Ideal protein and low protein diets for piglets

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Remark: This abstract should preferably be read in combination with the presentation

In Denmark, three recent experiments involving 67,000 piglets from 7-30 kg have had a big impact on the Danish protein and amino acid recommendations for piglets. The aim of the experiments was to find a way to achieve lower protein levels in piglet diets, as lower protein reduces the risk of diarrhea – which is crucial in a future without medical zinc. In summary, we have lowered the recommendations for SID (standardized ileal digestible) protein and increased the recommendations for added free amino acids by increasing the recommendations for SID lysine, methionine, threonine, tryptophane, and to a lesser extend valine, while lowering the recommendations for leucine, histidine, and isoleucine.

The effect of the above changes is feed with a lower risk of diarrhea in the piglet period. Lower protein also means lower inclusion of expensive protein sources, and the net effect is economic optimal feeding. Economic optimal feeding is achieved with protein levels considerably below the protein level needed to maximize daily gain end minimize kg feed per kg gain.

In general, the lower risk of diarrhea is a strong quality, particularly in a future without medical zinc!

Table 1 shows the Danish recommendation for amino acid profile in piglet diets.

Table 1. Danish recommendations for SID* amino acid profile in piglet diets

Period	2015-2019	2021-2022	
Piglet weight	6-30 kg	6-15 kg	15-30 kg
Name of profile**	**100%**	**86%**	**90%**
Lysine	100	100	100
Threonine	62	62	62
Methionine	32	32	32
Methionine + cystine	54	54	54
Tryptophane	21	21	21
Isoleucine	53	46	48
Leucine	**100**	**86**	**90**
Histidine	32	28	30
Valine	67	62 (93% of 67%)	64 (95% of 67%)
Phenylalanine + tyrosine	100	95	95

*SID= standardized ileal digestible

**Refer to leucine, isoleucine, and histidine as percent of earlier Danish profile. These three amino acids are normally more or less co-limiting in Danish piglet diet and their recommendations set the minimum for protein.

Three experiments changed our recommendations and include:

Experiment 1

Five levels of SID threonine and five levels of SID lysine giving 25 treatments, using 32,000 piglets. The protein level was the same in all treatments, except the protein coming from threonine and lysine.

Experiment 2

Two levels of SID protein and six levels of four amino acids per protein level (lysine, threonine, methionine, and tryptophane) giving 12 treatments, using 28,000 piglets.

Experiment 3
Four levels of SID protein and five levels of five amino acids (lysine, threonine, methionine, tryptophane and valine). 20 treatments with same feed from 7-30 kg + four treatments with inverse phase feeding (lower protein from 7-15 kg than from 15-30 kg). Inverse phase feeding is not included in this abstract - 6600 piglets used in experiment 3.

Experiment 1
The hypothesis of this experiment states that an inverse design of amino acid requirement experiments would give quite different answers to ideal amino acid profile. With an inverse approach, we mean keeping threonine constant and limiting while increasing lysine. The traditional approach is constant and limiting lysine and increasing levels of the amino acid in question, in this case threonine. The experiment showed:

Traditional design: Threonine level needed at constant and limiting lysine was around 63% of lysine.
Inverse design: Lysine level needed at constant and limiting threonine was around 190% of threonine. This means that the optimum relation in the inverse design was (100 threonine / 190 lysine) = 53%.

We also tested the requirement of each amino acid when the other amino acid was not limiting and found the relation to be 58% (max. requirement threonine/max. requirement lysine).

This gives three approaches to optimal relations:
- With 53% threonine of lysine, lysine is not limiting for maximum utilization of threonine
- With 58% threonine of lysine, both amino acids are equal limiting
- With 63% threonine of lysine, threonine is not limiting for maximum utilization of lysine.

In Denmark, we have chosen to recommend threonine at 62% of lysine, because threonine has been less expensive than lysine. Less expensive because you need lower additions in gram threonine than in gram lysine to give the same increase as percentage of requirement, and the price per gram has been nearly the same.

In experiment 1, the level of protein was limiting for the response, because the used protein level gave a level of SID leucine and histidine at "only" 11.9 and 3.8 g per kg. Looking at the effect of increasing lysine in the groups with plenty of threonine, we found a response with the linear plateau model until 13.5 g SID lysine per kg. This means we found positive effect of increasing lysine until lysine was 113-114% of leucine and 355% of histidine. In other words, until leucine and histidine were 88% and 28% of lysine (conclusions from inverse approach).

Experiment 2
This experiment was designed to explore the effect of increasing SID lysine, methionine, threonine, and tryptophane at two levels of SID protein. Both protein levels were limiting for maximum productivity – the limiting amino acids being valine, leucine, and histidine.

The hypothesis was that doses of free amino acids above the levels supported by the international amino acid profile would improve production results.

At both levels of SID protein, the lysine was increased from 92% of leucine until 125% of leucine. And methionine, threonine, and tryptophan were increased in the same way, because the relation between threonine, methionine, tryptophane, and lysine were held constant at all lysine levels.

This experiment showed improved feed conversion in the whole range of amino acid additions and improved daily gain until lysine to leucine reached 110-115% of leucine. The daily gain was slightly decreased at the highest amino acid level, because a decrease in feed intake had greater effect than the improvements in feed conversion.

The interpretation is as follows: increasing addition of four free amino acids improved feed conversion because of a combination of better amino acid balance and more nitrogen available to make dispensable amino acids from the surplus of added indispensable amino acids. At 92-105%, we expect the improved balance to be most important, while more available nitrogen probably is most important from 115-125% lysine to leucine. In the range from 105-115%, the two effects might be about equally important, both contributing to a good effect of extra amino acids.

Experiment 3
This experiment was conducted at our own research station to explore a larger range of combinations and to document the effect on diarrhea treatments. The protocol included registration of individual antibiotic treatments against diarrhea and strict rules for treatments. Piglets were put in experiment from weaning and there was no medical zinc in the feed and no preventive medicine. Benzoic acid was added at 0.5% in the whole period 7-30 kg and calciumformiate (1%) was also added from 7-15 kg.

The main experiment included four levels of protein combined with five levels of additions of five different amino acids (lysine, methionine, threonine, tryptophane, and valine in a fixed relation). This gives 20 treatments – but as mentioned, we also had four combinations of lower protein 7-15 kg with higher protein from 15-30 kg – combinations involved in our setting of recommendations for inverse phase feeding – but not presented here.

This experiment showed improved daily gain and feed conversion from lowest to highest protein level. The same was the case for increased additions of the five free amino acids, increasing lysine to leucine ratio from 98-136%. The effect of added protein or added amino acids on feed conversion and daily gain were higher at the lower protein levels. With the highest protein level (190 g digestible protein per kg), the feed conversion was below 1.3 kg feed per kg gain.

The first additions of free amino acids had bigger effects on gain and feed conversion, probably because of better amino acid balance, while the effect of more than about 115% of leucine probably was an effect of increased easily available nitrogen to build nonessential amino acids.

There was a big effect of protein level on diarrhea as the high protein level increased antibiotic treatments about four times compared to the lowest protein level. This was more og less expected from earlier experiments – however, earlier experiments have not tested the highest protein level.

But we were surprised to find increasing levels of free amino acids decreasing the incidents of diarrhea treatments. And the diarrhea reducing effect was at the same level as medical zinc – independent of protein level, the increase in amino acid additions lowered the treatments against diarrhea about 50%. This happened when a normal “optimized” diet with international amino acid profile was added about 35% extra lysine, methionine, threonine, tryptophane, and valine.

Conclusions

More protein to piglet diets improves daily gain and feed conversion for DANBRED piglets at least until 190 g SID protein per kg.

However, an increase in protein level has a big effect on antibiotic treatments against diarrhea, as diarrhea treatments increased about four times from 120 to 190 g SID protein per kg feed.

Extra additions of protein in the form of five free amino acids had the opposite effect, as 35% extra amino acids from international used amino acid profile reduced diarrhea with 50% at all four protein levels. This effect was similar to the effect from medical zinc (2500 ppm) in other experiments.

Extra additions of high doses of free amino acids are expensive, and the highest additions had negative effect on feed intake.

The Danish recommendations for optimal levels of amino acids are the economic reasonable conclusions, e.g., gaining the main effect of better balance for daily gain and feed conversion, and good effect on treatments without reaching levels risking lower feed intake.

It could be possible to use the concept of 25-35% extra amino acids (like experiment 3) in critical periods after weaning – for example in the first three weeks.