Are we feeding our cows too much protein?

by Glen Broderick, Jesus Olmos, and Leah Nell Adams

YOU may have seen several articles in recent issues about feeding too much phosphorus (P). But what about nitrogen (N)?

If you overfeed N, you reduce margins because of the relatively high cost of protein supplements. Plus, more and more of the N pollution of the environment is being attributed to livestock operations.

Overfeeding N in the form of crude protein (CP) will result in excessive output of urinary N, the most unstable form excreted. Farmers in Wisconsin typically feed diets with around 17 to 19 percent CP. At the Dairy Forage Research Center, Madison, Wis., we wanted to find out if there was a "best" level of CP, beyond which further additions would not benefit production. We also were concerned with overall N efficiency. How much N ends up in milk protein?

How protein is analyzed . . .

The way CP is analyzed in feeds has not changed in nearly 120 years. We measure total N and multiply by 6.25 because true proteins typically contain about 16 percent N. Of course, it is not CP but the amino acids in CP that are the building blocks of true proteins that are actually made by the cow.

You are well aware that dietary CP provides amino acid building blocks as both rumen-degraded protein that gets converted to microbial protein and rumen-undegraded protein ("bypass protein") that escapes the rumen and gets digested directly. High-energy feeds actually serve as supplements of amino acids — provided there is adequate rumen degraded protein — by stimulating microbial protein formation.

What we did . . .

We tested the effects of different dietary CP levels. We simply replaced high-moisture corn with solvent-extracted soybean meal (SBM) in two separate feeding trials conducted at our research farm at Prairie du Sac, Wis. Cows switched diets four times — every four weeks for 16 weeks — and ate four different diets during both trials. We only used the production data from the last two weeks of every four-week period.

The first study was conducted using nine diets . . . three CP levels at each of three energy levels. Replacing high-moisture corn with SBM gave diets averaging 15.1, 16.7, and 18.4 percent CP at each energy level. We varied energy levels by replacing alfalfa and corn silage with high-moisture corn to provide diets with 75, 63, and 50 percent forage dry matter. These averaged 36, 32, and 28 percent neutral detergent fiber at each CP level. Because the fiber in forages is much less digestible than the starch from corn and other concentrates, lower levels of neutral detergent fiber are a good indicator of higher energy. At this stage of our work, we did not formulate the diets for optimal bypass protein.

What protein level is needed?

We found a level of crude protein beyond which there is no production benefit, regardless of the level of dietary energy. (See bar chart.) Milk yield rose when SBM supplementation pushed CP from 15.1 to 16.7 percent, but there was no further gain switching from 16.7 to 18.4 percent. Protein and SNF yields had nearly identical patterns, going up when CP rose from 15.1 to 16.7 percent but showing no gain from 16.7 to 18.4 percent.

We found that there was a benefit to higher dietary energy level. With each higher energy level there was higher milk, protein, and SNF yields and improved feed and N efficiency. Higher energy levels also reduced milk urea nitrogen (MUN) and urinary N. So, the best production in this trial occurred with the highest energy and moderate (16.7 percent) CP.

While production benefits leveled off at 16.7 percent CP, we wondered about the environmental damage of more N excretion. As levels of CP rose, we found that urinary N, a highly unstable form of N, went up more and more. We noticed a number of other interesting effects including elevated milk MUN and poorer N efficiency which we explored further in a second trial.

We had found that 16.7 percent CP was sufficient, even for diets that were not optimized for bypass protein. This was surprising and suggested that we generally might well be feeding too much CP.

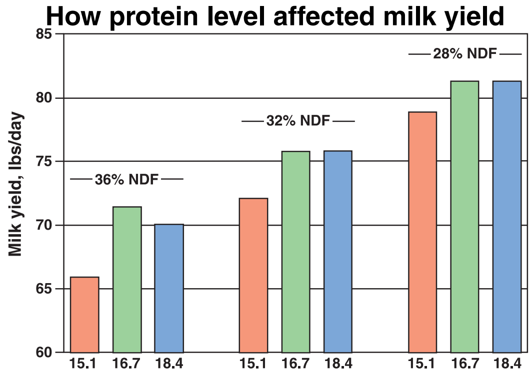
So, to better estimate CP levels, we followed up with a second trial that tested five CP levels. We used a diet with a single energy level containing 25 percent dry matter from both alfalfa silage and corn silage. Again, we replaced high-moisture corn with SBM to raise CP but this time in steps of approximately 1.5 percentage units from 13.5 to 19.4 percent CP. In this trial, 40 cows (eight groups of five) each were fed four of the five diets over four, four-week periods. That way, each diet was fed to 32 different cows.

As in the first study, milk and protein yield peaked at 16.5 percent CP. (See Table 1). Milk fat production also peaked at 16.5 percent CP. Because of the nature of the response to dietary CP, it was possible to use mathematics to find "the top of the hill" — the point at which both milk and protein yield reached maximums (the response of milk fat to CP did not allow us to make a comparable estimate). Doing the math indicated that there would be no further gain in milk at more than 16.7 percent CP and no further boost in protein at more than 17.1 percent CP on this basal diet. Indeed, production actually was falling off at the higher CP.

In a number of experiments, we have seen that high MUN levels are a strong indicator that dietary CP is being wasted. However, it is important that MUN be measured accurately.

Each MUN value in Table 2 is the average from 128 different milk samples collected over the trial. High concentrations of rumen ammonia are related to excessive amounts of rumen-degraded protein in the diet. Table 2 shows a strong relationship between rumen ammonia and MUN because high MUN partly reflects wastage of dietary CP due to excessive protein degradation.

How protein level affected milk yield



ENERGY WAS VARIED by changing alfalfa and corn silage levels to give diets containing 36, 32 and 28 percent neutral detergent fiber (NDF).

However, feeding wide ranges of CP makes little difference to excretion of fecal N, the form that is most stable. Statistically, it was influenced by the diets, but there were no differences in fecal N excretion between the lowest CP diet and the three highest CP diets. This has been found in a number of experiments.

Nitrogen ends up in urine . . .

Nearly all of the N in the extra dietary CP that was not captured as milk protein ended up in the urine, the form that causes the most problems in the environment. Urinary N more than doubled when CP went from 13.5 to 19.4 percent.

Over this same range of dietary CP, apparent N efficiency fell (Table 2). Nitrogen efficiency is important because it indicates how much of the N from the diet actually ends up in milk protein.

Even though N efficiency is at its highest around 13.5 percent CP, production is best at 16.5 percent CP. Beyond 16.5 percent CP, there is neither a production gain nor efficiency advantage. The key is to find the balance where you get the most efficient production for your feeds.

We want to emphasize again that the CP was raised in the diets fed in both trials only by replacing high-moisture corn with solvent-extracted soybean meal, a relatively low bypass protein. We speculate that the optimal level of dietary CP in these trials might have been even lower had we used the NRC rationing system to balance for protein degradability. However, we made no effort to use the 2001 NRC system or any other approach to optimize the diets for bypass protein. Most of these rations clearly contained excessive rumen degraded protein. Currently, we are investigating whether the CP optimum can, in fact, be lowered by this approach.

To summarize, we found in two feeding trials that optimal production of milk and protein was obtained when dairy cows were fed about 16.5 percent CP in diets formulated from alfalfa plus corn silage, high-moisture corn, and solvent-extracted soybean meal. Adding greater amounts of CP to the diet (by replacing high-moisture corn with SBM) did not improve production, or may have slightly reduced milk yield, but greatly raised N excretion. There was little change in fecal N over a wide range of dietary CP levels. Nearly all of the extra N in the diet was excreted in the form of environmentally unstable urinary N.

Table 1. Effect of dietary crude protein on production

	Dietary CP, % of DM				
	13.5	15.0	16.5	17.9	19.4
			(lbs./day)		
Dry matter intake	47.6	48.1	49.6	47.6	47.8
Milk yield	80.0	82.0	84.5	80.7	81.5
Fat yield	2.51	2.65	2.74	2.71	2.74
Protein yield	2.43	2.54	2.61	2.49	2.54

Table 2. Effect of dietary crude protein on N utilization

	Dietary CP, % of DM				
	13.5	15.0	16.5	17.9	19.4
Milk urea N, mg/dl	7.7	8.5	11.2	13.0	15.6
Rumen ammonia-N, mg/dl	12.2	15.4	18.3	25.4	25.6
Fecal N, g/day	190	173	191	188	199
Urinary N, g/day	111	141	180	213	255
Apparent N-efficiency, %	37	34	31	28	26

The authors are research scientist at the U.S. Dairy Forage Research Center (Agricultural Research Service, USDA), graduate student, and outreach specialist with the University of Wisconsin-Madison's Nutrient and Pest Management Program, respectively.