United States Department of Agriculture

U.S. Dairy Forage Research Center

Using MUN to reduce nitrogen emissions from dairy farms

The old adage that you can't manage what you can't measure is especially true when it comes to managing nutrients on a dairy farm. Recent research has shown that milk urea nitrogen (MUN), commonly used to monitor feed nitrogen efficiency, also can be used to help reduce nitrogen emissions from dairy farms.

Dairy producers need to manage nitrogen for two main reasons: profitability and pollution abatement. As nitrogen use efficiency improves (cows using more of their feed protein to make milk, not manure), profitability usually improves. At the same time, there's a reduction in the amount of nitrogen excreted in manure and lost to the environment. These are desirable outcomes.

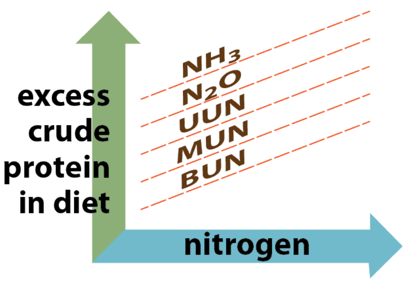

Figure 1: As crude protein in the diet becomes excessive, nitrogen in the cow's blood, milk and urine (BUN, MUN, UUN) increases proportionately. And the UUN in urine is proportionately transformed to ammonia and nitrous oxide. Therefore, an easily obtained measure of nitrogen use by the cow (MUN) can be used to estimate nitrogen emissions.

But cows utilize only 25% to 35% of the protein nitrogen that they consume; the unused nitrogen is excreted in urine and feces, mostly as urine urea nitrogen (UUN). Once it leaves the cow, UUN is transformed into different compounds, including ammonia (NH_3) and nitrous oxide (N_2O), the most potent greenhouse gas from agriculture. These nitrogen emissions are not desirable outcomes.

Researchers at the U.S. Dairy Forage Research Center (USDFRC) have studied the fate of nitrogen on dairy farms from many angles – the protein in the forage plant itself, the protein nutrition requirement of dairy cows, how rumen microorganisms digest feed, changes in manure chemistry with varying diets, manure management in the barn and field, and measurements of nitrogen in the environment.

They have been especially interested in the relationships between protein nitrogen in the diet, nitrogen excretion by dairy cows, and the fate of that nitrogen on the farm and in the environment. USDFRC and other researchers have found that there are very predictable relationships between feed nitrogen inputs and outputs – such that MUN can be used to measure not only feed nitrogen transformation into milk but also a farm's success at reducing the amount of nitrogen being lost to the environment (Figure 1).

As shown in Figure 2, crude protein in feeds meets three different fates when it enters the rumen. Some is digested by rumen microbes which produce more microbes; when these microbes pass out of the rumen, they're digested and absorbed as an excellent source of protein which the cow uses to make milk, maintain her body, and produce a calf. Some of the crude protein 'escapes' the rumen and is used directly by the cow for the same purposes.

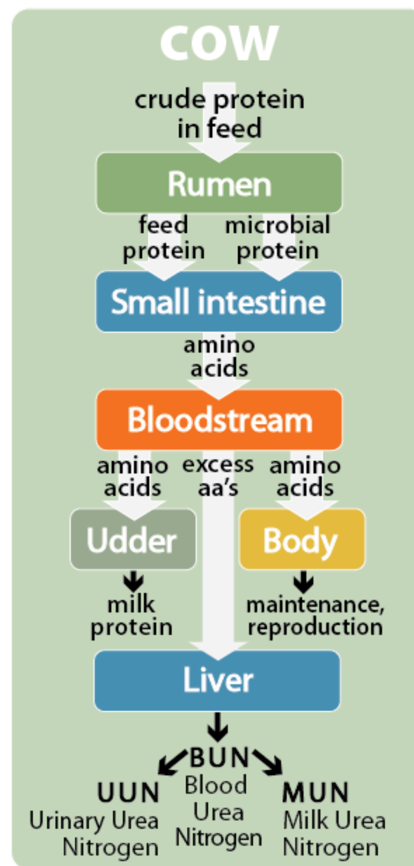

Figure 2: Crude protein in feed, which contains 16% nitrogen, is broken down in the rumen and small intestine. Excess protein nitrogen is converted to blood urea nitrogen (BUN) in the liver; this equilibrates rapidly throughout the body fluids, including milk (MUN) and urine (UUN). This equilibrium is why MUN can be used to accurately predict UUN (and subsequent nitrogen emissions).

Excess protein (not used by the microbes or directly by the cow), after being digested and absorbed from the small intestine, travels to the liver where it is converted to blood urea nitrogen (BUN). Urea equilibrates rapidly throughout body fluids, including milk and urine, so concentrations of MUN and urinary urea nitrogen (UUN) reflect those of BUN. Since milk samples are easier to obtain than blood or urine, MUN became the industry standard for measuring feed nitrogen use efficiency. MUN levels of ≤ 12 (mg/dL, where 100mg/dL equals 0.10% weight/volume) reflect adequate dietary nitrogen for high-yielding dairy cows.

The most recently completed MUN study was designed to evaluate the relationships between dietary crude protein, the secretion of urea in milk (MUN) and urine (UUN), and nitrogen emissions from dairy production systems. MUN data from Wisconsin dairy herds was gathered by randomly extracting 37,889 test-day records from a 2-year period and 197 herds.

Data from five nutrition trials with lactating cows in Wisconsin also was gathered; this data consisted of 18 dietary treatments comprised mostly of alfalfa silage, corn silage, corn grain, protein supplements and other minor ingredients fed as total mixed rations to 203 mid-lactation cows. This data was entered into the Integrated Farm System Model (IFSM) and then analyzed. Results are summarized here:

Looking at rations . . .

1. About half of Wisconsin's lactating dairy cows are likely fed dietary crude protein in excess of requirements (Table 1). This is more apt to happen on farms feeding the same ration to all cows and/or farms with more variability in feed quality and management.

2. Highly significant positive relationships were determined between dietary nitrogen, MUN, UUN excretion and state-wide nitrogen emissions. This implies that an expanded use of MUN as a nitrogen management tool may not only enhance dietary nitrogen use efficiency and reduce milk production costs, but also reduce the negative impacts of nitrogen emissions.

MUN	% cows	Implications
> 16	14	Excessive dietary nitrogen
15-16	16	
13-14	23	
10-12	28	Adequate dietary nitrogen
< 10	19	Possibly inadequate dietary N

Table 1: Percent of cows at different levels of MUN; MUN levels of 10-12 reflect adequate dietary nitrogen for high-yielding cows.

3. Within the range of 16 to 10 mg/dL, each MUN reduction of 1 mg/dL leads to a UUN excretion decrease of 16.6 g/cow/day which in turn results in ammonia and nitrous oxide reductions of about 7% to 12%.

Differences in manure management . . .

4. Simulation of five farm systems at the state-wide average MUN of 12.5 revealed that lowest nitrogen emissions (52% of UUN) were from pasture-based dairy farms (due to UUN conservation via direct deposition of urine in the pasture). The greatest nitrogen emissions (80 to 89% of UUN) were from farms with tie-stall barns and daily hauling of manure (due to late or no field incorporation of manure).

5. Ammonia emissions from farms with free-stall barns were greatest during land application of manure (42 to 50% of UUN) or directly from barns (30 to 35% of UUN). High ammonia losses from free-stall barns are due to greater surface exposure of urine and continuous mixing of feces and urine by animals and scrapers during manure removal.

6. For nitrous oxide, the highest emissions occurred from slurry manure and pasture-based systems, followed by the systems that used daily hauling or lagoon storage.

J. Mark Powell, lead scientist, believes that if the dairy industry developed MUN as a multi-purpose nitrogen management tool, it would offer a relatively straightforward and practical way to move the industry in a positive direction toward reductions in feed costs and abatement of ammonia and nitrous oxide emissions. ❑

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