Net energy system for pigs

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In some areas of the world the contribution of livestock production to environmental pollution has become a serious concern.

This has lead to the introduction of legislation to reduce excretion by farm animals and to minimise the contribution to environmental pollution. The dietary protein levels are often higher than actually required by pigs. These 'safety' margins are sometimes very large and lead to excessive nitrogen excretion levels.

The effect of reducing the protein level in diets for growing pigs has been investigated in a number of experiments. Most studies conducted over the past decade have shown that the crude protein content in diets for growing and finishing pigs can be lowered by up to four percentage units with no effect on growth rate and feed efficiency, when sufficient amounts of the essential amino acids are supplied to this type of diet.

However, there is a trend for fatter carcases when pigs are fed low protein diets supplemented with amino acids.

Lowering the dietary crude protein level is accompanied by a more efficient utilisation of energy, due to a significant reduction in heat production and energy lost in urine.

This results in a greater quantity of retained energy with low protein diets at identical digestible (DE) or metabolisable energy (ME) intake. The net energy (NE) system is able to take this effect into account.

The superiority of the NE system for predicting performance and carcase quality has been confirmed especially when reduced protein diets are fed. This article will discuss the applicability of the NE system in comparison to the DE and ME system.

Special emphasis is placed on the effects of energy system on performance, carcase quality, nitrogen excretion as well as diet costs.

System comparison

In theory, a reduced protein, amino acid supplemented diet should be nutritionally superior to an all intact protein diet, because this type of diet is formulated to closer meet the animals needs.

By feeding low protein, amino acid supplemented diets with less excess of amino acids, fewer amino acids are de-aminated, converted to urea and excreted in the urine.

As a result, less energy is needed for these energy requiring metabolic processes.

However, the savings in energy as a result of not having to de-aminate excess amino acids is, in some cases, simply deposited as body fat in pigs fed low protein diets.

The reason for the increase in carcase backfat is likely due to a higher NE content of the low protein, amino acid supplemented diet.

Although the ME content in corn and soybean meal is the same (3650 kcal/kg, Table 1), the NE content in corn is considerably higher (2970 versus 1930 kcal/kg, Table 1).

Therefore, in the case of a corn-soybean meal diet, a reduction of two percentage units in dietary protein results in an increase in dietary NE content by about 2%.

The digestible energy, is defined as the gross energy of feed minus the gross energy of faeces (Fig. 1).

The metabolisable energy, is defined as the digestible energy minus energy excreted in urine and as combustible gases, for example methane. Net energy (NE) values are defined as ME minus heat increment associated with metabolic utilisation of ME and the energy cost of ingestion and digestion of the feed. NE values provide the closest estimate of the 'true' energy available for maintenance and production purposes.

The data in Table 1 shows that the efficiency of utilisation of DE or ME for NE is not constant.

Therefore, the hierarchy among feedstuffs is different in the DE, ME or NE system.

Comparing some typical feedstuffs clearly illustrates that both, the DE and ME system in general overestimate the energy value of high protein and high fibre feedstuffs, whereas feedstuffs high in starch or fat are underestimated.

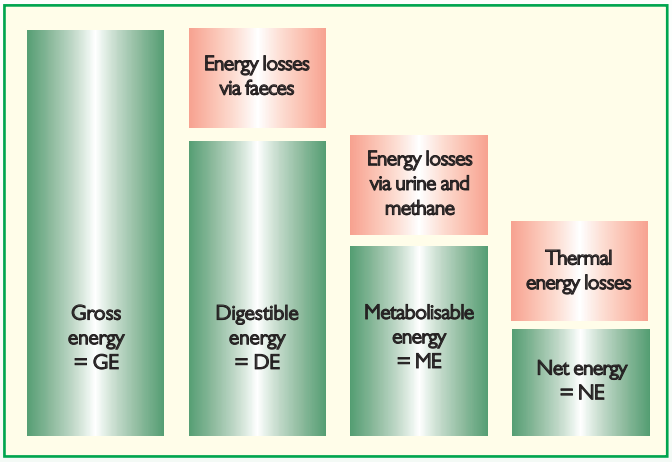

Fig. 1. Energy utilisation in pigs.

Ingredients	DE	ME	NE	ME:DE	NE:ME
Corn	3780/15.8	3650/15.3	2970/12.4	0.97	0.81
Wheat	3870/16.2	3780/15.8	2900/12.1	0.98	0.77
Tapioca	3790/15.9	3720/15.6	3080/12.9	0.98	0.83
Peas	3880/16.2	3750/15.7	2640/11.0	0.97	0.70
Soybean meal	3910/16.4	3650/15.3	1930/8.1	0.93	0.53

Table 1. Energy values (kcal/kg, MJ/kg) of some ingredients in DE, ME and NE system (Noblet et al., 1994).

Energy utilisation

The increase in fat deposition in pigs fed low protein, amino acid supplemented diets can be prevented by maintaining the same ratio of digestible amino acids to NE as in the intact protein diet.

Data from Dourmad et al. (1993) indicate that at controlled NE intakes, the dietary protein level affected neither growth of the animals nor carcase fat content at slaughter (Table 2).

In two performance trials, pigs in

Table 2. Effect of dietary crude protein level on performance of growing pigs (29-103kg BW, Dourmad et al., 1993).

Dietary CP (%)	17.8	15.5	13.6	Diet effect*
DE (MJ/kg) (kcal/kg)	14.1 (3370)	13.9 (3320)	13.7 (3270)	p<0.05
NE (MJ/kg) (kcal/kg)	10.2 (2440)	10.2 (2440)	10.2 (2440)	-
Performance				
Feed intake (g/d)	2292	2319	2307	NS
ADG (g/d)	846	867	852	NS
FCR (kg/kg)	2.71	2.68	2.72	NS
Carcase characteristics				
Dressing percentage	80.9	81.2	81.6	NS
Muscle content (%)	51.3	52.3	51.6	NS
Carcase fat content (%)	19.1	18.4	19.3	NS

**NS: p>0.05. All diets supplied at least 0.70% digestible lysine,with ratios of methionine + cystine, threonine and tryptophan to lysine of at least 60, 65 and 18 to 100, respectively. 40 pigs per treatment individually housed and fed ad libitum.*

	Dietary CP content			
Dietary CP (%)	High 16.5	Medium 14.5	Low 12.5	P
NE, MJ/kg (kcal/kg)	9.38 (2240)	9.38 (2240)	9.38 (2240)	
Ileal dig. lysine (%)	0.71	0.71	0.71	
Performance results				
Initial weight (kg)	54.8	54.9	54.8	NS*
Final weight (kg)	105.6	107.3	105.7	NS
Feed intake (kg/d)	2.361	2.341	2.334	NS
Weight gain (g/d)	793	819	795	NS
Feed conversion	2.98	2.86	2.94	NS
Ammonia emission of slurry (g/d/pig)	9.44	6.94	4.79	< 0.001
Relative (%)	100	73	51	

** p>0.05*

Table 3. Effect of reducing dietary nitrogen on finishing pig performance and ammonia emission of slurry (Canh et al., 1998).

the body weight range between 50-100kg were fed three different dietary protein levels, but constant ratio of digestible lysine to NE.

The level of dietary crude protein did not influence feed intake, daily gain, feed conversion and carcase characteristics in both performance trials (Tables 3 and 4).

Lowering the dietary crude protein level reduces the energy losses in urine and as heat.

According to the NE system, substitution of dietary protein by starch and/or fat reduces heat production and increases the NE value of the feed.

Le Bellego et al. (2001) determined the effect of reducing the crude protein level from 18.9 to 12.3%.

However, nitrogen excretion was linearly reduced, with a reduction of 58% between the high and the low

	Dietary CP content			
Dietary CP (%)	High 16.5	Medium 14.5	Low 12.5	P
Ileal dig. lysine g/MJ NE	0.76	0.76	0.76	
Performance results				
Weight gain (g/d)	805	805	797	NS*
Feed intake (g/d)	2249	2245	2257	NS
Feed/gain ratio	2.75	2.75	2.79	NS
Backfat thickness (mm)	15.2	15.4	15.9	NS
Lean meat (%)	57.2	57.1	56.7	NS
Muscle thickness (mm)	56.9	56.5	57.0	NS

** p> 0.05*

Table 4. Effect of reducing dietary nitrogen on performance and carcase characteristics (52-104kg BW, Canh et al., 1998).

dietary crude protein content on performance, nitrogen excretion, heat production and utilisation of energy in growing pigs.

Pig performance and nitrogen retention (Table 5) were not affected by reduction of the dietary protein diet. These results agree with those of Dourmad and Henry (1994) and Canh et al. (1998), who proposed a 10% decrease of nitrogen excretion for each percentage point reduction in dietary crude protein.

Table 5. Effect of dietary crude protein on weight gain and nitrogen balance (mean BW 65kg, Le Bellego et al., 2001).

Crude protein (%)	18.9	16.7	14.6	12.3	Diet effect[1]
Daily gain (g/d)	1064	1035	1020	1050	NS
Nitrogen intake (g/d)	69.7[a]	61.8[b]	54.6[c]	44.7[d]	**
Nitrogen retention (g/d)	32.7	30.7	29.8	29.0	NS
Nitrogen excretion (g/d)	37.0[a]	31.1[b]	24.8[c]	15.7[d]	**
Relative (%)	100	84	67	42	

*Diets based on wheat, corn and soybean meal with 0.76g standardised ileal digestible lysine per MJ NE. [1] Statistical significance: analysis of variance with diet as the main effect. Statistical significance: NS: p>0.05; **: p<0.01. Different superscripts indicate significantly different means (p<0.05).*

The objective of a study conducted by Rademacher and Hagemann (2004) was to determine the effect of energy system on performance, carcase quality and production cost.

Wheat-Barley-Rye-Soybean meal based diets were formulated.

Within each growth phase (Phase I, II and III), three diets (A, B, C) were formulated (Table 6) to provide similar digestible amino acid contents. Diets A within each phase were formulated on ME basis and standard dietary CP levels.

Diets B within each phase were reduced CP diets formulated on ME basis.

Diets C within each phase were formulated to the same CP contents as diets B but taking into account the NE values of the ingredients.

Phase I diets were fed between 30-50kg BW, Phase II diets from 50-80kg BW and Phase III diets were offered from 80-110kg BW.

During the overall growing finishing period, feed intake and feed efficiency were not affected (p>0.05) comparing the three experimental groups (Table 7).

Growth rate was significantly affected (p<0.05) with group B having a lower ADG compared with group C (836 vs 868 g/d) and group A being intermediate (Table 7).

Formulating diets based on the NE system (Group C) resulted in a tendency towards higher lean meat percentage as well as loin eye area (Table 7).

Results of least cost formulation will depend on the energy system. For instance, diets formulated based on the NE concept generally have a lower crude protein content and subsequent higher supplementation of amino acids, while dietary costs can be reduced.

The potential effect of the energy system on least-cost formulation is shown in Table 6.

The economic impact of formulating low CP diets based on NE system (Group C) compared with standard dietary CP content and based on ME system (Group A) is shown in Table 7.

Feed cost per pig were reduced by €0.63 (€30.62 vs 29.99), carcase value was improved by €1.10 (€109.63 vs 110.73) and carcase value minus feed cost was improved by €1.73 per pig comparing Group A vs Group C.

With this, the results of this trial nicely show the benefits of using the NE system in diet formulation on improved pig performance, better carcase quality and savings in feed cost. ■

BW range	Phase I 30-50 kg			Phase II 50-80 kg			Phase III 80-110 kg		
Treatment	A_1	B_1	C_1	A_2	B_2	C_2	A_3	B_3	C_3
Dietary CP content (%)	19.0	16.9	16.9	18.0	16.0	16.0	17.0	15.0	15.0
ME (MJ/kg)	13.5	13.5	13.4	13.2	13.2	13.1	13.0	13.0	12.9
ME (kcal/kg)	3227	3227	3203	3155	3155	3131	3107	3107	3083
NE (MJ/kg)	9.58	9.64	9.58	9.41	9.47	9.41	9.28	9.33	9.28
NE (kcal/kg)	2290	2304	2290	2249	2263	2249	2218	2231	2218
Feed cost* per 100kg (€)	16.82	16.78	16.67	15.80	15.77	15.65	14.95	14.92	14.80

**Feed ingredient prices EU, Spring 2005*

Table 6. Dietary crude protein and energy level as well as feed cost (Rademacher and Hagemann, 2004).

References are available from the author on request.

Table 7. Effect of reduced dietary protein and energy system on growing finishing pig performance, carcase quality and economics (Rademacher and Hagemann, 2004).

Group/treatment	A Stand. CP, ME	B Low CP, ME	C Low CP, NE
Pig performance (30-110kg)			
Daily gain (g)	854[ab]	836[b]	868[a]
Daily feed intake (kg)	2.10	2.07	2.10
Feed:gain (kg/kg)	2.47	2.48	2.42
Carcase characteristics			
Carcase weight (kg)	88.7	89.0	89.3
Lean meat (MFFOM, %)	57.8	57.6	58.0
Lean meat (g/d)	422	411	431
Loin eye area (cm^2)	50.2	51.9	51.5
Feed costs/carcase value			
Feed cost per pig*(€)	30.62	30.91	29.99
Feed cost per kg weight gain (€)	0.38	0.39	0.35
Carcase value** (€)	109.63	109.65	110.73
Carcase value minus feed cost (€)	79.01	78.74	80.74

** Refer to Table 6 for feed cost ** Base price: 1.20€kg carcase weight at 56% lean meat. Adjustment: + €0.02/% point increase in lean meat above 56% [a,b,c] means within a row that are significantly different are denoted by different superscripts*