7 MJ/kg and fish meal, 17,0 MJ/kg.

Data summarized in Table 2 show distinct differences in performance of piglets given the different diets.

Average daily gains (ADG) of piglets receiving treatments 3 and 4 (high lysine : DE ratios), were significantly ($P \leq 0,01$) higher than those of piglets receiving treatments 1 and 2 (low lysine : DE ratios). Feed conversion efficiencies (kg feed/kg gain) also differed significantly ($P \leq 0,01$) between piglets receiving the high lysine : DE ratio treatments and those fed diet 1 ($P \leq 0,01$) and diet 2 ($P \leq 0,05$). Piglets receiving the high lysine : DE ratio diets performed highly significantly ($P \leq 0,01$) better for all parameters. The most prominent improvements being the 42% for ADG, 32% for final mass and 25% for feed conversion .

Zhang *et al.* (1984) found an improvement in growth rate and feed conversion in response to an increase in dietary ideal protein content. They ascribed their findings to increased lean deposition and decreased fat deposition. Results of Zhang, Partridge & Mitchell (1986) confirmed the hypothesis. The higher ADG and better feed conversion ratios found for the piglets receiving the high lysine : DE ratio diets in the present study, could therefore probably be ascribed, not only to the higher feed intake, but also to the higher ideal protein content of the diets.

Piglets receiving the high DE level diets performed significantly better for all parameters except feed intake and feed cost. The most prominent improvements included the 12% for ADG, 10% for final mass and 14% for feed conversion. The improvement caused by the higher

Table 2 Effect of dietary digestible energy (DE) and lysine : DE ratio on the performance of weaned piglets from 3 to 10 weeks of age

	Final mass (kg)	Feed intake (g/d)	ADG (g/d)	Feed conversion (kg/kg)	DE conversion (MJ/kg)	Feed cost (c/kg gain)
Treatments						
1	19,0	614	269	2,31	32,8	93
2	23,3	665	353	1,90	28,3	83
3	27,7	753	438	1,72	24,9	76
4	28,5	731	452	1,61	24,6	77
DE level						
Low	23,6	668	359	2,00	28,6	84
High	25,9	698	403	1,76	26,5	80
Difference (%)	9,8	4,5	12,3	13,6	7,9	5,0
Lysine : DE ratio						
Low	21,3	641	313	2,09	30,4	88
High	28,1	742	445	1,67	24,8	77
Difference (%)	31,9	15,8	42,2	25,1	22,6	14,3
S.E. (internal)						
Treatments						
1	1,072	34,6	20,2	0,101	1,43	4,08
2	0,903	29,5	14,3	0,069	1,03	3,99
3	0,804	25,6	13,0	0,023	0,33	3,03
4	1,143	39,0	18,2	0,050	0,77	2,40
DE level						
Low	1,322	27,6	25,2	0,092	1,24	3,01
High	0,976	25,0	17,1	0,055	0,78	2,03
Lysine : DE level						
Low	0,881	22,8	16,2	0,080	1,02	2,75
High	0,684	22,7	11,0	0,030	0,40	1,27
Statistical significance						
Treatments*						
1	a	a	a	a	a	a
2	b	ab	b	b	b	b
3	c	b	c	c	c	b
4	c	b	c	c	c	b
DE level**	x	NS	xx	xx	x	NS
Lysine : DE ratio**	xx	xx	xx	xx	xx	xx
Interaction:						
DE and lysine : DE level**	NS	NS	x	x	x	x

* Means with different symbols differ significantly:

			$P \leq 0,01$	$P \leq 0,05$
LSD:	Final mass	(kg)	3,8	2,8
	Feed intake	(g/d)	6,1	4,6
	ADG	(g/d)	63	47
	Feed conversion	(kg/kg)	0,25	0,18
	DE conversion	(MJ/kg)	3,6	2,7
	Feed cost	(c/kg)	11	8

** x – $P \leq 0,05$; xx – $P \leq 0,01$; NS – Not significant.

DE level was, however, not as dramatic as the improvement caused by the high lysine : DE ratio. Piglets receiving treatment 2 performed significantly better in all parameters except feed intake, when compared to piglets receiving treatment 1. This indicates the need for a high DE content in low lysine : DE ratio diets. It seems, however, that for early weaned piglets, dietary ideal protein content is of greater importance than the DE content of the diet. This is evident from the fact that piglets receiving diet 3 with a DE content of only 14,5 MJ/kg, performed better than the piglets receiving diet 2 with a DE content of 14,9 MJ/kg but with a lower lysine : DE ratio. However, the significant interaction ($P \leq 0,05$) between DE level and lysine : DE ratio, show that both

factors must be considered in optimizing the nutrient requirements of the early weaned piglet.

The lower lysine : DE ratios (0,75—0,79) for maximum performance of early weaned piglets found by Campbell (1977; 1978) and Campbell & Taverner (1986), could well be due to the protein sources used in their diets. These authors included milk powder as a protein source. Campbell & Taverner (1986) concluded that the digestibilities of protein and amino acids from plant sources are lower than that of milk protein, particularly in the period immediately after weaning. The improved performance of the piglets fed the higher lysine : DE ratios in the present study (using a combination of plant and fish proteins), as well as in the study of Zhang *et al.* (1984) (using plant protein), could therefore be ascribed to the fact that protein sources other than milk protein were used. A further factor which may have influenced the results in the present study is the different inclusion levels of fish meal in the diets (Table 1), since fish meal is the main contributor to protein and amino acids in the test diets. The high lysine : DE ratio diets contained at least 5% more fish meal than the low lysine : DE ratio diets, which resulted in different ratios of animal to plant protein in the diets. Differences in the supply of available amino acids to the piglets through using fish and plant protein sources may therefore have contributed to the differences in performances found. In future studies conducted to evaluate the use of different protein sources, it would therefore be advisable to consider amino acid availability.

Although the piglets receiving treatment 4 performed better in terms of growth rate and feed conversion efficiency than those fed diet 3, feed cost per kg live mass gain (c/kg gain) was similar for treatments 3 and 4. It was respectively 21% and 8% more economical to feed the high lysine : DE ratio diets (treatments 3 or 4) than to feed diets 1 and 2. No economic advantage was gained by feeding a high lysine : DE ratio diet with a DE content above 14,5 MJ/kg. The high lysine : DE ratio diets lower feed costs significantly ($P \leq 0,01$) by 14%, whereas no significant effect ($P \leq 0,05$) of DE level on feed cost was found. However, the significant ($P \leq 0,05$) interaction between DE level and lysine : DE ratio showed that DE level is certainly a contributing factor to the cost effectiveness of an early weaning diet.

It can therefore be concluded that, until more is known about the availability of amino acids from different protein sources, a dietary lysine : DE ratio of about 0,94 g/MJ DE and a DE value of 14,5 MJ/kg is suggested for efficient performance of piglets between 3 and 10 weeks of age when a combination of plant and animal protein sources is used. Both lysine : DE ratio and DE level must be taken into account when determining the piglets' nutrient requirements.

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