The cud chewing index and rumen taps today show that your fresh cows are not currently acidotic, but the group 1 cows tend towards moderate rumen acidosis. The hay that you hate to feed has helped the fresh cows and should be fed to all milking groups. Fortunately, you have enough forage inventory to easily feed the required higher forage diets.

Your dry cows and bred heifers are too fat on the average, and should not be fed the 5 pounds of grain mix that they are getting. This is costing you money and probably adding to the current fresh cow problems.

The $66,000 in excess grain purchases for 1995 probably cost you twice to three times that much in reduced production and cow health problems. If you had not spent that money, you could have lost 5.2 pounds of milk per cow per day every day of the year, and you would have broken even. This should help remind you to not feed extra grain to "push the cows."

This will be a very difficult 6-18 months, but you can make this recovery successfully, IF you dedicate yourselves to the task of intensified nutrition management and health and performance monitoring. Other herds have done it, you can too."

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Practical Application of MUN Analyses

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Definition and Origin

Urea is the detoxified form of protein waste in the mammalian body. In the ruminant, excess rumen ammonia is absorbed from the rumen through the rumen wall to the blood stream. It is carried to the liver and is converted into urea by the liver. Urea can be recycled through the blood stream back to the rumen.

The protein waste, ammonia, originates either from the diet or from normal tissue breakdown throughout the cow's body. The high producing milking cow has most of this urea originate from un-used dietary protein. Ropstad, *et.al.*[21] nicely showed the relationship between dietary protein, rumen ammonia, and milk urea in 21 adult and 7 first lactation Norwegian Red cows (Figures 1 and 2). The excess protein can be from any of the protein fractions. We tend to think only of soluble protein, but it can also originate from insoluble degradable, or undegradable protein.[6]

Urea is extremely water soluble and is carried by the blood into all tissues, including the lungs, kidney, rumen, small intestine, uterus and the mammary gland.

Blood and *plasma* and *serum* urea nitrogen (BUN, PUN, SUN) are synonyms for urea levels taken from blood samples. *Milk* urea nitrogen (MUN) measures the level of urea in milk. Until recently, it was believed that milk urea nitrogen levels were about 85-90% of blood urea nitrogen. Very recent work done at the University of Pennsylvania[1] (Figure 3) and Cornell University has demonstrated that milk urea nitrogen is nearly equal to blood urea nitrogen; MUN/BUN = .96-.98. The apparent difference in prior studies was due to improper sample preparation, with milk fat and/or milk

protein interfering with the correct determination of milk urea level.

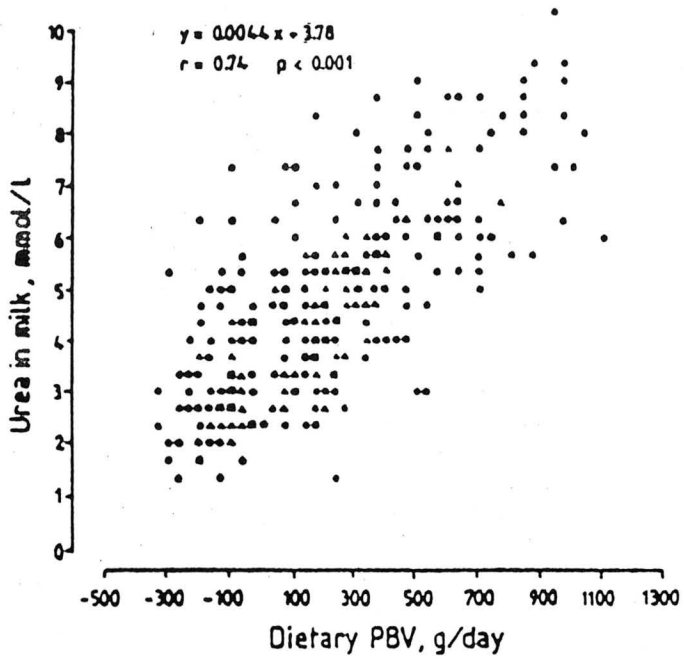

Figure 1: Relationship between total dietary protein and the levels of urea in milk. Twenty-eight cows were studied during the first 3 months of lactation. Once-weekly observations are included. • = 1 observation, ▲ = 2 observations, ■ = 3 or more observations. E. Ropstad *et al.*

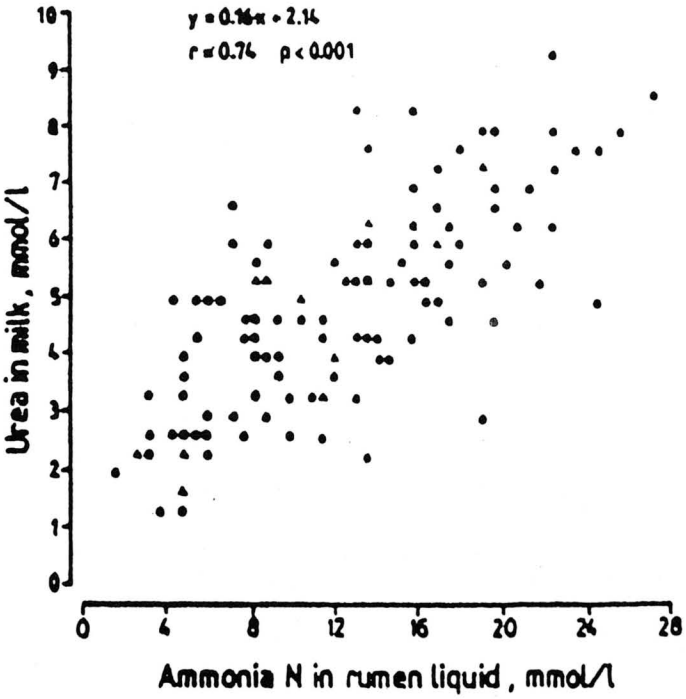

Figure 2: Relationship between levels of ammonia in rumen liquid and urea in milk. Twenty-eight cows were studied during the first 3 months of lactation. Samples of rumen liquid were collected every second week. • = 1 observation, ▲ = 2 observations, ■ = 3 or more observations.

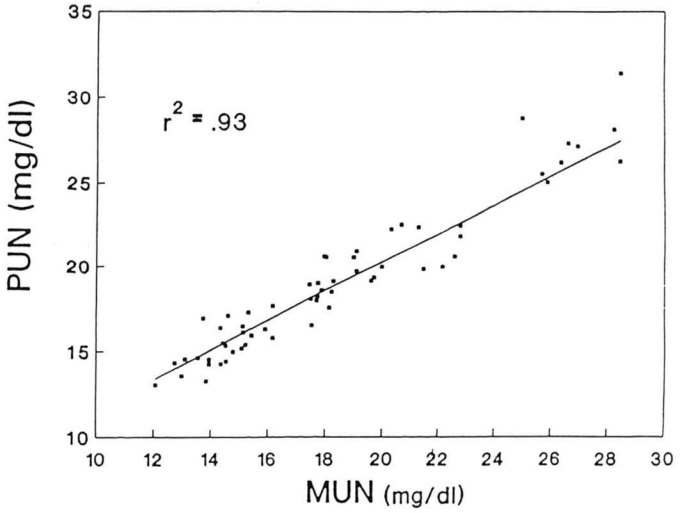

Figure 3: Relationship of milk urea nitrogen (MUN) to plasma urea nitrogen (PUN). Parentheses contain values for standard error of coefficients. PUN = 3.20 mg/dl (.63) + .85 mg/dl (.03) MUN. *Journal of Dairy Science* Vol. 78, No. 11, 1995.

It is believed today that urea diffuses into and out of the mammary gland, and that urea in milk will equilibrate with blood in a short time span. Gustafsson and Palmquist[11] showed that serum urea peaked 1.5-2.0 hrs after rumen ammonia peaked in cows fed once daily. Milk urea changes lagged behind serum urea changes by 1.0-2.0 hrs (Figure 4). When urea in serum was increasing, milk urea lagged and was lower; when serum urea was decreasing, milk urea lagged and was higher.

How do we measure MUN ?

Because cow's milk is more easily obtained than blood, milk seems like an extremely useful fluid for analyzing nitrogenous waste in the cow's system. Scandinavian work in this area has been going on since 1983.[10,11,16,18,19,20,21] Two hand chemistry methods using colorimetry are available for measuring milk urea nitrogen. One is the Sigma kit available from Sigma Diagnostics (Sigma Chemical Company St, Louis, MO 63178), the other one is the Dupont A.C.A. kit. The Technicon Autoanalyzer (Bran & Luebbe, Buffalo Grove, IL 60089) is an automated colorimetric method. Some veterinarians that have modified their in-house blood chemistry machines to do milk urea nitrogens.

Milk samples collected for solids and somatic cell determination on test day can be used for MUN determination. Automated infrared instrumentation is now available that will measure butterfat, protein, somatic cell counts, but also MUNs, citric acid, total solids and lactose; all with one pass of the milk sample through the machine. Two machines have this capability today: Foss Electric's Foss 4000 (Foss Food Technology, Eden

Prairie, MN 55344) and Perstorp Analytical's FIA Star (Perstorp Analytical-Tecator, Silver Spring, MD 20904).

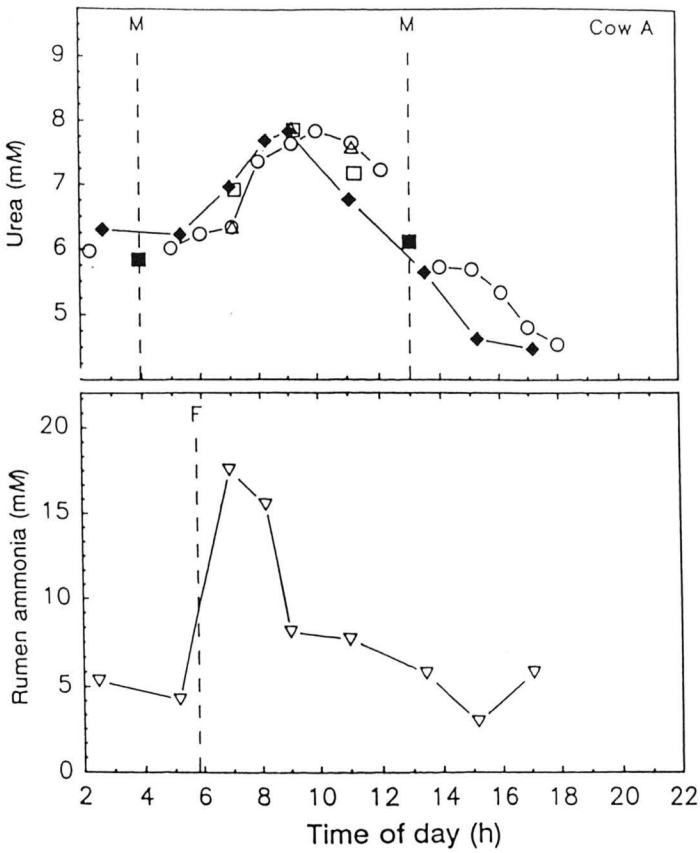

Figure 4: Serum (◆) and milk urea concentrations and rumen ammonia over time of day in cow A. Small (10 ml) milk samples were taken from left (△) and right (○) front quarters; all milk was milked out in left rear (□). Regular milking (M,■) and feeding (F) are indicated.

Calibration and Maintenance of the Foss 4000

Initial and ongoing validation of the Foss 4000 infrared machine at Northeast Dairy Herd Improvement Association (NEDHIA) is done with the Sigma wet chemistry method. Correlation for June 1995 of the NEDHIA Foss 4000 MUNs with the Sigma MUNs is shown in Figure 5. This infrared technology, like its forage analyzing counterparts, is only as good as the reference tables that are used to calibrate and maintain the analyzer's accuracy.

Sampling and Sample Handling

The Milk Sample

NEDHIA recommends that the milk samples represent the whole milking, not just foremilk or post-milking strippings. Therefore, milk samples should be taken only from a milk meter sampler or from milk that has been caught in a bucket. The Foss 4000 has been calibrated to read MUN in "normal milk", and cannot be expected to give accurate readings in milk with abnormal fat, protein or SCC content.

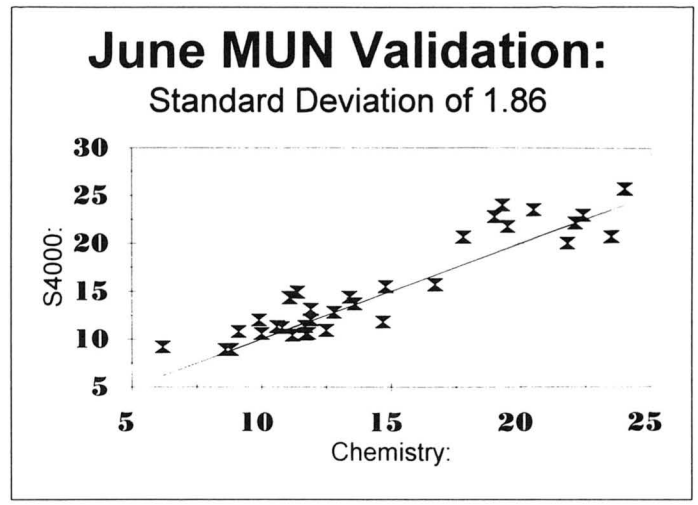

Figure 5: Northeast Dairy Herd Improvement Association correlation between Foss 4000 infra-red analyzer MUN values and Sigma Kit wet chemistry results for June 1995.

Samples must be treated with 1 Microtab® preservative tablet (10 mg bronopol and .45 mg natamycin, D & F Control System, Inc. San Ramon, CA 94583) per sample, and agitated several times during the first few hours after taking the sample. Refrigeration is necessary, but freezing is not allowed. If taken correctly and stored at proper temperatures, samples appear to yield accurate MUN readings for 7-10 days. Without proper sampling and storage, MUN values deteriorate at a rate of 50% every two days.[16]

How many samples?

Bulk Tank Samples

Bulk tank samples can be used for gross diagnoses of protein nutrition mismanagement, however group samples, at least, or individual cow samples at best will give us the clearest, most detailed picture for fine tuning rations for high producing cows. Tank samples have been observed to differ from the mean of all cows by as much as 3.0-4.5 mg/dl. Refsdal[19] found a correlation of .77 ($p<.01$) for bulk tank MUNs and herd mean MUNs. If the tank sample shows MUN of 24 mg/dl, most of us would conclude that there is indeed a nutrition management problem. If the tank sample is 16 mg/dl MUN, does the herd have nutrition management opportunities or not? Do we want to fine-tune nutrition management or only do gross tuning?

The situation with MUNs and volume of milk from various cows appears to be the same as the tank SCC and individual cow samples. A milk-weighted MUN aver-

age would probably be closer to the tank sample. However, this still leaves the possibility of missing a problem in one group of cows because the rest of the cows in the herd drop the average to "acceptable levels". It makes sense that since we feed different rations to different groups, we should at least have MUNs by groups.

Group Milk Samples

Individual dairy clients have sampled group milk for follow-up MUN analysis prior to the next DHI test day. If a severe problem exists, you and your client may not wish to wait until the next test day for follow-up samples. Group sampling is accomplished by sampling the tank after a specific group is milked into an empty tank. This method is easier if the dairy has two bulk tanks. If not, we obtain only one group's sample after each milk pick-up.

Individual Samples - All Cows

The easiest method of sampling a herd for MUNs is on DHI test day in the Northeast. No special handling or labor is required, and sampling of all cows costs the least per sample. Sampling of all cows presents the opportunity of looking at the MUN results by group, by DIM, by lactation, by milk production, or the whole herd.

The large variation in MUN may cause some to question the validity of MUN interpretation. Indeed, MUN levels are measures which include biological variability, just like % milk fat and % milk protein. Scattergraphs, demonstrating the variation in a 300 cow dairy versus DIM for fat %, protein %, and MUNs are shown in Figures 6,7,8.

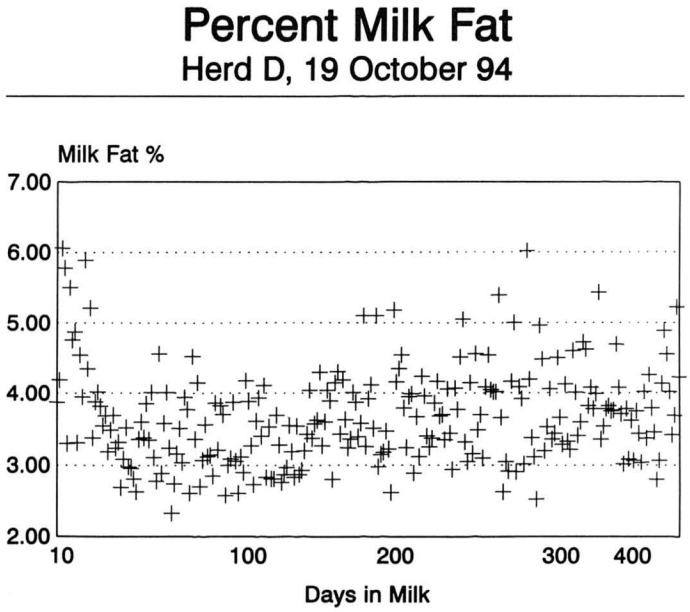

Figure 6: Distribution of percent milk fat for Herd D from October 1994 DHI test day results.

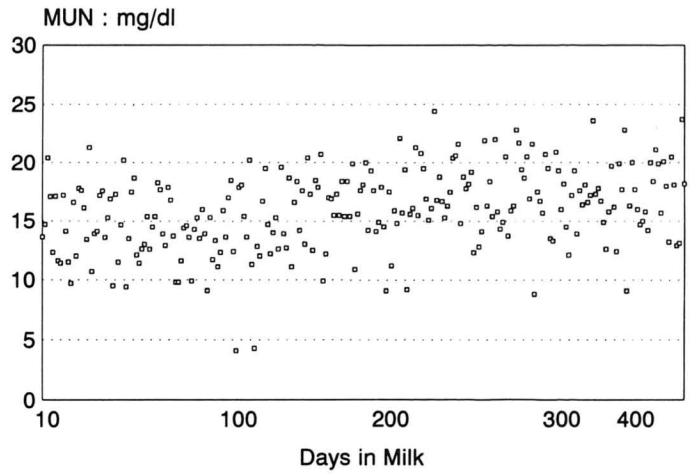

Figure 7: Distribution of percent milk protein for Herd D from October DHI test day results.

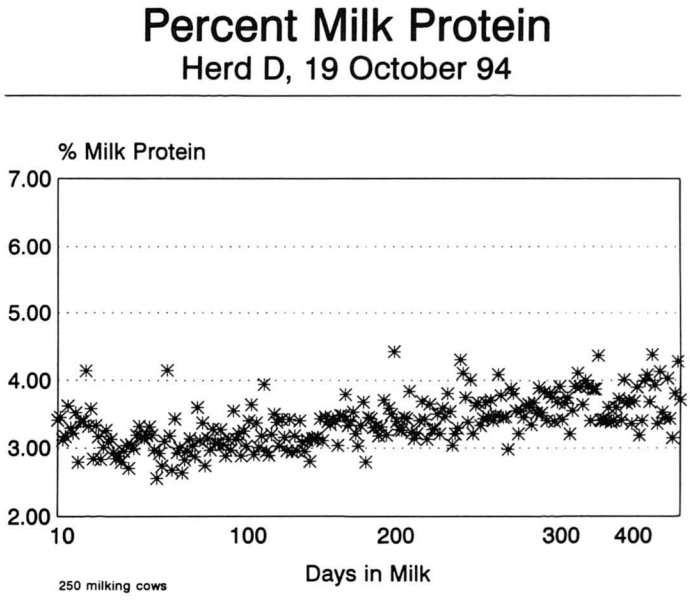

Figure 8: Distribution of milk urea nitrogen for Herd D from October DHI test day results.

If we assume a normal distribution of MUNs in an example herd with 100 cows milking (Figure 9), a standard deviation within herd of 4 mg/dl, and a mean MUN of 14, we expect that 2/3 of the MUNs will fall between 10 and 18. One sixth of the samples will be over 18 and one sixth will be under 10. Therefore, 95% of the samples will fall between 6 and 22 mg/dl.

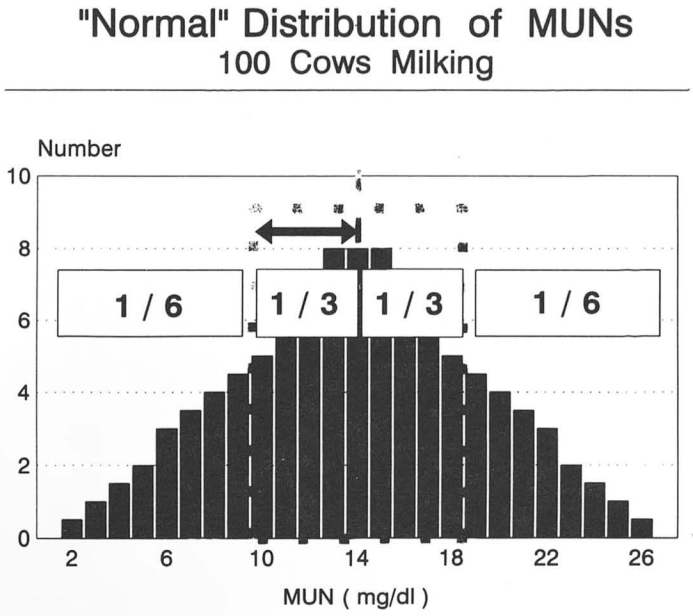

Figure 9: Hypothetical distribution of MUNs in a 100 cow herd based on field experiences during 1994-1995. 67% of samples will be between 10 and 18 mg/dl. 16% of samples will be over 18 mg/dl or under 10 mg/dl.

Statistics help us understand the magnitude of change necessary for us to be confident that the change is not due to chance alone. In general, with typical MUN means and population standard deviations, the change in herd mean MUN for 100-300 cow dairies needs to be >2.5 mg/dl. Herds of less than 50 cows milking need to have MUN means change >2.5 mg/dl before we are sure that the change in means was not due to chance alone. Table 1 shows how the confidence intervals vary as dictated by sample numbers, with typical MUN results.

Table 1. Typical Population Statistics for Herd MUN Determinations.

Number Cows Milking	MUN mean	Standard Deviation [A]	Standard Error [B]	95% Confidence Interval of mean [C]
50	13	4.0	.57	11.86-14.14
100	13	4.0	.40	12.20-13.80
150	13	4.0	.33	12.34-13.66
200	13	4.0	.28	12.44-13.56
250	13	4.0	.25	12.50-13.50
300	13	4.0	.23	12.54-13.4

A: Standard deviation of population
B: Standard Error = standard deviation / square root of n
C: 95% Confidence interval = mean +/- 2*SE

Consider the example of a dairy with 100 cows milking. Last month's mean MUN was 16.5, standard deviation (SD) of 4.0, standard error (SE) of .40 mg/dl. This month's mean MUN was 14.0, SD=4.0, and SE=.40. Calculation of the 95% confidence intervals for each test yield the following. Last month's MUN mean is expected statistically to lie between 15.7 and 17.3 mg/dl 95% of the time. This month's mean MUN is expected to lie between 13.2 and 14.8. Since the 95% confidence intervals do not overlap, this month's mean is statistically significant at the 95% confidence level.

Individual Samples - Selected Cows

If one does not have access to total herd sampling of individual cows, I suggest sampling 10-15 cows per feeding group, to assure a reliable mean MUN for a group of cows. While this method saves on MUN analysis costs, the cost per sample is considerably higher. Costs include selection of cows, metering or collecting total milk produced for one milking for each selected cow, sampling of milk, sample bottle preparation, package delivery costs, and the MUN analysis cost.

I consider testing all cows on test day the best approach, followed by composite group milk sampling for follow-up, to be the most cost-effective strategy.

How High is High, How Low is Low For MUN'S ?

In March 1994, NEDHIA began investigating the operation and reliability of a Foss 4000 infrared machine that does MUN determinations. The following observations and recommendations are results of my involvement with this field research project and are from MUN observations in approximately sixteen herds over twenty-four months time. Many milk samples have been measured for MUN content at NEDHIA, with 37,000 samples being run during the first 45 days of 1995.

The observed range in mean MUN samples on a group basis has been from 7 to 24 mg/deciliter of milk. The suggested acceptable range for MUN's on a cow group basis are from 12 to 16 mg/deciliter. I personally get quite concerned when we are approaching 16, especially if we have 20% or more of the cows above 18 mg/deciliter. Field experience has shown that cow production performance has not improved when protein has been added to well balanced rations with mean MUNs of 10-14 mg/dl.

Research has demonstrated that conception rate decreases at an MUN level above approximately 18-19 mg/deciliter. In 1993, Elrod and Butler[6] showed conception differences in virgin heifers with different PUN levels. Figure 10 depicts the decrease in conception from 87.5% at PUN<10.0 to 42.8% when PUN averaged over 16. Ferguson *et.al.* [9] demonstrated differences in conception with changes in SUN in nine herds and 627 AI breedings (Figure 11). Conception decreased from 54.5% for SUN<10.0 to 30.4% for SUN>25 mg/dl. Cows with SUN>25 mg/dl were 2.7 times less likely to conceive than cows with SUN<10.0 mg/dl.

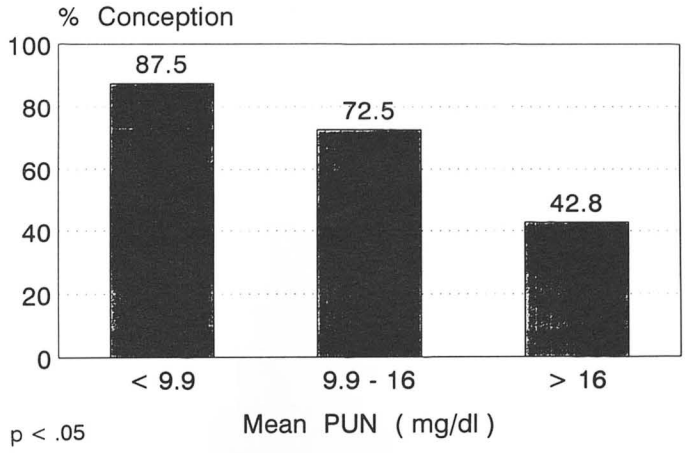

Figure 10: Mean plasma urea nitrogen versus percent first service conception on prostaglandin synchronized virgin heifers. Serum samples were collected twice weekly from coccygeal vessels and analyzed with the Technicon Industrial Method 339-01 for urea nitrogen. Pregnancy was determined by trans-rectal palpation at 45 days post AI breeding.

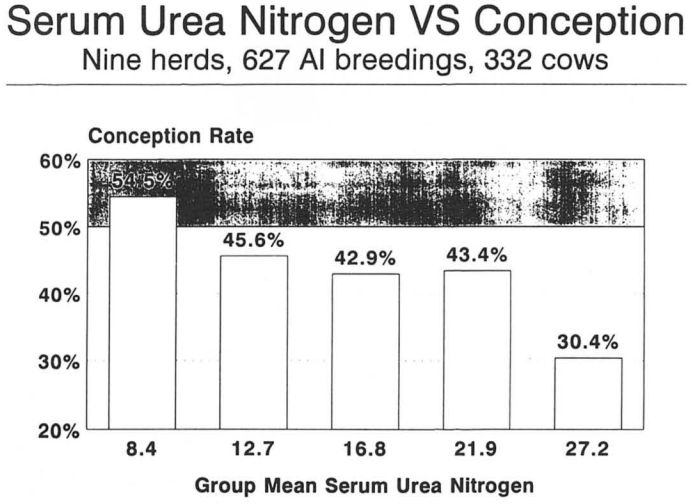

Figure 11: Conception rates versus mean group serum urea nitrogen levels for 627 AI breedings in 332 Holstein cows in nine herds. Breedings were between 50 and 150 days post-calving. Blood was sampled from day of calving until day 150 post-calving every two weeks by coccygeal vessel puncture. Urea nitrogen was determined with the DuPont ACA5.

It may be argued that this reproductive interference is not a true protein waste effect, it is merely an *energy effect*, with high MUNs meaning only that energy is deficient and it is the energy that is causing the conception decreases. It costs the cow 7.3 kcal for each gram of ammonia that the liver converts to urea. Therefore, a diet change that results in MUN decreasing from 20 mg/dl to 16 mg/dl will save a Holstein cow 1.0 megacalorie of energy that can be used for production or reproduction.

Elrod *et.al.* [7] demonstrated that uterine pH is lowered by excess dietary protein on day 7 post-breeding. This uterine specific environment alteration may be responsible for embryo losses that appear clinically as conception failures.

Interpretation of MUN Levels

Table 2 represents the translation and conversion of Scandinavian work[10,11,16,18,19,20,21] to Holstein cows by Dr. Charlie Sniffen and Dr. Arden Nelson while serving on the NEDHIA MUN Field Investigation Committee.

Table 2. Interpretation of Average MUN in Groups of Holstein Cows.

Milk % Crude Protein	LOW MUN < 12 mg/dl	DESIRED MUN 12-16 mg/dl	HIGH MUN > 16 mg/dl
< 3.0	Low NSC +/or NEL Low SIP +/or DIP +/or UIP	SIP, DIP, UIP, AAA in balance. Low CHO +/or NEL.	Excess SIP +/or DIP relative to CHO/NEL. Excess UIP or imbalance in AAA.
3.0 - 3.2	Low SIP +/or DIP +/or UIP.	Balanced SIP, DIP, UIP, AAA, and CHO/NEL.	Excess SIP +/or DIP relative to CHO. NEL balanced.
> 3.2	Low SIP +/or DIP +/or UIP. AAA balanced. Excess CHO/NEL.	Balanced SIP, DIP, UIP, AAA. Excess CHO/NEL.	Excess SIP +/or DIP relative to CHO. Excess of UIP vs NEL or AAA imbalance.

* this table should be used on average MUN for the whole herd or groups of Holstein cows. (std dev of individual cow MUNs = 3-4 mg/dl)

MUN = milk urea nitrogen (mg/dl)
SIP = soluble intake protein
DIP = degradable intake protein
UIP = undegradable intake protein
AAA = amino acids that are actually absorbed
CHO = rumen fermentable carbohydrate
NEL = Net Energy for lactation

This table is presented by Dr. Charles Sniffen and Dr. Arden Nelson. It should be used as a first draft, and is subject to change as new knowledge is obtained.

This interpretation chart should be looked upon as a first draft with changes coming as we start to apply MUN measuring technology to the practical management of nutrition for high producing cows.

Using MUN and milk crude protein levels enables the investigator excellent insight into protein and energy digestion/utilization in the cow.

A simpler interpretation approach is to be concerned when a group of cows, or a herd of cows is below 12 mg/deciliter and likewise be concerned when it is above 16 mg/deciliter. As we learn more, my belief is that this acceptable range will be narrower and lower.

Low MUN levels signify an absolute protein shortage of one of the protein fractions. This is easy and economical to correct because it is often rumen degradable or soluble protein that is in short supply. This correction often results in more milk production.

High MUNs, on the other hand, come about from two scenarios: a. *Absolute protein excess* of one of the protein fractions; or b. a *relative protein excess* due to poor availability (timing or absolute level) of rumen fermentable carbohydrate. A classic example is feeding excellent haylage with both high protein content and high protein solubility. Little corn silage is fed and high moisture corn is the main energy source. If the high moisture corn is not processed properly or not fermented properly, the carbohydrate substrate will not be readily available to allow the bacteria to utilize the soluble and degradable rumen protein. This leads to excess rumen nitrogen waste, even with the protein levels in the diet being "normal". With our silage based diets in the northeast, many of which rely heavily on haylage during certain times of the year, this is a very typical and difficult problem.

Will Hoover at West Virginia University evaluated 8 studies[2,3,4,5,12,13,14,15] conducted during 1989 and 1990 where BUN and dietary information on DIP and NSC was available. Figure 12 shows the results of Hoover's analysis. Diets lower than 35% NSC had higher BUNs at the same DIP levels.

In 7 herds and 22 groups of cows in the author's practice, NFC:DIP ratio vs MUN means yielded the relationship seen in Figure 13. It seems that our real lack of nutritional knowledge is in the area of commercially available carbohydrate digestibility measures for energy feeds. We appear to have a pretty good handle on protein fractions...we need the same level of sophistication in the area of non-fiber carbohydrate digestion predictions.

MUN Analysis Costs

Currently, Northeast DHI Association is offering MUN testing on a commercial basis on each cow that is milking on DHI test day. The cost for this program is $.15/cow/month and requires no special sampling or handling of milk samples on test day. Reports of results will be mailed to two addresses and includes individual cow results, group averages, distribution of high and low MUNs, and a scattergraph showing MUNs versus DIM. MUN data is included in the herd files available on the NEDHIA LOOP with access to dairymen and consultants.

Another service of NEDHIA, Checkmark Lab, is for non-DHI herds or DHI herds between test days. Bulk milk samples or individual cow samples can be submit-

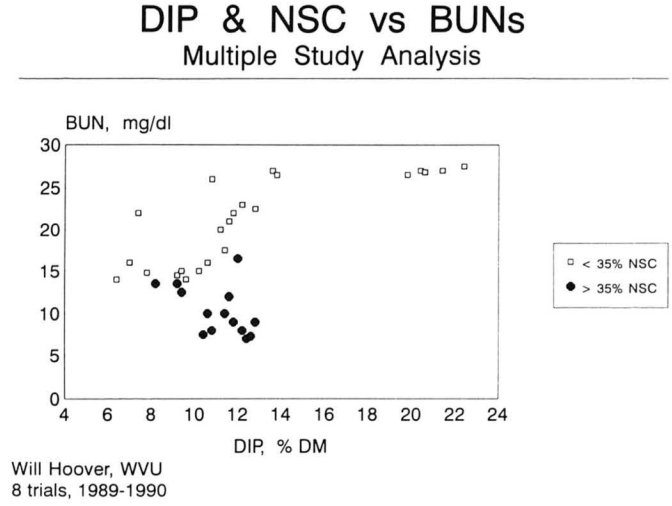

Figure 12: Results from eight research trials conducted 1989-1990 where information was available on dietary NSC and DIP, as well as BUN determinations show that dietary NSC content plays a significant role in determining the resultant BUN level.

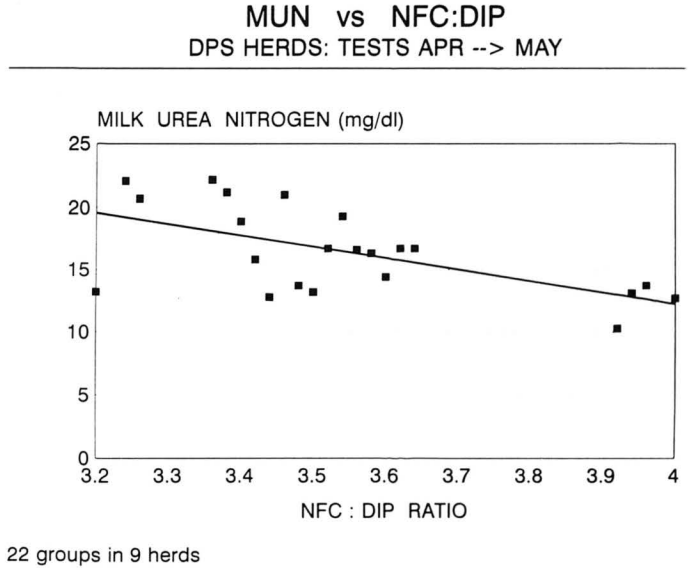

Figure 13: Relationship of dietary NFC:DIP ratio on mean MUN levels from 22 TMR fed groups of cows in 9 Dairy Production Services herds from April-May 1994.

ted for $.65/sample. There is a $ 5.00 accession fee charged per herd per group of samples. Results are faxed back and include % protein and MUN levels. Additional tests are $.20/test and include % fat, % lactose, and SCC.

Herd Examples

These examples will illustrate field experiences with MUN manipulation, both intentional and unintentional, in Dairy Production Services client herds during the last 24 months. Data is from individual samples on all milking cows on DHI test days. The initial and only goal was to simply observe if ration changes did indeed result in MUN changes in these herds. No attempt was made to correlate these MUN changes with production, reproduction, nor cow health changes.

Herd A

The MUNs in Herd A (23,000 RHAM, 2X, BST) were fine until test day in August. (Figure 14) We were concerned and puzzled at the results until the haylage analysis showed an increase of 8.0% in protein level (13% to 21%). Diet adjustments, which included reducing the protein level and the DIP fraction in the grain mix, worked nicely.

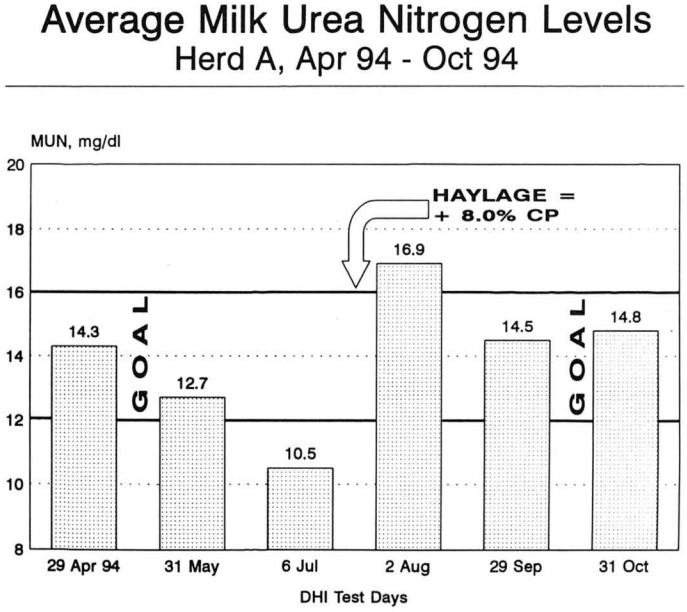

Figure 14: Mean herd MUN for Herd A for test days from April 94 through October 94. Significant changes in haylage quality (13% CP to 21% CP) between 6 Jul and 2 Aug test days resulted in dramatic increase in MUN for the herd. MUN determinations for 1 Sep 94 test day were not available.

Herd B

Herd B produces fairly well (20,000 RHAM, 2X, no BST) and breeds extremely well. It is my one client herd that uses pasture in the summer and is also on DHI. The first MUN results (see Figure 15) received in May 94 were a shock until I learned that the cows had gone out to lush spring pasture four days prior to the May test day. Subsequent changes in grain mix formulation and grain intakes changed the MUN picture for June test day. As pasture was eaten down, cows' appetites for corn silage and grain increased.

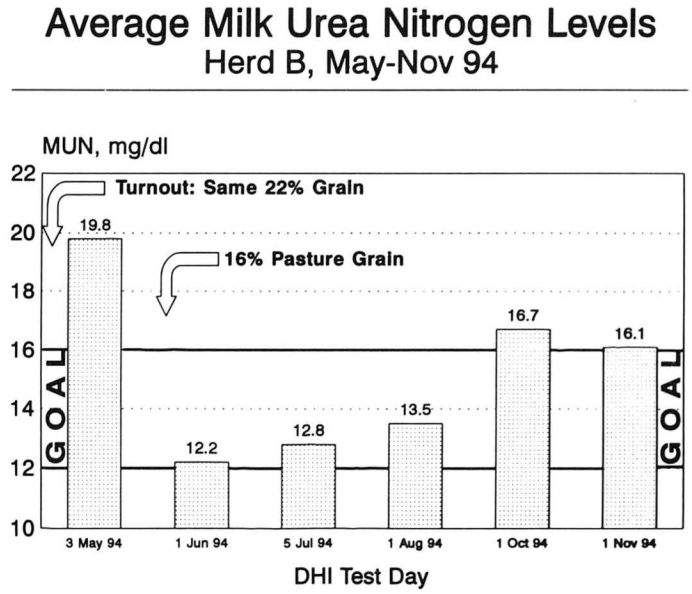

Figure 15: Mean herd MUN for Herd B for test days from May 94 through November 94. Cows had been turned out to spring pasture 4 days prior to the May DHI test. Grain mix changes and increased appetites for barn-fed corn silage and grain decreased MUN levels for June test day. MUN determinations for 1 September 94 test day were not available.

Herd C

The MUN results (Figure 16) were extremely high for the low group cows in May 94 in Herd C (RHAM 23000, 3X, some BST). Even though the diet looked good on paper (Table 2), we decided to believe the cows and act on the MUN information. Ration changes were to add 5.0# (3.5#dm) of high moisture corn and decrease 5# corn silage (1.3# dm) to allow the cows more rumen available energy to handle the high amount of degradable protein.

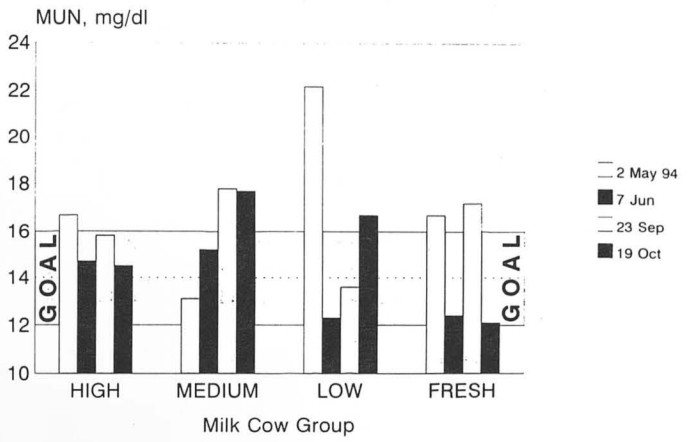

Figure 16: Mean herd MUN for Herd C by feeding groups for test days from May 94 through October 94. Alterations to low cow diet after the May 94 test day consisted of increasing HMSC to assist in the utilization of rumen degradable protein. MUN levels for June test day reflected the success of dietary changes. MUN determinations for July and August were not available.

Ration changes resulted in much lower MUN levels. Actual changes in nutrient analysis were minimal, but the BIG change in MUNs most probably resulted from quicker digesting energy that matched the fast sources of rumen degradable protein. This is an example of the cows telling us that our traditional means of diet formulation does not measure up to further consultation with the cows themselves...through MUNs. Cows know; it is our job to properly translate their comments made via test results into appropriate management changes.

Table 3. Low Group Milk Cow Diet Differences. Before vs After Added HMSC

	Before HMSC Added	After HMSC Added
DMI (#/c/d)	47.5	49.6
Crude Protein (% of DM)	15.1	14.8
Soluble Protein (% of CP)	32.7	32.5
Undegraded Protein (% of CP)	30.9	31.1
NEL (mcal/# diet)	.71	.72
Low Group MUN (mg/dl)	22.2	12.2
Total Intake Nel (mcal)	33.6	35.8
Total Intake CP (#)	7.1	7.4
Total Intake Sol P (#)	2.3	2.4
Total Intake Deg P (#)	4.9	5.1

MUN Impact

As a veterinarian, my first concern with excess protein waste was from a reproduction management viewpoint. As I worked with MUNs, the reality of feed cost and cow production performance came quickly to the forefront. MUN analysis will impact several economically important dairy management areas.

1. Nutrition economics

It makes no sense whatsoever to overfeed protein, then feed more energy in the form of more grain or added fat to compensate for the energy cost to the cow of excreting the excess protein waste. Both the protein and the added energy cost the dairyman dollars! With feed costs being the single largest expense item for dairy farms, impact here is obvious. Even if the MUN levels tell of under-feeding of protein, increases in production performance should easily pay for MUN testing and increased ration cost.

MUN analysis gives the veterinarian/nutritionist a direct window into energy protein relationships in cows. It allows us to consult the cows themselves and learn of the limitations of our ration balancing capabilities with current feedstuff analyses.

2. Energy status of cows

a. Production
b. body condition
c. reproduction

We have little direct measuring ability of energy status in a herd of cows other than production performance, body condition change, and reproductive performance. Production performance can be misleading in the short term because of the cows' ability to mobilize energy reserves. Body condition scoring also is too retrospective for "real-time" energy monitoring that can direct nutrition management. Reproductive performance definitely suffers from too much time lag between energy insults and information that can be trusted and acted upon.

MUNs offer "*real time energy and protein monitoring*".

3. Product yield, quality

Yield of manufactured products from high MUN milk is reduced. The difference between milk crude protein (DHI measurement) and true protein (New York State milk payment measurement) is milk non-protein nitrogen. Average values for true protein and NPN in milk are 94-95% and 5-6% respectively. Range of NPN content in milk is large, with levels as low as 2% or as high as 11%...! MUN makes up 85-90% of NPN in milk. Therefore, milk crude protein can be as much as 9.9% urea nitrogen.

Non-protein nitrogen does not make cheese. Casein does. I predict that milk handlers and processing plants will be using MUN as a quality measure in the foreseeable future.

4. Environmental impact

Current and impending legislation in several states will regulate the amounts of nitrogen and phosphorus our country's dairymen can apply to the land as manure. Monitoring MUNs on a regular basis can limit the over-feeding of protein to the cows and to the land.

I predict that MUN monitoring will become a larger positive economic influence on the dairy industry than somatic cell counting has been. The wasting of protein has impact on nutrition management, feed costs, production, reproduction, product yield and quality, and on our environment. Somatic cell counting *only* influences udder health management, product yield and quality.

MUN Economics

Dwight Roseler studied MUNs for his Masters thesis at Cornell University.[22,23] He estimated a cost of $ 23,600,000 ($.09/c/d) to the dairy industry in New York state because of feeding excess protein to milking cows. He proposed a potential payback to the New York dairymen of between $ .01 and $ 3.96 per cow per month in feed savings from adjusting rations due to MUN monitoring. Costs of testing used were $.60-.90/MUN test/cow/month, for *non-automated* MUN testing.

With the availability of automation that can determine MUN, costs for testing are lower. Using the costs in Table 4 below, we have projected scenarios that would return $10.00 for each $1.00 invested in MUN testing costing $.15/c/month. Please note that *any one* of these scenarios will return $10 for each $1 spent on MUN testing.

Table 4. Costs used in calculation of potential dollar returns from MUN monitoring.

Cost Item	Cost
MUN testing	$ .15/cow/month
Milk price	$ 12.00/cwt
48% soybean oil meal	$ 220/ton
Corn meal	$ 110/ton
Excess Days Open	$ 2.00/day/cow

Scenarios Returning $10 for each $1 spent in MUN Testing

Table 5 shows partial budget calculations on the following scenarios, each of these returns $10 for each $1 spent on MUN testing.

A. Save .5# 48% Soybean meal/c/d
B. Replace 1.0# Soybean meal/c/d with 1.0# corn meal/c/d
C. Replace 1.0# corn meal/c/d with 1.0# soybean meal/c/d and yield 1.0# milk/c/d
D. Save 9 days open/c/year

Table 5. Partial Budgets for Management Returns with MUN Analyses.

Scenario A: Decrease Dietary Protein

Expenses:	MUN analysis	= $ .15/c/month
Savings:	.5# SBOM/c/d x $.11/# x 30 d/mo	= $1.65/c/month
	Net= $1.65 - $ .15	= **$1.50/c/month**

Scenario B: Decrease Dietary Protein, but Replace Energy

Expenses:	MUN analysis =	= $ .15/c/month
	1.0# cornmeal/c/d x $.055/# x 30 d	= $1.65/c/month
Savings:	1.0# SBOM/c/d x $.11/# x 30 d	= $3.30/c/month
	Net= $3.30 - $1.80	= **$1.50/c/month**

Scenario C: Increase Dietary Protein, Equal Energy, More Milk

Expenses:	MUN analysis	= $ .15/c/month
	1.0# SBOM/c/d x $.11/# x 30 d	= $3.30/c/month
Savings:	1.0# cornmeal/c/d x $.055/# x 30 d	= $1.65/c/month
	.92# milk/c/d x $.12/# x 30 d	= $3.30/c/month
	Net= $4.95 - $3.45	= **$1.50/c/month**

Scenario D: Save Days Open with Lower Protein Diet

Expenses:	MUN analysis	= $ .15/c/month
Savings: (excludes unknown amount of protein savings)		
	9.9 DO/c/yr x $2.00/DO x 1 yr/12 months	= $ 1.65/c/month
	Net= $1.65-$ .15	= **$ 1.50/c/month**

Conclusion

MUN monitoring can be an economically rewarding management tool, enabling the veterinarian to become involved more intimately with nutrition, production, reproduction, and economics of client dairies. It is a tool that enables more thorough consulting of the cows in the pursuit of the performance truths necessary for improved dairy management.

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