Introduction to MUN

What is Urea

Urea is a small organic molecule composed of carbon, nitrogen, oxygen, and hydrogen. Urea is a common constituent of blood and other body fluids. Urea is formed from ammonia in the kidney and liver. Ammonia is produced by the breakdown of protein during tissue metabolism. Ammonia is very toxic. Urea is very non-toxic and can be at very high levels without causing any problems. If urea was not produced from ammonia we would very quickly become ill every time we ate a meal containing protein. The conversion of ammonia to urea, primarily in the liver, prevents ammonia toxicity. Urea is then excreted from the body in urine.

Urea diffuses readily into body tissue spaces with water. Urea, readily diffuses from blood into milk. Urea is a normal constituent of milk and comprises part of the non-protein nitrogen normally found in milk.

Urea concentrations in blood vary. Urea concentrations will be influenced by protein intake, energy intake, and urinary excretion. Consuming higher protein diets will result in higher blood urea levels. Increasing energy intake will often decrease the concentration of blood urea. Since urea is passed out of the body in the urine, increasing water intake, which may increase urinary production, will tend to decrease blood urea concentration. Conversely, slight dehydration will be expected to increase blood urea concentration. Thus, urea is sensitive to protein intake, energy intake, and water intake.

Blood urea will fluctuate throughout the day. Concentrations will be highest about 4 to 6 hours post feeding, and lowest just prior to feeding. Since milk is collected twice (or three) times a day, milk urea will be slightly less volatile than a blood sample. However, a.m. versus p.m. samples of milk will have urea concentrations which reflect the time of feeding relative to milking. Furthermore, feeding a total mixed ration versus separate feed ingredients will influence the change in urea concentration with feeding. Separate ingredient feeding has tended to increase urea concentration more than TMR feeding following consumption.

In dairy cows, blood urea will reflect not only the catabolism of protein by the ruminant tissues, but also catabolism of protein within the rumen by bacteria. Digestion of protein in the rumen releases ammonia which can be utilized by rumen bacteria or be absorbed into the blood stream. Ammonia absorbed from the rumen must be converted to urea for detoxification. Thus, in dairy cows there are two entry points which may elevate blood urea. The first is rumen degradation of protein, and the second is degradation of protein by tissues.

The capture of ammonia in the rumen will be influenced by grain intake, which improves rumen microbial growth. Therefore, in the cow, digestion of protein and carbohydrates in the rumen will influence blood urea concentrations in addition to tissue metabolism of energy and protein. Increasing carbohydrate in the diet, which enhances rumen microbial production, will decrease rumen ammonia and decrease blood urea. Increasing the amount of energy absorbed from digestive processes will spare protein catabolism and result in lower blood urea levels.

In conclusion, urea is a small organic molecule. Blood concentration is influenced by protein catabolism, energy intake, and water intake. It's purpose is to prevent ammonia toxicity and to act as a carrier of excess nitrogen out of the body primarily through urine. Blood concentrations are influenced by dietary energy and protein supply, liver and kidney function.

Since blood urea concentration is influenced by many factors, we don't expect cows consuming the same diet to have the same blood urea concentration. Dry matter intake, water intake, milk production, protein and energy requirements will be different, which will influence urea concentrations. However, research has shown that mean urea concentration from a group of cows and the range in urea values for a group of cows should fall into specific ranges. Thus, urea concentration may serve as a monitoring tool for assessing protein nutritional status.

Milk Urea Nitrogen

Blood urea is freely diffusable into milk and is part of the normal nitrogen constituents in milk. We may estimate the concentration of blood urea by measuring milk urea. All the factors which influence blood urea will influence the concentration of urea in milk. Since milk is an easy fluid to collect and is done at least twice a day on most farms, measuring milk urea is a useful estimate of blood urea levels.

All the factors which influence blood urea will influence milk urea. This includes rumen degradable protein intake, undegradable protein intake, energy intake, water intake, liver function, and urinary output. Since milk is produced throughout the day and is pooled in the gland, milk urea concentrations may dampen some of the changes which occur rapidly in blood. If milk is sampled from an evacuated gland, urea concentrations are very close to blood concentrations at that time. However, as milk fills the gland between milkings the urea diffusion space increases and concentrations will be slightly different from blood.

Testing for Milk Urea

Urea concentrations may be tested in several ways. Traditionally, testing has involved taking a sample of blood or milk and using a spectrophotometer to measure the change in color when a reagent was added that acts specifically with urea. Usually this tests uses urease, an enzyme which specifically breaks down urea to ammonia. A dye is then added which reacts with ammonia and forms a blue color which can be measured in the spectrophotometer. The intensity of the blue color correlates with the concentration of urea in the sample.

Another method involves a dye agent, diacetylmonoxime which reacts with the urea molecule to form a pink color. Again the intensity of pink correlates with concentration of urea in the fluid.

The third method that has been available has been a dipstick urease/pH method which reacts with urea and turns an orange to deep green color depending upon urea concentration.

Recently a fourth method has become available using infrared technology. Infrared technology has long been used to measure fat and protein in milk. Organic molecules, when heated give off an infrared reflectance spectrum that is consistent with the type of molecules present. The reflectance spectrum may be correlated with the concentration of the molecule and used to assess content in a sample. Within the last year, DHIA centers have begun to employ this technology to measure milk urea. This affords a very rapid, easy way to measure urea in milk.

Typical Concentrations of Urea Found in Milk

Concentrations of urea in milk are variable from herd to herd and within cows in the same herd. Across all cows in Pennsylvania we would expect to find a wide variation in MUN concentrations. Samples run in the PA DHIA testing laboratory indicates a range of .5 to 39.5 mg/dl for MUN concentration (312,005 samples, 1,731 herds). The mean urea concentration in Pennsylvania has been 14 mg/dl. with a standard deviation of 4.03. This means that 95% of the cows sampled through the DHIA have had urea levels roughly from 6-20 mg/dl Obviously there is quite a variation within cows that have been sampled. This raises questions about the usefulness of MUN testing.

The variation in milk urea concentrations between herds and between cows indicates a wide variation in protein, energy and water intake within dairy cows and herds. The idea of ration formulation is to appropriately balance diets for rumen digestion and absorption of needed nutrients for maintenance of body tissue and production of milk. When rations are appropriately formulated they contain acceptable ratios of rumen degradable and undegradable protein, rumen fermentable carbohydrate, and post-ruminal absorption of energy metabolites. Given typical ranges of dry matter intake and production within a herd of cows consuming a diet that is blended for a certain level of milk, the mean MUN for these cows would be expected to fall within a predictable range. If the MUN was outside this range it would suggest problems in protein supply. The mean MUN could be used to signal potential problems with our feeding program. It could not be used to identify specific problems. Urea concentration in milk may provide an opportunity to look at problems with the feeding program and system within our farm.

A word of caution. Given the variation in MUN, values for individual cows should not be interpreted. They are not to be used to move cows from different rations. They should only be used to indicate mean values for a group of at least 8 cows.

What Should Urea Values Be?

A major question becomes, what should milk urea concentrations be. What should my herd average be? What should cows average at different production levels. Just as somatic cell counts are only interpretable within the frame work of a goal, milk urea concentrations are only interpretable in relation to a goal of ranges that should be acceptable in dairy farms. Deviation outside an acceptable range suggests that there are factors within the feeding program that need to be examined. If mean MUN is outside an acceptable range, however, MUN concentration may not be ammendable to correction without some functional in forage program on the farm, on the ration formulation program, or on the feed delivery program on the farm. Urea values should not be interpreted as an entity in themselves, that is urea values should not be interpreted without also examining the entire feeding program on the farm, including ration formulation, the ration delivery, mixing of feeds, feed intake and water intake.

Given these provisos, what should urea values be? MUN values in cows fed and at optimal dry matter intake typically fall in the majority range of 10-14 mg/dl. The range of MUN concentration for individual cows consuming the same diet is +6 or - 6 from the mean of the group. That is if a group of cows averaged 12 MUN mg/dl, 95% of the group would fall between the values of 6 -18 mg/dl MUN.

How many cows should I sample? Given the variation of milk urea, 8 cows at least need to measured within a group of cows to have interpretable results. Testing under 8 cows will not result in a meaningful average value of milk urea and cannot be interpreted. Eight cows or more need to be tested to estimate the mean urea value of a group. In addition, the cows that are tested need to be cows that have free access to feed and are healthy.

If mean values of milk urea should to be 10-14 mg/dl, why is my herd at 16 mg/dl and should I be concerned about it. The fact that the mean milk urea nitrogen concentration of 16 mg/dl is found in your herd means that there is some inefficiency in protein feeding occurring within your herd. This may represent a change in forage from that tested, it may represent different approaches to ration formulation, it may indicate problems in feed delivery. High MUN suggests that more protein is fed than is necessary for production with that group of cows, or that feed intake is not as uniform as you would within that group of animals. If forages contain high amounts of rumen degradable protein such as high alfalfa diets, MUN may be “high” and represent “normal” values. Alfalfa haylage or hay provides a high concentration of rumen degradable nitrogen which may not be able to be captured as microbial protein given constraints on rumen fermentable carbohydrate which can be included in rations, due to the risk of rumen acidosis.

Under this scenario, elevations of milk urea nitrogen may be expected or anticipated and there might be little you can do about this until forage supply is brought into a more focused balance to account for the rumen degradable nitrogen.

Well, if my milk urea levels are 16 mg/dl, should I try to reduce them? The higher levels of MUN concentration suggests that there are opportunities to improve your protein feeding system. Just what may be done to improve protein feeding, needs to be addressed with your feed consultant. You need to discuss with your nutritionist what factors maybe contributing to the elevated milk urea and examine management options which may result in improving nitrogen supply in your rations to decrease the milk urea concentration. There may be opportunities to reduce ration costs and improve efficiency of feed delivery and lower milk urea nitrogen.

Experiences With Milk Urea Nitrogen

At our dairy at the University of Pennsylvania we have been examining blood urea, milk urea through the DHIA test, and milk urea from a.m. samples and p.m. samples using our clinical laboratory. We have had 166 samples or cows in which we have measured the blood concentration, the milk concentration through DHIA and also the morning and evening concentration through our own laboratory.

Urea	Mean Urea mg/dl	Standard Deviation	Range
Blood Urea	12.11	2.31	6.0-19.0
Milk Urea, a.m.	12.25	2.25	7.6-20.6
Milk Urea, p.m.	14.35	2.20	8.2-20.1
DHIA Milk Urea	13.11	2.99	2.3-23.0
DMI, kg	22.22	3.82	10.5-31.8
Milk, lbs	72.19	16.57	28.3-118.3

The table contains information presenting the mean values for blood, milk urea a.m., milk urea p.m., and DHIA milk urea for 166 samples from 37 cows that were sampled repetitively from December through April in our dairy herd. Briefly, our management program is cows are fed a total mixed ration at 11:00 a.m. Two groups are fed a high production group balanced for 90 lbs. of milk and a low production group balanced for 55 lbs. of milk Milking occurs twice a day at 5:00 a.m. to 7:00 a.m. and 4:00 p.m. to 6:00 p.m. Blood samples were collected around 2:00 p.m.

The milk urea DHIA concentration represents a composite sample taken from morning and evening samples. The milk urea a.m. and the milk urea p.m. represents samples taken on sample day and analyzed for urea concentration. Mean values for blood urea, milk urea a.m., milk urea p.m., and DHIA milk urea are very similar. Blood levels are .913 of the (SE = .014) DHIA milk urea concentration. The milk urea a.m. is lower then the milk urea p.m. by about 2 mg/dl (.856 x MUN p.m.) (SE = .009). We would expect the milk urea in the afternoon to be higher than the morning due to the fact that we feed at 11:00 a.m. The average of the a.m and the p.m. milk MUN is 13.30, SE = 2.04, very close to the average of DHIA milk urea of 13.11.

Standard deviations are very similar with the different tests. The DHIA MUN has the highest SD 2.99 compared to 2.20 to 2.31 from milk and blood from the clinical laboratory. The range in urea values is very similar across the different tests but note, the low 2.3 on the milk urea DHIA test and the high 23.0. The range on the MUN DHIA is wider than the clinical labs. However, overall we would make similar conclusions about the MUN using any of the tests. The average fat test is 3.6% and protein 3.3 % for these cows.

In Conclusion

Milk urea may be a useful test for diagnosing herd problems and identifying opportunities to improve protein supply. However, one word of caution, milk urea may be within acceptable ranges of 10-14 but protein may still not be adequately balanced. Therefore, don't be falsely led either, but if your urea levels in your herd are between 10-14, then protein is adequate. Protein supply may still be imbalanced in milk urea levels be within acceptable ranges. Additionally, milk urea should never be interpreted without evaluating overall feeding management programs. Milk urea is a useful tool but should not be used in isolation from evaluating other management procedures involving production and nutritional efficiency within your herd.