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Nutritional possibilities to reduce the N and P excretion of pigs (A review)

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ABSTRACT

Manure disposal is a major problem in highly intensive pig production areas, especially for nitrogen and phosphorus, because of water and air pollution. Among farm animals the monogastric species excrete most of the nitrogen and phosphorus, due to the digestibility properties, protein and amino acid supply and improper manure handling. Sows, weaners and slaughter pigs excrete approximately 75%, 45% and 70% of the nitrogen, and 75%, 40% and 60% of the phosphorus consumed, respectively. In total about 34000 ton N and 8000 ton P can potentially pollute the environment yearly from the pig and poultry sector in Hungary. Therefore, it is important to reduce the amount of these elements in the manure and urine. Our objective was to discuss the nutritional possibilities to reduce N and P excretion of pig farming in Hungary. The potential N and P pollution in Hungary is about 5.0 and 1.1 kg per ha of arable land, respectively. These values are far below the legislation in France, Denmark and The Netherlands (Jongbloed et al., 1999). However, by improper manure and slurry handling the regional emission can be even higher. In Hungary the introduction of dietary nutrient recommendations based on ileal digestible amino acids, ideal protein concept and digestible phosphorus is in progress. Therefore, about 20-percentage reduction in N excretion can be expected. Shifting recommendation from total P to digestible P will not reduce significantly the P emission. Since the P emission per ha is quite low in Hungary and legislation is not foreseen, the dietary inclusion of microbial phytase will depend on economical considerations.
(Keywords: phosphorus, nitrogen, pig, excretion)

INTRODUCTION

Nowadays, there is an increasing awareness of the impact of livestock production systems on the environment, especially in countries with dense animal populations. In countries facing with a surplus of manure and a serious concern about the effect of ammonia emissions on environmental acidification and the pollution of ground and surface water the most important pollutants are nitrogen and phosphorus. Among farm animals the monogastric species excrete most of the nitrogen and phosphorus, due to the digestibility properties, protein and amino acid supply and improper manure handling. Sows, weaners and slaughter pigs excrete approximately 75%, 45% and 70% of the nitrogen, and 75%, 40% and 60% of the phosphorus consumed, respectively (*Peet-*

Schwering and *Hartog,* 2000). *Table 1* shows the estimated N and P excretion of pigs , broilers and laying hens in Hungary.

Table 1

Estimated N and P excretion of pigs , broilers and laying hens in Hungary in 2000

	Sows	Fattening pigs	Piglets	Total	Laying hens	Broilers	Total
N excretion[a] kg/year/head	22.4	4.24	0.56		0.77	0.07	
Total N excretion[b], t/year	7795	13992	595	**22382**	10980	1152	**12132**
P excretion[a] kg/year/head	5.4	0.82	0.13		0.22	0.012	
Total P excretion[b], t/year	1879	2706	138	**4723**	3137	197	**3334**

[a]*Jongbloed and Lenis (1993);* [b]*Based on Jongbloed and Lenis (1993) and Statistical Yearbook of Hungary (2001)*

A single pig in the 30 to 100 kg live weight range consume 6.8 kg N, but only 2.6 kg N used for maintenance and tissue accretion (*Jongbloed* and *Lenis,* 1993). The remaining nitrogen is excreted via faeces and urine into the environment. In the case of phosphorus we can calculate with 1.5 kg intake during fattening period and with 0.8 kg excretion. In total about 34000 ton N and 8000 ton P can potentially pollute the environment yearly from the pig and poultry sector. Therefore, it is important to reduce the amount of these elements in the manure and urine.

The actual N an P emission depends on many factors, therefore, in this paper, we aim to discuss the nutritional possibilities to reduce the N and P excretion of pig operations in Hungary.

REDUCING NITROGEN EXCRETION

The first approach for improving the efficiency of N utilisation by the pigs is to ensure that the supply is at all times appropriate for growth potential of the animals, or to their physiological needs. The digestibility of dietary proteins and amino acids was for a long time expressed by means of the apparent digestion coefficient measured from the faeces, similarly to that of other nutrients. However, results obtained from digestion physiology research prove that bacterial flora in the colon not only synthetises protein, but at the same time catabolises it. This is why digestibility of dietary proteins measured from the faeces underestimates the actual value in some cases, while in others overestimates this value (*Schröder*, 1988).

For this reason, in a number of western European and north American countries calculations are based upon the ileal digestibility of proteins and amino acids. The apparent disadvantage of this method is that the amount of amino acids absorbed in the colon is not taken into account.

However, it would not be correct to regard this as a source of error, since in the postileal section of the intestine (the colon) the various nitrogen bonds are absorbed almost exclusively in the form of ammonia, and thus are not involved in protein synthesis (*Just et al.,* 1981) but are excreted in the urine. Hence, only the amount of amino acids absorbed before the end of the small intestine has significance with respect to animal nutrition.

In swine diets lysine is the first limiting amino acids in most cases. Without crystalline amino acids the requirements of lysine can be met only with higher crude protein level. This results that other amino acids are supplied in excess, which amount needs to be deaminated and excreted via urine. In growing pigs, amino acid composition of balanced, or ideal, protein represents the balance in which amino acids are required for maintenance and body protein accretion (ARC, 1981; *Fuller et al.,* 1989). An important benefit of the ideal protein concept is, that the requirements for all dispensable amino acids and total crude protein can be quickly derived after the requirements for one amino acid are established. This concept may also be used to reduce amino acid excesses that occur in practical swine diets, without affecting animal performance. The improvement of the amino acid profile can result about 20-30% reduction in N excretion *(Table 2).* The crude protein level can be reduced about 10-20% without negative effect on daily gain and feed conversion ratio. However, with a very low protein diet (about 11%) optimally balanced in amino acids, a reduction in growth performance can be expected (*Tuitoek et al.,* 1997), suggesting a deficiency of non essential amino acids. Changing the feeding strategy is also an efficient way to reduce N excretion. The protein and amino acid requirements gradually change by age forming a curve. Therefore, a single diet can not meet exactly the requirement. Even using only a two phase feeding the N excretion can be reduced about 8% (*Latimier* and *Dourmant*, 1993; *Kim et al.,* 2000). Using multi-phase or blend feeding the N emission could be reduced up to 50% compared to a single phase feeding (*Bourdon et al.,* 1997). However, it must be pointed out, that the development of such feeding techniques for reducing N excretion by the pigs requires a good knowledge of amino acid availability in the feedstuffs, and of changes in amino acid requirements according to growing stage or physiological status (*Dourmad et al.,* 1999). Therefore in practical conditions only moderate reduction of dietary crude protein content can be proposed.

Table 2

The effect of dietary crude protein content reduction with amino acid supplementation on growth performance and N excretion

LW range, kg	CP reduction to control, %	Effect on daily gain	Effect on feed conversion	Reduction in N excretion, %	Source
30-102	13	ns[a]	ns	21	*Dourmad et al*., 1993
	24	ns	ns	36	
33-96	12	ns	ns	24	*Gundel et al*., 2000
20-55	10	ns	ns	14	*Tuitoek et al*., 1997
	22	ns	ns	35	

[a]*Not significant*

REDUCING PHOSPHORUS EXCRETION

According to the data obtained from various investigations, pigs retain for maintenance and weight gain barely 30% of phosphorus ingested with the diet, the remaining 70% being excreted in the faeces and urine (*Table 3*).

Table 3

Phosphorus retention in growing pigs

	***Tossenberger* and *Kakuk* (1992)**	***den Hartog* and *Swinkels* (1993)**	***Schwarz* (1994)**
Intake, %	100	100	100
Excretion, %	70	70	67
Retention, %	30	30	33

Similarly to the protein and amino acid supplementation, the first approach to reduce phosphorus excretion is to ensure that the supply is at all times appropriate for the growth potential of the animals, or to their physiological needs. The low net utilisation of P is mainly due to the quite low P digestibility in pig diets, resulting in a high faecal excretion of P. At other hand, the recommendations for P requirements were based on total P content. Therefore, they were imprecise and included large safety margins (*Fernández et al.,* 1999). Consequently a more precise basis for P recommendations would be digestible P. This can be justified by model calculations (*Table 4*). If diets formulated on the basis of total P content, only diets with components having highly digestible P content reach the recommended dietary digestible P level. However, the differences between total and digestible phosphorus content of diets is identical in all case although decreasing with increased P digestibility of dietary components. This means, that applying the digestible phosphorus concept in diet formulations will decrease the P excretion if components with higher P digestibility will be preferred in swine diets.

Table 4

Total and digestible P content of diets formulated to meet either total or digestible P recommendation[a] of NRC (1998)

		Main dietary components							
		Soybean meal Maize		**Soybean meal Maize Fishmeal**		**Soybean meal Maize Wheat**		**Soybean meal Barley Wheat**	
	NRC, 1998	Basis of diet formulation							
		TP[b]	DP[c]	TP	DP	TP	DP	TP	DP
Total P, g/kg	5.0	5.0	5.2	5.0	5.1	5.0	5.0	5.0	4.6
Dig. P, g/kg	2.3	2.1	2.3	2.2	2.3	2.3	2.3	2.7	2.3
Total-Dig., g	***2.7***	***2.9***	***2.9***	***2.8***	***2.8***	***2.7***	***2.7***	***2.3***	***2.3***

[a]Growing pigs from 20-50 kg; [b]Diets formulated to meet the NRC (1998) recommendation for dietary total P; [c]Diets formulated to meet the NRC (1998) recommendation for dietary digestible P

Most phosphorus of plant origin is present as phytic acid (30-70%), which is poorly available to non-ruminant animals. The availability of phytic acid P may be improved either by adding microbial phytase or by using phytase-rich cereal diets (*Tossenberger et al.,* 1993). The intrinsic phytase activity is high in wheat, triticale and barley, and low in maize, oats and oil meals. Due to the different intrinsic phytase activity, 10% of the

phytate content of maize and 48% of the phytate content of wheat can be transformed into an absorbable form (*Tossenberger et al.,* 1993). Therefore, the effectiveness of microbial phytase supplementation depend on diet composition.

The regulation of P homeostasis in the body occurs mainly through control of P excretion in urine and P absorption. Physiologically, fractional P absorption decreases and the urinary P excretion increases when pigs are fed above their requirement. Conversely, fractional P absorption increases and the urinary P excretion decreases when pigs are fed below their P requirement. When pigs are fed P according their physiological P requirement, urinary P excretion is very low. This is well demonstrated in *Table 5*. The experimental data demonstrate that, if phosphorus is supplied according to the recommendations and phytase supplementation is applied, the amount of P excreted in the faeces is decreased, due to better digestibility of phosphorus. The excess phosphorus absorbed from the intestine was, however, excreted in the urine. This indicates that pigs had substantially more P available that their physiological requirements. Experimental results published indicate that the digestibility of P can be improved about 10-30 percentage units (*Simons et al.,* 1990; *Cromwell et al.,* 1993; *Tossenberger,* 2001). Addition of microbial phytase to pig diets (about 500 FTU/kg) can improve P digestibility up to about 65% (*Poulsen et al.,* 1999). If the diets are heat treated, most of the phytase, intrinsic and microbial, might be inactivated. Therefore, the effect of feed processing should also be accounted in calculation of P requirements.

Table 5

Changes in phosphorus balance in growing pigs by the effect of phytase addition, given identical daily phosphorus intake

	Phytase supplementation, FTU/kg feed		
	0	500	1000
Daily P Intake, %	100.0	100.0	100.0
Daily P excretion, %			
in urine	9.5	19.3	23.4
in faeces	50.7	41.9	37.7
Daily P retention, %	39.8	38.8	38.9

(Tossenberger, Pálos, Babinszky, unpublished data)

IMPLICATIONS

The potential N and P pollution in Hungary is about 5.0 and 1.1 kg per ha of arable land, respectively. These values are far below the legislation in France, Denmark and The Netherlands (*Jongbloed et al.,* 1999). However, by improper manure and slurry handling the regional emission can be higher. In Hungary the introduction of dietary nutrient recommendations based on ileal digestible amino acids, ideal protein concept and digestible phosphorus is in progress. Therefore, in N excretion about 20-percentage reduction can be expected. Shifting recommendation from total P to digestible P will not significantly reduce the P emission. Since the P emission per ha is quite low in Hungary and legislation is not foreseen, the dietary inclusion of microbial phytase (500 FTU/kg) will depend on economical considerations.

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