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Relationship between Livestock Nutrition and Excreted Nitrogen and Phosphorus Content

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The conflict between intensive animal rearing and the environment is revealed in manure management. Intensive and simultaneously environmentally friendly animal farming is primarily based on an appropriate feeding strategy by which it is possible to affect the amount of excreted manure and nutrient content.

Livestock and poultry do not use feed nutrients entirely for their maintenance and production synthesis, so wastes are discharged from the body with faeces and urine (Figure 41.1).

In intensive livestock management, which aims at achieving high production (profit), nutrients originating from manure frequently become a source of pollution. The main risk factor for pollution of the environment is excreted nitrogen − its emission to the atmosphere in the form of ammonia and nitrogen oxides, leaching as nitrates into groundwater and surface water − and also phosphorus and potassium leaching into surface water and groundwater. Reducing the nutrient content of the diet can decrease the content of excreted nutrients (N, P) and thus also the risk of nutrient emissions (odour emissions, leaching) to the environment. The nutrient content of diets can be reduced, simultaneously covering the animals' needs, by improving the digestibility of the feed and by balancing the concentration of essential nutrients in the diet, thus improving the efficiency of the body's protein synthesis.

For both pigs and poultry, a 1% reduction in the protein content of the diet leads to a 10% reduction in the nitrogen content of excreta.

In several EU Member States (Belgium, Denmark, France and Germany) where agriculture is responsible for high environmental pressure, the minimum and maximum limits for the nutrient content of pig and poultry feeds (concentrates) are legally regulated. Farmers in these four Member States are also obliged to keep a record of their nutrient (N, P) applications at farm level.

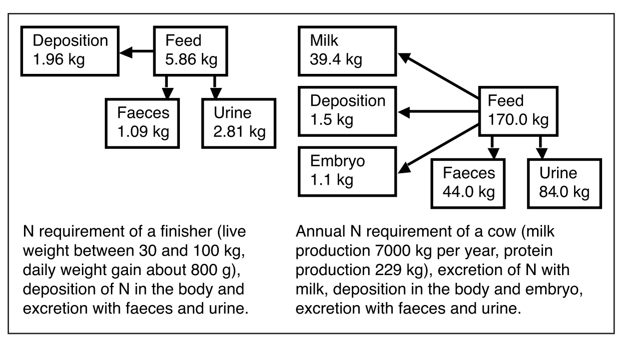

Figure 41.1. Efficiency of protein consumption for a finisher pig and a dairy cow.

FACT BOX 1

In order to use a diet with lower nutrient content, the following measures can be applied:

- Improving the quality (digestibility) of the diet, through the:
  - application of low protein levels, use of synthetic amino acids and related compounds
  - application of low phosphorus levels, use of phytase and/or digestible inorganic phosphates
  - use of other feed additives for improving digestibility (enzymes etc.)
  - use of highly digestible feeds.
- Formulating a balanced feed based on the animals' need for digestible phosphorus and amino acids (following the ideal protein concept).

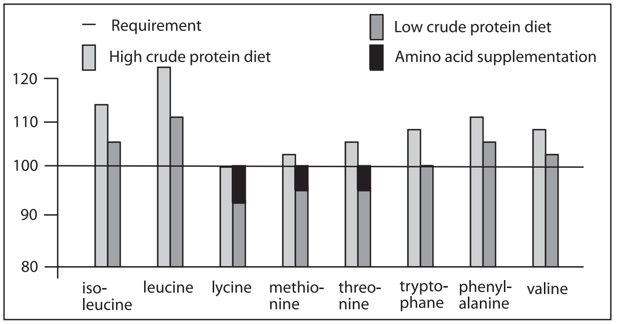

Figure 41.2. Effect of synthetic amino acid supplementation on diet protein content.

Multiphase Feeding Strategies

Multiphase feeding strategies aim to cover the needs of animals/poultry of all ages and production groups. Precision feeding at different stages of age and production enables the excreted nutrient content to be reduced significantly (EC, 2003).

a) Poultry farming. In the diet of layers, concentrates with different levels of Ca and P are used according to the stage of age and egg production. A uniform group of animals and a gradual transition from one feed to the next are required.

In broiler farming, multiphase feeding strategies aim at optimising the feed conversion ratio. Frequently, a three-phase feeding strategy is used, as broilers show a considerable change in their nutritional requirements with age. Applying a slightly restricted feeding regime in the first phase results in more efficient growth at a later stage. At the same time, proteins and amino acids must be fed at a high level and balanced. In the second phase the digestive tract of the birds is fully developed and they can convert maximum amounts of feeds. The proportion of energy-rich feeds in the diet is increased. In the third phase, the protein and amino acid content are increased, but the energy concentration remains at the level of the second phase. In all phases, Ca-P balance remains the same, but the concentration is reduced according to the age of the broilers.

b) Pig farming. Phase feeding for finishers consists of giving 2 to 4 concentrates with different contents of nutrients to pigs with weights 25 to 100 kg. In high-tech pig farms multiphase feeding strategies are used where the content of amino acids, energy and minerals in the diet is changed according to the growth of pigs. For sows, phase feeding consists of giving at least two different concentrates: one for lactation and one for gestation. In fewer cases, a specific feed might be given before farrowing.

FACT BOX 2

Applying the multiphase feeding strategy, the average reduction in nutrient excretion is as follows:

- Broiler chickens: 15-35% reduction in N excreted
- Finishing pigs: three-phase feeding reduces N (3%) and P (5 %) excretion; multiphase feeding reduces N (5-6 %) and P_2O_5 (7-8%) excretion
- Sows: two-phase feeding reduces N (7 %) and P_2O_5 (2 %) excretion.

Use of Amino Acids in Low-protein Diets

The aim of feeding synthetic amino acids is to reduce the use of expensive protein feeds in poultry and pig diets, but also to meet animal requirements (EC, 2003). It should be considered that natural feeds do not contain essential amino acids in the correct proportions. Due to that, compound feeds with excessive amino acids increase the excretion of nutrients, especially that of N (Figure 41.2).

Table 41.1. Relationship between dietary protein, nitrogen excretion and ammonia emissions for finisher pigs.

Parameters	Effect of 1 point reduction of dietary protein, %
Total nitrogen excreted	- 10
Ammonia content in slurry	- 10
Ammonia emission	- 10
Water consumption (ad libitum)	- 2…- 3
Slurry volume	- 3…- 5

Some currently produced and supplemented amino acids are lysine (L-Lysine), methionine (DL-Methionine and analogues), threonine (L-Threonine) and tryptophan (L-Tryptophan).

The effects of using low-protein diets (supplemented with synthetic amino acids) in poultry farming are the following:

The excretion of N decreases by 10% per 1% reduction in dietary protein for finisher pigs (Table 41.1). It is possible to reduce the protein level in feed by up to 2% for all age and production categories. However, it is necessary to add four essential amino acids (lysine, methionine, threonine and tryptophan) to prevent growth reduction.

Use of Phytase in Pig and Poultry Diets

Phytate-phosphorus (compound of phytanic acid and phosphorus which is normally present in plant feed materials) is not available to pigs and poultry as they lack the appropriate enzyme activity in their digestive tract (Table 41.2). This leads to large amounts of non-digestible phosphorus being excreted, posing a great risk to the environment. The digestibility of P can be improved (reducing its content in the diet and excreta) by the following methods (EC, 2003):

- Adding the enzyme phytase,
- Increasing the availability of P in plant feed materials,
- Reducing the use of inorganic phosphates in feeds.

Four phytase preparations are currently authorised as feed additives in the European Union (Directive 70/524/EEC).

Effects of using phytase in pig diets:

- Improvement of plant phosphorus digestibility by 20-30% in piglets and 15-20% in growers, finishers and sows
- A 0.1% reduction in phosphorus in the diet through using phytase results in a reduction in phosphorus excretion of 35-40% for piglets, 25-35% for growers and finishers, and 20-30% for sows.

Effects of using phytase in poultry diets:

FACT BOX 3

A reduction in dietary protein content of 1% results in a reduction in N excretion of 10% for layers and 5-10% for broilers.
Low protein diets contribute to a reduction in ammonia emissions from poultry houses. A 2% reduction in crude protein in the broiler ration results in a 24% reduction in ammonia emissions.
Water consumption of poultry decreases. When the protein level in broiler diet is decreased by 3%, there is an 8% reduction in water consumption.

Table 41.2. Content of total phosphorus and phytate-phosphorus in selected plant feedstuffs.

Feedstuff	Total P, %	Phytate-P, %
Maize	0.28	0.19
Wheat	0.33	0.22
Barley	0.37	0.22
Triticale	0.37	0.25
Rye	0.36	0.22
Sorghum	0.27	0.19
Wheat bran	1.16	0.97
Rice bran	1.71	1.10
Soybean meal	0.61	0.32
Peanut meal	0.68	0.32
Rapeseed meal	1.12	0.40
Sunflower meal	1.00	0.44
Peas	0.38	0.17

Table 41.3. Comparison of feed phosphates used in poultry diets.

Feed phosphate	Digestibility, %	Inclusion rate, %	Inclusion rate of P, g	Absorbed P, g	Excreted P, g
Defluorinated phosphate	59	1.56	28.0	16.5	11.5
Monocalcium phosphate	84	0.87	19.6	16.5	3.1

- Improvement of plant phosphorus digestibility by 20-30% in broilers, layers and turkeys
- A 0.1% reduction in total P in the feed through using phytase results in a reduction in phosphorus excretion of more than 20% for layers and broilers.

Highly Digestible Inorganic Feed Phosphates

In pig and poultry diets several inorganic phosphates with different chemical composition (different P content and digestibility) are used (EU Directive 96/25/EC; (EC, 2003)). The inclusion of highly digestible feed phosphates in animal feed will result in lower phosphorus levels in the feed and thus a reduction in nutrient excretion into the environment. Table 41.3 presents some comparative results for different inorganic feed phosphates used in poultry rations.

Inclusion of highly digestible inorganic feed phosphates in pig diets is also efficient.

Other Feed Additives

Other feed additives that are added in small amounts to the feed of poultry and pigs are (EC, 2003):

- Enzymes,
- Micro-organism cultures

As a result of using enzymes, the feed conversion rate of the pigs and poultry improves (less feed is needed to achieve the same rate of growth) and the amount of excreted nutrients is reduced. A 3% reduction in total nutrients excreted by pigs (as a general approximation) can be obtained; for poultry the corresponding reduction is approximately 5%.

Cattle Diets with Reduced Protein and Cattle Diet Balancing

The peculiarities of bovine digestive organs require the protein content of the diet on a dry matter basis to be significantly lower than that of monogastric animals and poultry. Due to diverse microbe populations in the forestomach, ruminants are able to consume large amounts of grass feeds rich in fibre. Inclusion of amino acids in the diet of cattle is not effective, as ruminal microbes are able to synthesise from dietary nitrogen those amino acids which are present in low concentrations in the rumen or not present at all. Consequently, the content of excreted nitrogen can be regulated mainly by balancing the diet protein content, nitrogen compounds available to ruminal microbes in synthesis (ruminally soluble and degradable protein), and energy (carbohydrates). Reducing the dietary crude protein content from 19% to 13% on a dry matter basis can reduce ammonia emissions from excreta three-fold (Frank et al., 2002; Swensson, 2003). Besides adjusting dietary protein content, excreted nitrogen losses can also be reduced by regulating the amounts of ruminally soluble, degradable and undegradable protein. Ammonia emissions from cattle excreta can be mostly reduced by decreasing the content of rumen-degradable protein (van Duinkerken et al., 2005; Reynal et al., 2005).

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