Protein efficiency and ammonia excretion in dairy cows

Besides energy and nutrients, sufficient nitrogen in ruminants or essential amino acids in non-ruminants are vital for high protein synthesis in animals.

N-excess is mainly excreted via the urine and contributes to inefficient N-use, higher feed costs, and environmental problems. Agriculture and livestock represent 90-95% and 50% of the ammonia emission (in the USA) respectively.

by Thierry Aubert, Ruminant Expert, Delacon France SAS. www.delacon.com

The protein efficiency is calculated based on the ratio between the nitrogen produced in milk and the nitrogen content in the diet. Dairy cows have a low protein efficiency of around 25% due to the specific rumen digestion.

However, this protein efficiency is improved by a best nitrogen balance and by a reduction of the diet protein level.

In ruminants, nitrogen utilisation is relatively inefficient, with 50-80% of the nitrogen consumed excreted as urea-N (mainly in urine) and other organic nitrogen components (mainly in faeces). Nitrogen losses come from losses in urine (from ammonia losses from the rumen and metabolism losses in the liver) and, secondly, from the undigestible protein (in faeces).

Consequences of nitrogen losses for the environment

Excreted nitrogen increases with the nitrogen intake of dairy cows. In Fig. 1, Castillo et al., have shown that faeces losses decreased linearly in relation to the protein intake:

- 0.40g nitrogen losses per g nitrogen intake for 200g nitrogen intake.
- 0.25g nitrogen losses per g nitrogen intake when dairy cows eat 750g/day of nitrogen.

In contrast, conversion of dietary nitrogen to urine nitrogen increased exponentially as nitrogen intake increased.

In parallel, this nitrogen excretion decreases with:

- The balance between protein requirements and protein in the diet.
- The balance between fermentable energy and degradable protein in the rumen.

Sauvant et al., (2015) have proposed a new approach to estimate urinary losses from the nitrogen balance in the rumen with the new system to predict the requirement in ruminants (INRA, SystAli) (Fig. 2).

Ammonia (N-NH_3) is volatilised after nitrogen excretion in manure under both confinement and grazing conditions. The ammonia production is, on average, 60g/head/day in dairy cows.

N-NH_3 is increased by the crude protein level in the diet, the feed intake, but decreases with milk production.

In addition, outdoor temperature and wind increase ammonia volatilisation due to the urease activity in manure.

Continued on page 10

Fig. 1. Nitrogen utilisation and losses in dairy cows in relation to protein intake (Castillo et al, 2000).

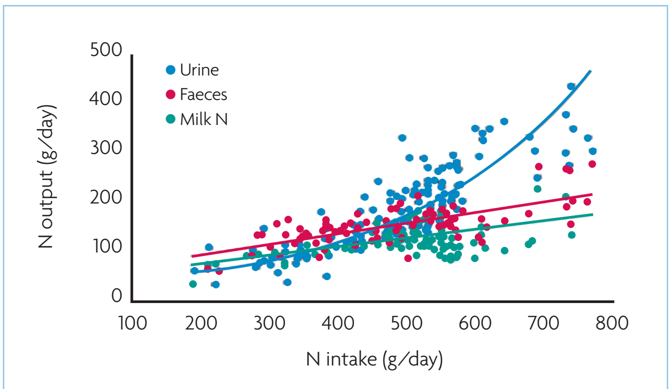
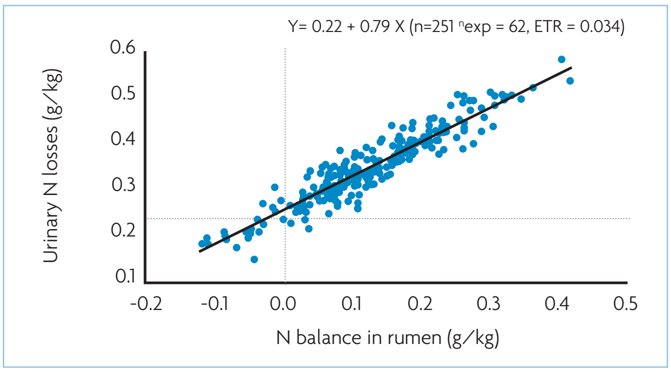


Fig. 2. Urinary nitrogen losses in relation to rumen balance between fermentable energy and degradable protein (adapted from Sauvant et al, 2015).



Continued from page 9

The manure handling system and housing type also have an impact on ammonia production. The nitrogen excreted in the urine is transformed by an enzyme activated in the manure (urease), which is capable of changing liquid ammonia into gas ammonia. This liquid ammonia spread on the soil will be transformed into nitrites (N_2O) and nitrates (NO_3).

This manure production can contribute to nitrate pollution if fertilisers are used. With a level of nitrates above 50mg/L (water norms) in rivers, this is often enough to promote eutrophication. This imbalance of nutrients in the water (excess of nitrates and phosphorus) will help the growth of algae and aquatic plants. When these plants die they use a high quantity of oxygen, with harmful consequences on the balance of the ecosystem.

An increase of greenhouse gases (CO_2, CH_4, N_2O) in the atmosphere leads to global warming. Increasing concentrations of nitrous oxide (N_2O) and methane (CH_4) are particularly dangerous as both have a much higher oxidation number and therefore contribute more to the greenhouse effect than carbon dioxide:

- Methane with a global warming potential 28 times higher than CO_2.
- N_2O with a global warming 310 times higher than CO_2.

Agriculture is responsible for 24% of the carbon footprint. In 2011, the FAO showed that agriculture produces the equivalent of 5.3 billion of Eq CO_2 T/year.

Around 39% comes from enteric fermentation (methane produced by the rumen fermentation), and 25% comes from nitrogen (NO_2).

In addition, nitrous oxide (N_2O) in the air contributes to air pollution (and can therefore cause lung disease), acidification of rain, and tree death in forests.

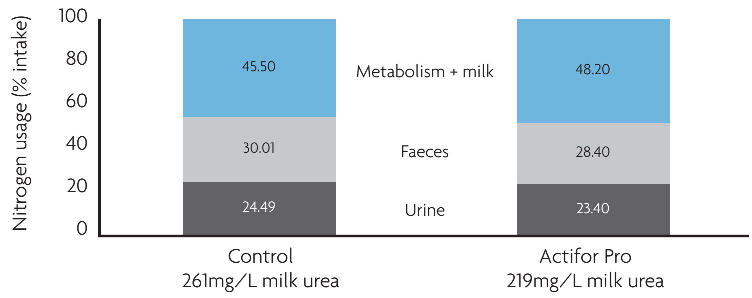


Fig. 3. Effect of Actifor Pro in nitrogen utilisation by dairy cows (Delacon in vivo trial, 2015).

How to reduce protein losses in the environment with PFAs

It is essential to consider diet management (rumen balance, requirement recovery) and roughage quality predictions to reduce protein losses. Additionally, the phytogenic feed additive (PFA) will help to reduce the protein losses to the environment.

The main targets of these PFAs are:

- A reduction of protein degradation in the rumen to bypass the rumen and reduce ammonia losses.
- Increased microbial protein efficiency with more fermentable organic matter available and a better balance of microbes in the rumen.
- Improved protein digestibility in the small intestine. In this case, faecal protein losses will be reduced.

In Fig. 3, Actifor Pro has reduced both protein losses in the urine and the faeces. It means that nitrogen has been used for milk production, maintenance, and growing.

The protein efficiency has been improved by 2.7%. The Actifor product line belongs to the range of phytogenic feed additives containing only natural substances that are carefully selected and tested for optimal effects on efficiency without leaving residues in the meat or milk.

By improving performance (up to 7-10% without matrix), reducing feed costs (up to 5-10% with matrix), and reducing emissions (for example NH_3, CH_4), they increase feed efficiency in a holistic, yet natural way.

A major challenge

Protein efficiency in ruminants is a major challenge for the environment and the farmer's margin. The crude protein content in the diet has decreased in Europe and the United States of America over the last 10 years. At the same time, milk production has increased.

This trend is essential for the environment and the reduction of feed costs. With the help of phytogenic feed additives, we can improve protein efficiency (more milk protein produced per kg of protein in the diet) and, consequently, ensure there are fewer residues in the environment. ■

References are available from the author on request