HOARD'S DAIRYMAN

NITROGEN EFFICIENCY is the ratio of nitrogen used in milk and meat to the amount consumed from the diet. It's affected by fed protein and energy levels.

Protein intake and nitrogen efficiency go hand in hand

Finding the right ration inclusion rates and types of protein can enable you to manage nitrogen efficiency.

by Fernando Diaz-Royon, D.V.M.

WHILE unique at converting fiber into protein, the rumen remains a low efficiency nitrogen converter when measuring the ratio of nitrogen found in milk and meat to nitrogen intake. In the rumen, this number is around 25 percent, with a wide range of variation between animals as shown in Table 1.

On average, ruminant efficiency is much lower than other animals in intensive systems such as poultry or swine. On these farms, the protein needs of the animals can be more closely met and efficiency may average 30 to 40 percent.

Using data from peer-reviewed papers, European researchers calculated the efficiency of nitrogen utilization of typical European Union (EU) diets based on grass or grass silage and United States diets based on corn silage. Within the EU diets, the authors found that feeding higher nitrogen efficiency diets (32 percent) resulted in cows with higher dry matter intake, more milk, and a lower proportion of forage in the ration compared to lower nitrogen efficiency diets (21 percent). In contrast, the U.S.-type diets with high nitrogen efficiencies (32.8 percent) resulted in cows that produced more milk on diets that had lower protein content and higher nonfiber carbohydrates.

Protein intake the biggest factor

A meta-analysis evaluated the effects of dietary protein intake on milk nitrogen efficiency using two large data sets based on North American and North European feeding trials. The average nitrogen efficiencies were 24.7 and 27.7 percent, respectively.

This analysis demonstrated that protein concentration of the diets is the most important dietary factor influencing nitrogen efficiency. The authors also indicated that upping milk yield would boost milk nitrogen efficiency, but the effect is considerably smaller than the effect of reducing protein intake.

Two studies conducted at the U.S. Dairy Forage Research Center in Prairie du Sac, Wis., confirmed these results. In the first study, the nitrogen efficiency dropped from 30.3 to 27.0 and 23.4 percent when the protein content of the diet climbed from 15.1 to 16.7 and 18.4 percent, respectively. In another study, milk nitrogen efficiency declined from 36.5 percent (at 13.5 percent protein) to 25.4 percent (at 19.4 percent protein).

Despite the fact that these studies show a linear reduction in nitrogen efficiency as dietary protein concentration goes up, dairy producers continue to feed high protein diets to maximize performance.

Survey says

Results from a survey conducted on 454 dairy farms located in the Chesapeake Bay Drainage Basin showed the average efficiency of feed nitrogen utilization for milk production was 28.4 percent. On average, farmers fed 6.6 percent more nitrogen than recommended by the National Research Council. In a survey of management practices conducted on 103 large U.S. commercial dairies, the average percentage of crude protein in nonpregnant cow diets was 17.8 percent on a dry matter basis. Similarly, the protein content average in eight commercial dairies located in south central Idaho and 45 commercial Ontario dairy herds were 17.6 and 17.5 percent, respectively.

Table 1. Nitrogen efficiency by cattle type

	Percent
Male beef cattle less than 1 year	30.7
Lactating cows	23.3
Male beef cattle more than 1 year	15.7
Dairy heifer less than 1 year	14.0
Dairy heifer more than 1 year	6.4

Table 2. Nitrogen losses in dairy cattle

	Percent
Rumen microbial nucleic acids	31.9
Endogenous secretions	22.0
Undigested microbial protein	14.1
Milk protein synthesis	13.8
Inefficient rumen microbial protein synthesis	13.3
Maintenance	4.9

Maximizing nitrogen efficiency

As these research studies and surveys demonstrate, diets containing 16.5 percent crude protein support maximum production in dairy cows with minimal nitrogen excretion to the environment compared with diets with higher protein content.

The theoretical upper limit of milk nitrogen efficiency was reported at the 2013 International Symposium on Energy and Protein Metabolism and Nutrition. This glass ceiling was set at 43 percent nitrogen efficiency for a cow weighing 1,430 pounds and producing 88 pounds of fat and protein corrected milk. The theoretical basis assumed 53 pounds of dry matter intake and a true crude protein of 3.15 percent. The estimated minimal nitrogen losses in feces and urine were 89 and 174 grams per day, respectively. The main areas where nitrogen losses in dairy cattle occur are shown in Table 2.

The scientists concluded that strategies to reduce nitrogen losses should focus on providing an optimal supply of rumen degradable protein and optimal efficiency of absorbed amino acids utilization for milk protein synthesis.

Making theory a reality

Researchers from Virginia Tech demonstrated that postabsorptive nitrogen efficiency improves when energy content of the diets goes up. They evaluated mid-lactation cow diets with two energy densities (0.70 versus 0.65 megacalories of net energy for lactation per pound of dry matter) and two protein concentrations. Elevating energy concentration improved postabsorptive nitrogen efficiency from 31.0 to 37.1 percent and from 38.5 to 43 percent in high- (19 percent) and low-protein diets (15 percent), respectively. Likewise, cows fed low-protein diets had greater nitrogen efficiency compared to cows fed high-protein diets. The efficiency of nitrogen utilization was maximized when feeding a combination of high energy and low protein in the diet.

Charles Schwab from the University of New Hampshire and his colleagues suggested several strategies to improve the conversion of feed nitrogen into milk protein:

1. Feed for greater microbial synthesis in the rumen, which enhances the opportunity to capture recycled nitrogen and the end products of protein breakdown in the rumen.

2. Fine-tune and balance diets more precisely for essential amino acids.

3. Fine-tune and balance the supply of rumen degradable protein (RDP) and rumen undegradable protein (RUP) such that the requirements of both are met but not exceeded. In this case, neither portion of dietary protein is overfed and intake of nitrogen is minimized.

Protein supplements that are rich in digestible rumen-undegraded feed protein and used commonly in high-producing dairy cow diets include treated soybean meal products. One option is the heat generating expeller process that produces 61.2 percent digestible rumen-undegraded protein as dry matter basis. Another option is treatment of soybean meal with lignosulfonate that results in 64.5 percent digestible RUP. A final soybean meal treatment is the use of heat and soyhulls providing 62.2 percent digestible RUP.

Other nonsoy inclusion options are blood meal at 54.3 percent digestible RUP and corn gluten meal at 44.6 percent.

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