True Protein vs. 'Funny Protein'

by Jerry Brunetti

Many years ago, one of my mentors, John Whittaker, D.V.M., then a regular columnist for *Acres U.S.A.,* frequently referred to numerous herd and flock disease outbreaks resulting from too much "funny protein" showing up in the ration. What he was referring to wasn't protein *per se,* but non-protein nitrogen, examples being nitrates in feed and/or water and other nitrogenous compounds that mimic urea. The feed/forage test will report this as "crude protein," because in reality the test is only for nitrogen. Since all protein contains an average of 16 percent nitrogen, a simple mathematical extrapolation is made, the formula being:

Crude Protein = Nitrogen x 6.25
(100% ÷16% = 6.25)

So it is clear that from the numbers derived from this test one cannot determine the true protein quality *(i.e.,* amino-acid content). To test for amino acids would be prohibitively expensive, so one must use other information to determine protein quality. We will address these criteria in this article, but first let's discuss what protein is and examine its importance.

Table 1: List of the Essential & Nonessential Amino Acids

Essential Amino Acids	Nonessential Amino Acids
Arginine (Arg)*	Alanine
Histidine (His)	Aspartic acid
Isoleucine (IIe)	Citrulline
Leucine (Leu)	Cysteine
Lysine (Lys)*	Cystine
Methionine (Met)*	Glutamic acid
Phenylalanine (Phe)	Glycine
Threonine (Thr)	Hydroxyglutamic acid
Tryptophan (Trp)	Hydroxyproline
Valine (Val)	Norleucine
	Proline
	Serine
	Tyrosine

**Most-Limiting Essential Amino Acids for Ruminants*

From Feed to Milk: Understanding Rumen Function, *Penn State University Extension Circular No. 422*

THE NATURE OF PROTEIN

The word *protein,* coined in the 1800s, comes from the Greek word *proteios,* meaning "of first importance." Protein is distinct from all other nutrients due to its nitrogen content. Protein as defined by *The Concise Dictionary of Biology* is "any of a large group of organic compounds found in all living organisms." Protein molecules consist of one or several long chains of amino acids, the "bricks" from which proteins are constructed. An amino acid is the combination of an amino group with nitrogen (-NH_2) and an acid group (-COOH). The amino acids that an organism is unable to synthesize are classified as "essential amino acids," and therefore must be present in the diet. From these essential amino acids, the remainder, or non-essential amino acids, can be created within the animal.

As it stands now, there are considered to be 23 commonly occurring amino acids. Ten of these are considered essential. Each amino acid has a unique structure, and all of them contain nitrogen.

Amino acids form chains called peptides (less than 10 amino acids) and polypeptides (more than 10 amino acids, usually containing 100 to 300 amino acids). Examples of peptides include glutathione, which is critical for immune function, and the pituitary hormones vasopressin and oxytocin. An example of a polypeptide is adrenocortcotrophic hormone (ACTH).

The sequence of these amino acids in the protein polypeptides determines the shape and properties, and thus the biological role, of a protein. Chemically, proteins comprise carbon, hydrogen, oxygen and nitrogen. Many also contain sulfur.

Proteins may be broadly classified into globular and fibrous categories. Globular proteins have compact, rounded molecules and are usually water soluble. These include antibodies (immunoglobulins); the catalysts known as enzymes; carrier proteins, such as hemoglobin, which transports oxygen through the bloodstream; and storage proteins, such as albumin in eggs and casein in milk.

Fibrous proteins are generally insoluble in water and consist of long, coiled strands or flat sheets, which confer strength and elasticity. Examples in this category include keratin (found in hair, feathers, nails, hooves and horns), collagen (the connective tissue of skin, tendons and bones), actin and myosin (muscle-fiber proteins), and fibrin (blood-clotting proteins).

It is therefore evident that an organism's complex structure and its metabolic functions are highly dependent upon the presence of an adequate quantity and quality of protein in the diet. Immune function, tissue regeneration and repair, fertility, rate of gain, milk production and so forth depend extensively on the protein factor.

Reprinted from
ACRES USA®
A VOICE FOR ECO-AGRICULTURE
February-April 2004 • Vol. 34

Table 2: Essential Amino Acid Profiles of Milk, Ruminal Bacteria & Feeds

	Percentage of Total Essential Amino Acids									
Item	ARG*	HIS	ILE	LEU	LYS*	MET*	PHE	THR	TRP	VAL
Milk	7.2	5.5	11.4	19.5	16.0	5.5	10.0	8.9	3.0	13.0
Bacteria	10.4	4.2	11.5	15.9	16.6	5.0	10.1	11.3	2.7	12.3
Corn Silage	6.4	5.5	10.3	27.8	7.5	4.8	12.0	10.1	1.4	14.1
Hay crop silage	8.9	5.3	11.0	18.9	10.3	3.8	13.5	10.3	3.3	14.7
Barley	12.8	5.9	9.6	18.4	9.6	4.5	13.3	9.1	3.1	13.6
Blood meal	7.6	11.2	2.1	22.8	15.7	2.1	12.3	8.1	2.7	15.4
Brewer's grain, dry	8.9	6.4	10.6	17.6	11.4	4.8	10.3	11.4	3.0	15.6
Canola meal	14.0	6.7	9.3	16.9	13.1	4.8	9.5	10.5	3.0	12.4
Corn grain	10.8	7.0	8.2	29.1	7.0	5.0	11.3	8.4	1.7	11.5
Corn gluten meal	6.9	4.7	9.3	36.4	3.8	5.5	13.8	7.5	1.5	10.7
Corn distillers, dark	7.7	7.2	9.8	26.3	6.2	5.2	11.1	10.3	2.7	13.4
Cottonseed meal	25.4	6.0	7.7	13.9	9.6	3.8	12.2	7.7	2.9	10.8
Feather meal	14.7	1.1	10.0	29.3	3.9	2.1	10.0	10.5	1.5	17.1
Fish meat	13.1	5.7	9.3	16.5	17.0	6.3	8.8	9.5	2.4	11.3
Meat and bone meal	20.5	5.5	7.8	16.2	14.2	3.6	9.2	9.0	1.8	12.1
Sorghum grain	9.4	5.8	9.4	30.9	5.6	4.3	12.6	8.0	2.2	11.8
Soybean meal	16.3	5.7	10.8	17.0	13.7	3.1	11.0	8.6	3.0	10.6
Wheat middings	15.2	6.6	9.7	18.9	8.0	4.6	12.6	8.3	3.4	12.6

**Most-Limiting Essential Amino Acids for Ruminants*

Source: C. Schwab, "Amino Acid Nutrition of the High Performance Ruminant," in Rhone-Poulenc, Animal Nutrition and Health Symposium, *pages 1-75.*

AMAZING AMINOS

The fact is that amino acids are the real heroes of the miracle of protein production. It's appropriate to point out some of the remarkable characteristics of a few of these champions in order to help us recognize and remember that amino-acid diversity in the livestock ration is what we should be thinking about when our thoughts turn to proteins. Following are brief descriptions, properties and sources of the essential amino acids. They are not necessarily more important in their function than the non-essential amino acids — their significance lies in the fact that the body cannot synthesize them, therefore they must be consumed in the diet. The following text draws from *The Healing Nutrients Within,* by Eric R. Braverman, Carl C. Pfeiffer, Ken Blum and Richard Smayda, and *Thorsons Guide to Amino Acids,* by Leon Chaitow.

Methionine. One of the essential amino acids and a major limiting amino acid in the ration. This one is called a methyl (CH_3) donor, which means it has the capacity to alter the structure of other molecules. The methyl molecule is essential for the formation of nucleic acid (RNA/DNA), the genetic material of every cell in the body, which determines the blueprint of all the different proteins of the body.

Methionine is the precursor to the amino acids cysteine and cystine, which along with methionine, are involved in synthesizing a number of valuable compounds, such as coenzyme A (needed for fatty-acid synthesis), heparin (an anticoagulant mucopolysaccaride), lipoic acid (necessary for carbohydrate metabolism) and glutathione (a strong free-radical scavenger and immune stimulant). Methionine, one of the few sulfur-bearing amino acids, is critical for producing lecithin, detoxifying the liver, transporting selenium, and is also an antioxidant.

Methionine is about 5 percent of the total essential amino acids found in milk and rumen bacteria. Feeds highest in methionine are forages from properly fertilized soils, corn, corn gluten meal, corn distillers, fishmeal, barley, brewer's grain and canola meal. Soy is low, as are oats.

Lysine. Research has proven that lysine is critical for proper growth and metabolism. It is the precursor for the important amino acid citrulline, needed for normal protein metabolism.

Lysine makes up 16 percent of the total essential amino acids found in both milk and rumen bacteria and tends to be found in richer amounts in forages, beans such as soy and canola, and animal product. All cereals tend to be low in this amino acid.

Arginine. An essential amino acid important for the detoxification of blood ammonia, arginine promotes growth-hormone production and is necessary to manufacture insulin and hemoglobin. Eighty percent of seminal fluid is arginine, and this amino acid is also important for ovarian development and ovulation. Arginine

Table 3: Average Distribution of Protein & Nitrogen Fractions in Select Feedstuffs

Feedstuff	% DM Basis Crude Protein	A*	B1	B2	B3	C
Concentrates						
Blood Meal	91.7	0.2	4.7	93.9	0.0	1.2
Brewers grain, dry	25.4	2.9	1.2	55.5	28.4	12.0
Canola	42.3	21.1	11.3	57.0	4.2	6.4
Corn Grain	10.1	7.7	3.3	74.0[a]	10.0	5.0
Corn Grain (high moisture)	10.1	40.0	0.0	44.1[a]	10.6	5.3
Corn, ear (dry)	9.0	11.2	4.8	66.2[a]	10.0	7.8
Corn, ear (high moisture)	9.0	30.0	0.0	51.3[a]	10.4	8.3
Corn Distillers, dry	29.5	17.0	5.0	14.9[a]	43.1	20.0
Corn Gluten feed	25.6	49.0	0.0	43.2[a]	5.7	2.1
Corn Gluten meal	65.9	3.0	1.2	84.8[a]	9.0	2.0
Cottonseed, whole	23.0	0.8	39.2	54.0	0.0	6.0
Cottonseed meal	44.8	8.0	12.0	48.4	2.4	7.6
Fish Meal	66.6	0.0	12.0	87.0	0.1	0.9
Soybean meal, 44%	49.9	11.0	9.0	75	3.0	2.0
Soybean meal, 48%	55.1	11.0	9.0	75	3.0	2.0
Soybeans, raw	42.8	10.0	34.2	51.4	1.5	2.9
Soybeans, heated	42.8	5.7	0.0	70.7	16.3	7.3
Wheat midds	18.4	12.0	28.0	56.0	1.4	2.6
Forages						
Alfalfa hay, prebloom	21.7	28.8	1.2	55.0	5.0	10.0
Alfalfa hay, early bloom	19.0	28.8	1.2	52.2	7.8	10.0
Alfalfa hay, mid bloom	17.0	26.9	1.1	46.8	11.2	14.0
Grass hay, late vegetative	16.0	24.0	1.0	44.0	25.3	5.7
Grass hay, mid bloom	9.1	24.0	1.0	44.0	24.9	6.1
Grass hay, mature	7.0	24.0	1.0	44.0	24.5	6.5
Alfalfa silage, early bloom	19.0	50.0	0.0	23.3	11.7	15.0
Alfalfa silage, mid bloom	17.0	45.0	0.0	23.0	14.0	18.0
Corn Silage, 45% grain	9.0	45.0	0.0	38.6	8.5	7.9
Corn Silage, 34% grain	8.6	50.0	0.0	34.0	8.0	8.0
Corn Silage, 25% grain	8.3	55.0	0.0	29.0	7.5	8.5

A* Corn products contain zein, a slow-degrading prolamine protein that is soluble in neutral detergent fiber.

Fraction A is 100 percent rumen-soluble (0 percent nondegradable) and consists of nitrates, ammonia, amino acids and peptides. Fraction B1 is mostly soluble (less than 30 percent is nondegradable) and consists of globulins and some albumins. Fraction B2 is variable in its solubility, ranging from 30 to 70 percent nondegradable and consisting mostly of albumins and glutelins. Fraction B3, which is mostly prolamins, is highly (+70 percent) nondegradable, meaning low solubility. Fraction C is 100 percent nondegradable (0 percent soluble) and consists of maillard products bound to lignin. When heating grains during processing, the nondegradable fraction increases because the globulins and albumins in the B1 fraction are now denatured and become part of the B2 and B3 fraction.

Source: Russell, J.B., J.D. O'Connor, D.G. Fox, P.J. Van Soest, and C.J. Sniffen, "A Net Carbohydrate and Protein System for Evaluating Cattle Diets: 1. Ruminal Fermentation," Journal of Animal Science *(1992), 70:3551-3561.*

Reprinted from
ACRES USA
A Voice for Eco-Agriculture
February-April 2004 • Vol. 34

also supports the thymus, the immune gland.

For livestock, high levels of arginine can be found in good forages, barely, canola, soy, wheat midds, cottonseed meal, peanuts, most nuts (cashews, pecans, almonds, etc.), garlic and ginseng. It is low in most cereal grains, fruits and vegetables.

Histidine. Another essential amino acid, histidine helps maintain the myelin sheath insulating nerves, stimulates production of both red and white blood cells, is required for sexual arousal, and is metabolized into the neurotransmitter histamine, which is associated with contraction and expansion of blood vessels and other smooth muscle function. Adequate histidine can be found in soundly grown forages, corn, barley, cottonseed meal, sorghum, soybean meal and wheat midds; for carnivores and omnivores, it is available in animal protein products such as fish meal and blood meal, etc.

Leucine and Isoleucine. These are two of the three branched-chain amino acids, the third being valine. They are the second and fourth most abundant essential amino acids, respectively, available in various feed sources. They are useful in the formation of hemoglobin and also contribute to the production of natural endorphins for pain.

Rich sources of these two amino acids are quality forages, brewer's grain, corn, barley, corn gluten, corn distillers, sorghum, soybean meal and wheat midds.

Phenylalanine. This amino acid, the third most abundant essential amino acid available in various feedstuffs, is the precursor of the amino acid tyrosine, which is associated with the production of dopamine, norepinephrine and epinephrine (adrenaline). These substances affect blood pressure, oxygen metabolism, blood sugar, fat metabolism, heart rate and multiple functions of the brain. The thyroid requires it for normal function.

Farm sources for phenylalanine are good forages, barley, cottonseed meal, wheat midds, sorghum grain, corn gluten meal, brewer's grain, miscellaneous nuts, pumpkins and beans (especially garbanzo, lentil, lima and soy).

Threonine. An essential amino acid that is capable of producing the amino acid glycine, an important amino acid for the brain. Threonine is an immunostimulant, promoting the health of the thymus gland, the master immune gland. It also inhibits fat accumulation in the liver, and is necessary for digestive and intestinal tract function.

Cereal grains are not the best source of this amino acid, and once again, good farm-raised forages are the key. Canola meal and brewer's grain are also sources.

Tryptophan. This amino acid is needed to synthesize nicotinic acid or niacin (vitamin B_3) and is also the precursor of the neurotransmitter serotonin, required for normal sleep and mood patterns. Deficiencies create poor skin pigmentation, poor digestion and brittle hooves.

The best sources for livestock are grass and legume forages, soybean meal, wheat midds, canola meal, brewer's grain and barley.

Valine. The third branched-chain amino acid (along with leucine and isoleucine), valine is required for proper nitrogen utilization in the body, muscle coordination, neural and mental function. It also acts as an anti-inflammatory.

Valine is the most abundant essential amino acid available in various feed sources, and again, its richest source is good forage. It's plentiful in most cereal and beans, as well.

PROTEIN SYNTHESIS BY LIVESTOCK

Feed ingredients vary in their amino-acid quality, and by incorporating various sources, livestock producers can better meet the animal's requirement. For ruminants, a sufficient proportion of the essential amino acids must "escape," or bypass, rumen degradation.

Table 3 illustrates rumen solubility or, conversely, nondegradability of various protein sources.

Although heating of grains seems to produce some measurable benefits, which include producing more bypass protein for ruminants and destroying certain enzyme inhibitors, there's another way of looking at this beneficial practice. Denaturing protein by heating it in order to make it less soluble is a practice predicated on the increase in silage production and feeding. This practice has had the opposite effect on protein quality than that of heating grains. Silage fermentation makes less-soluble proteins more soluble. Looking at alfalfa in this table, one can see how producing alfalfa silage dramatically increases the protein solubility as compared to making alfalfa hay. Fraction A (100-percent soluble) is nearly twice as high in the silage as hay. Conversely, the B2 (nondegradable) fraction is nearly twice as high in the hay as in the silage.

Thus, in a typical conventional operation, the bypass albumins and glutelins in the forages have been reduced, via fermentation, to highly soluble components that must be efficiently and quickly metabolized by the rumen micro-flora in order that they don't end up as blood urea nitrogen (BUN). Then, in order to balance the protein diet correctly, purchased bypass protein is needed so that rumen ammonia levels don't accumulate. Since the energy in these forages is typically low, purchased energy in the form of acid-forming starch is needed to supply rumen microbes the quick source of energy they require to accommodate this excessively soluble protein.

And so it goes. If grass silage is a necessity on the farm, if it has been grown with ecologically sound principles, it will have a lot more rumen-friendly energy such as sugars, polysaccharides, cellulose, hemicellulose, pectins, etc. It will also have the correct mineral ratios — N:S; Ca:K; Ca:Mg; Mg:K; K:Na — plus the important trace minerals that are not found in adequate levels in conventionally grown grains and forages, such as copper, boron, manganese and zinc. It seems to me that mineral-rich, balanced forages in the form of pasture and hay provide an amazing myriad of economic solutions to the complicated feed dilemma in which we find ourselves. We can produce inexpensive feed that allows animal productivity to pay its way, while we and our livestock enjoy the benefits of optimum livestock health, good conception rates, and livestock longevity.

As Table 3 illustrates, forages are excellent sources of bypass protein as compared to grain on a percentage basis. Recognizing that the GI tract is a complex of ecosystems and that feeding to maximize the health of those ecosystems will greatly contribute to how efficiently a milk cow, steer, hog, ewe, goat or horse will perform with regard to rate of gain, milk production, fertility, longevity and so on.

Reprinted from
ACRES USA
A Voice for Eco-Agriculture
February-April 2004 • Vol. 34

For example, it really needs to be emphasized that microbial protein — that is, protein produced in the rumen by healthy, high populations of rumen microbes — is a high-quality bypass protein that escapes rumen degradation and is absorbed in the small intestine. Why are so many stockmen, especially dairymen, purchasing excessive amounts of expensive bypass protein when their forages and their cows make the best there is? As much as 3 to 3.5 pounds of high-quality microbial protein can be synthesized per day in the rumen of a mature Holstein dairy cow, and it's 100 percent bypass!

Stockmen have been led to believe that the production-limiting factor is protein, when in fact (especially regarding ruminants) the limiting factor in nutrition is energy, *i.e.* being able to efficiently capture, transmit, and store the sun's energy in grasses and legumes.

CREATING QUALITY PROTEIN ON THE FARM

Creating both quality and quantity of protein on a farm involves incorporating the following disciplines:

First, make sure that your soils are properly mineralized and balanced. A proper balance should include ample levels of major minerals such as calcium, phosphate, potash, sulfur, magnesium and nitrogen, as well as minor nutrients such as boron, copper, zinc, manganese and perhaps iron. Minerals such as selenium, iodine, cobalt and chromium, considered non-essential for crop production, are important for livestock health and should be considered as "fertilizers" that can enrich forages.

Second, many pastures and meadows that were once in row crops suffer from having a plow pan. Ripping that pan using a narrow shank with a coulter cutter in front will open up these soils so that roots can dive deep into the subsoil, with its rich moisture and nutrients. This procedure will cause little damage to the pasture and will greatly increase forage quality and drought resistance. Applying a liquid biostimulant in the grooves made by the shank will facilitate this process. Suitable biostimulants could be a mixture of liquid calcium, humic acids, molasses and kelp; or a well-brewed compost tea. Andre Voisin, in *Soil Grass and Cancer,* demonstrates the importance of sulfur in producing quality alfalfa (lucerne), especially with regard to the presence of methionine.

Tables 4 and 5 clearly show that as sulfate levels in solution increase, so does methionine — up to a given threshold. Likewise, higher levels of methionine are found in samples with the lowest nitrogen (crude protein), which clearly illustrates that high levels of crude protein do not necessarily imply high-quality protein.

Soils that were treated with calcium and phosphate were likewise producing crops measurably higher in the amino acid tryptophan. Voisin suggests that not only does the extra tryptophan mean higher quality protein for the animal, but since tryptophan is very similar to indoleacetic acid, a growth hormone for plants, it also produces a higher yield of forage.

Another trial measured the influence of Boron on tryptophan content of alfalfa. The tryptophan levels actually doubled when boron concentrates in the nutrient solution were increased from .22 ppm to 1.08 ppm.

I'm usually wary of looking at nitrogen as the primary fertilizer to be used on pastures, especially if there is a healthy mix of legumes, grasses and herbs. Voisin's experiment on Italian ryegrass (a non-legume monoculture), however, does illustrate that applying higher levels of nitrogen as either nitrate of soda or ammonium sulfate improved not only the crude protein, but also the levels of seven amino acids, indicating — in this case, anyway — that crude protein and quality protein were associated.

A caveat on these tables from the Voisin text: some of these tests were done in an "in-vitro" arrangement, that is, a hydroponic design that doesn't mimic an actual soil ecosystem and the tremendous dynamics of the soil foodweb, which recycles, mobilizes, and transforms nutrients, works symbiotically with plant roots, and provides a much more efficient system of nourishment. It is my belief that crops adequately nourished from a biologically active and mineralized soil will be even more effective in increasing the nutritional density of plants grown upon them.

Looking at a forage sample will help determine protein quality. First, examine the nitrogen-to-sulfur ratio. Ideally, it should be a maximum of 10 parts of nitrogen to one part sulfur. To determine nitrogen, divide crude protein by 6.25 *(e.g.,* crude protein = 21% ÷ 6.25 = 3.36% nitrogen x .10 = 0.336% sulfur, the minimum desirable level). Many forages contain an N:S ratio of 13:1 or higher. The extra nitrogen is suspect of being non-protein nitrogen, which completely degrades into rumen ammonia and possibly blood ammonia (blood urea nitrogen, or BUN) for ruminants and mono-gastrics.

While you're looking at the N:S ratio, take a look at the calcium levels. William Albecht, Ph.D., of the University of Missouri noted that calcium was the delivery system of all the other nutrients taken up by plants and demonstrated that the calcium-rich soils of the Great and High Plains produced high-protein forages.

If calcium uptake is the key to quality protein production, then we ought to examine forage for actual calcium levels and subsequently the expected higher levels of magnesium, phosphorous, silica and trace minerals such as boron, copper, zinc, cobalt, iron, manganese, iodine, selenium and molybdenum. The difference in forage calcium levels varies tremendously, in my experience.

Forages grown on mineral-deficient soils should be foliar fed the appropriate minerals to meet these deficiencies, while the soils can be economically restored with the requisite applicable minerals.

Excessive potassium in soils will especially depress calcium, magnesium and boron in forages. This will produce forage of a lower quality protein, as we have just witnessed in Voisin's research. In addition, excessive potassium is toxic to dry dairy animals and will affect the blood levels of magnesium and calcium. Additional suppression of calcium and magnesium in cows is associated with BUN or blood ammonia levels being too high. A general rule of thumb would be a calcium-to-potassium ratio of 1:1 in legumes and 1:2 in grasses; and a calcium-to-magnesium ratio of 3:1 or 4:1 in legumes and 2:1 in grasses.

A prevalence of mycotoxins (mold poisons) has been observed with high-potassium forages. Some cattlemen have attempted to address excessive potassium (cation) levels by increasing chloride (anion) levels. In these instances, it was reported that forages were showing high

Table 4: Influence of Sulfate Ions in Nutrient Solutions on Methionine Content in Lucerne

Sulfur (ppm)	Methionine (mg per gram of dry matter)
0	1.96
16	4.5
32	5.01
64	5.37
96	4.61
128	2.70

Source for all tables: Andre Voisin, *Soil Grass and Cancer*

Table 5: Influence of Sulfate Ions in Nutrient Solution on Total Nitrogen, Cystine & Methionine Content in Lucerne

SO_4 ions (per 1,000 parts)	Nitrogen (% of dry matter)	Sulfur (% of dry matter)	Methionine (mg/g of N)	Cystine (mg/g of N)
0	3.96	0.096	28.1	27.8
1	3.66	0.097	36.3	34.2
3	3.10	0.099	38.3	48.1
9	2.88	0.122	56.4	67.3
27	3.0	0.138	54.1	66.0
81	2.91	0.206	55.9	65.5
Mean	3.25		44.9	51.5

potassium levels (*e.g.,* 3.5 percent) and low chloride levels (*e.g.,* 0.24 percent).

By adding extra chloride in the form of potassium chloride (muriate of potash) at the rate of 200 pounds per acre, chloride levels rose to 0.34 percent and cow performance improved, presumably because the cation-anion balance was improved. In addition, the presence of molds decreased, allegedly due to the potassium chloride additions.

This is a classic case of a "Band-Aid" approach to a holistic problem. Since potassium chloride is the source of the chloride, the problem won't go away. Why? The potassium levels will never drop, and calcium and boron will be suppressed by the excess potassium. The reason mycotoxins are showing up is because the two primary protectant minerals against fungal invasion of the cells of that forage are calcium and silica and secondarily sulfur and copper.

Adding gypsum and burnt lime along with borax and copper sulfate (if soil copper is low) would be a better approach. If there is a need to Band-Aid the problem, applying 50 to 100 pounds of rock salt per acre in addition to the other amendments would be a better alternative than potassium chloride — the sodium is needed by the cattle anyway, it's more aggressive than potassium at getting into the plant, and it will raise depressed chloride levels just as readily as muriate of potash without increasing toxic levels of potassium.

My feeling is that the preferred anion to be taken up by plants would be sulfur, since crops use as much sulfur as they do phosphate. Providing a pantry of all appropriate minerals and in the right amounts/rates not only reduces the risk of mold toxicity, but provides the required amounts of calcium, phosphate, sulfur, boron and other traces as well as keeps the excessive potassium levels in check and encourages the ideal nitrogen to sulfur ratio thereby insuring the production of quality protein instead of non-protein nitrogen ("funny protein").

BUN: RUNAWAY ROGUE PROTEIN

Blood urea nitrogen (a.k.a. blood ammonia, or serum urea nitrogen) is a significant problem in modern animal agriculture. BUN has serious implications for livestock growth, production, lactation and fertility. Ammonia (NH_3)+ is a cation that has a positive charge like calcium (Ca++), magnesium (Mg++), and potassium (K+), important mineral ions that are maintained at critical ratios in the blood.

In *Grass Productivity,* Andre Voisin states that grass tetany (which is associated with magnesium deficiency) can be caused by an excess of ammonia dropping the blood's content of magnesium as well as causing a poisoning of the bulbar respiratory center. Plants accumulate nitrates due to stress, such as drought. Plants produce more NPN (non-protein nitrogen) instead of true protein when there are excesses in soil minerals such as potassium and nitrogen, or deficiencies in minerals such as calcium, sulfur and boron. If the magnesium levels are excessive in the soil, for example, the plant would accumulate either additional nitrate and/or NPN. This same plant will most likely be deficient in magnesium, which is necessary to prevent grass tetany, even though the soil contains an excess.

University of Pennsylvania researchers concluded in the mid 1980s that dairy cows with serum urea nitrogen levels above 20 milligrams per deciliter (100 milliliters) at the time of breeding were three times less likely to conceive. This is especially true for older cows. For virgin heifers, however, the threshold is only 16 milligrams per deciliter. Blood ammonia interferes with conception because it is toxic to the fertilized egg. It also interferes with vitamin A metabolism and suppresses phagocytosis of macrophages, the neutralizing of pathogenic organisms by certain white blood cells. John Whittaker, D.V.M., appropriately called this phenomenon “lazy leukocyte syndrome.”

This build-up of blood urea nitrogen is also a good substrate for growing pathogens, even as it inhibits an immune response. Vitamin A is important in the replication of new cells in the lining structures (epithelia) of the body *(e.g.,* the gut, uterus, vagina, mucosal passages such as the nose, trachea and esophagus, the udder, the eye). Vitamin A is also an antioxidant that neutralizes harmful free radicals, preventing them from damaging cells, and enhances the immune response. It is also necessary for normal follicular development in the ovaries. Most livestock ingest vitamin A in the form of carotene (the orange pigment in plants which is the precursor of vitamin A). In order for carotene to be absorbed into the system, it must be attached to a protein complex, which must come from quality protein sources — not non-protein nitrogen, which yields BUN.

Blood ammonia, being quite toxic, is quickly converted by the liver, which converts it to less toxic urea, which is then converted to uric acid via the kidney prior to excretion.

Table 6: Influence of Calcium & Phosphorus in Soil on Tryptophan Content in Agrostis

Calcium	Phosphorus Tryptophan (mg/g) High	Medium
High	2.65	2.38
Medium	2.21	1.88
Low	2.09	1.38

Table 7: Influence of Boron on Tryptophan Content in Lucerne

Boron in the nutrient solution (ppm)	Tryptophan (mg/g)
0	1.27
0.22	1.36
0.44	2.17
1.08	2.55

The rumen schematic below illustrates the pathways of true protein and non-protein nitrogen through ruminants. As one can see, 60 percent of true protein degrades into ammonia in the rumen to feed rumen microbes, which in turn become microbial protein for the animal. Forty percent bypasses the rumen to be absorbed in the intestine. In contrast, 100 percent of the NPN in feeds degrades into rumen ammonia and, if it is not metabolized by rumen microbes, passes directly through the rumen wall, thus eventually becoming BUN. This phenomenon is a big reason why contemporary nutritionists want to know how much soluble versus bypass protein is in the ration. You need enough to feed the rumen microbes, but too much is not only a waste, it is also detrimental to production, reproduction and longevity.

Often, a dairyman is perplexed when he changes his feeding program, which might consist of, say, replacing an 18 percent protein dry hay with 22 percent protein grass silage, after which milk production begins to drop. What is happening is that the extra “protein” is either NPN or highly soluble protein, which is showing up as BUN. The liver is working overtime to remove the BUN, and this additional work requires *energy,* which must come from the diet. Since you can’t spend your paycheck on two things at once, the energy that would have been “spent” to make milk or growth is diverted to detoxification, because maintaining one’s life is more important than extra production.

Dairies that commercially produce and sell milk have historically been compensated on quality by the amount of protein their milk contains. The measurement of milk protein was originally determined by the formula:

Crude milk protein = N x 6.38

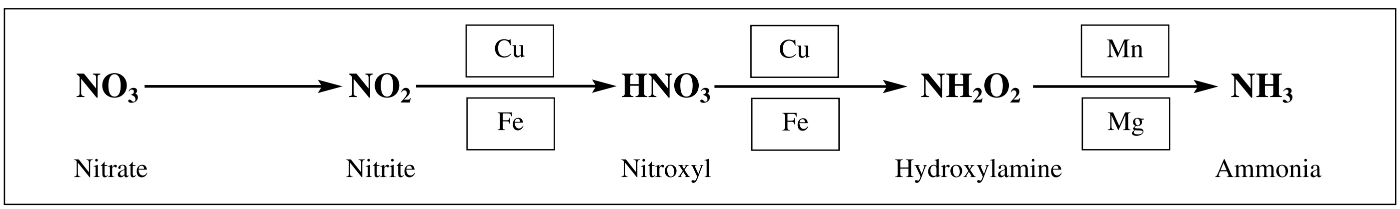
This is similar to the formula for determining crude protein in the feed. Lately, however, the milk industry has modified the criteria for milk protein because they recognize that this protein isn’t merely nitrogen — 50 to 85 percent of the total protein should be casein. Other milk proteins include serum albumin, immunoglobulins and non-protein nitrogen. As casein levels drop in the milk due to udder infection, the free amino acids will increase dramatically, especially alanine, asparagines, isoleucine, leucine and proline.

One cannot economically get good cheese yields from a high-protein milk if that protein is a non-protein nitrogen (NPN) compound and not casein. Consequently, there is a corollary to the Blood Urea Nitrogen test called the Milk Urea Nitrogen (MUN) test. Dairy producers can have their cows tested individually on a monthly basis to monitor MUN and thereby make determinations as to how to adjust the ration. Ecological dairymen can use the test to determine how effective their forage/soil programs are, that is, how efficiently their forages are synthesizing peptides, polypeptides and other amino-acid complexes that create a quality feed for livestock. MUN levels are often looked at to determine whether or not a ruminant feed ration needs to be adjusted. If the MUN level is too low, then one would be advised to feed more soluble protein such as alfalfa silage or soybean meal (and even urea); if the MUN

Table 8: Nitrogen Fertilizer & Protein Content in Italian Ryegrass

	Without Fertilizer	Sulfate of Ammonia		Nitrate of Soda	
Nitrogen application per Acre (lb)	0	19	39	19	39
N% in dry matter	2.5	2.6	3.0	2.9	3.1
Total N% (of x-amino N) in Amino Acids					
Leucines	9.4	10.1	11.2	9.8	11.7
Phenylalanine	2.0	2.4	2.5	2.5	2.4
Tryptophan	0.8	1.1	1.2	1.3	1.3
Aspartic acid	5.7	4.9	4.3	4.9	4.0
Glutamic Acid	7.2	6.1	5.9	6.0	5.0
Arginine	4.2	5.0	5.1	4.9	5.3
Lysine	2.9	3.3	3.4	3.6	3.4

Reduction of Ingested Nitrates



levels are considered too high, then the advice would be to feed more "by-pass" protein (such as corn distillers) and/or higher levels of non-structural carbohydrates to provide rapidly available source of energy to balance the excessive soluble protein indicated.

These levels are typically set at:

<12 ppm — too low

13-14 ppm — ideal range

>15 ppm — too high

These values are appropriate for bulk samples representing the herd. Individual cow levels for MUN can vary a great deal.

My experience has been that ruminants consuming ecologically raised forages as pasture, hay and silage are not going to be as challenged by MUN gyrations as a herd fed forages raised conventionally, in which calcium, magnesium, phosphorous, sulfur and trace minerals are low, and potassium, iron, aluminum and NPN are high.

If the BUN is originating from actual nitrates (NO_3) from contaminated water or toxic silages rather than from the NPN or soluble (degradable) protein that is often fed excessively to ruminants, the results can be the same, or worse. When nitrates are ingested, they are quickly reduced as the "Reduction of Ingested Nitrates" formula (at left) illustrates.

In this case, nitrate reduced to nitrite combines with hemoglobin, which then is no longer capable of carrying oxygen to tissues. Eventually it is further metabolized to BUN, which then must again be detoxified by the liver and kidneys. This nitrate syndrome creates a condition known as anoxia. Simply put, there's an oxygen deficiency to the cells, and symptoms such as respiratory illness *(e.g.,* shipping fever) or abortions or chronic mastitis appear. Vaccines in these cases are not going to do "squat" — the animal's cells are dying of asphyxiation. In fact, vaccines could aggravate the symptoms by temporarily lowering the immune response.

The proper treatment is often neglected because the cause is never addressed. We are too preoccupied with hunting and killing "bugs," when in fact an approach that addresses a metabolic problem's origins in the soil or water or an incorrect feeding practice is what is desperately needed.

REDUCING NON-PROTEIN NITROGEN IN PASTURE

Every stockman has observed the lush, deep green ring of grass growing around a cow pie, the result of excessive nitrogen. Cows won't touch it unless they're forced to because this "feed" is too high in non-protein nitrogen (NPN) or nitrates and has poor cation-anion balance of minerals. Meanwhile, the conventional stockman grows his corn and alfalfa silages with similar imbalanced fertility and then forces his cattle to consume it with the most sophisticated automated machinery. He then watches in horror as they become ill and typically tries to rescue them with ever-more exotic feedstuffs such as animal fat, feather meal, buffers and the like.

Table 9: Symptoms Regularly Experienced by Workers in Pig Confinement Units

Symptoms	Percent of Surveys
Cough	67
Phlegm	56
Sore Throat	54
Runny Nose	45
Burning or Watering Eyes	39
Headaches	37
Chest Tightness	36
Shortness of Breath	30
Wheezing	27
Muscle Aches & Pains	25

Source: K.J. Ponham and K. E. Gustafson, "Human Occupational Hazards from Swine Confinement," Annals of the American Conference of Governmental Industrial Hygienists, *vol. 2 (1982): 137-142.*

If that doesn't do the trick, he then pumps them full of antibiotics, vaccines, steroids and other nefarious substances that at best only temporarily ameliorate symptoms and at worst suppress the vital force.

PREVENTING/REDUCING NITRATES & NPN

Since this problem really originates in the soil, let's begin there to address this concern.

First, make sure that minerals such as calcium, magnesium and potassium are in the proper balance. The base saturation of calcium should be approximately 65-75 percent, magnesium 12-15 percent, potassium 3-5 percent. Phosphorous and sulfur should be at 50-100 pounds/acre. Boron should be at 2-3 ppm (or 4-6 pounds/acre).

If the soil has a hardpan or plow pan, subsoiling will allow mineral salts, especially nitrogen, to leach out of the zone where the pan causes a salt accumulation. These conditions can stress the roots with an excess of mineral salts and encourage a surplus uptake of nitrogen. Of course, subsoiling does other wonders such as bringing oxygen down to the roots, and allowing roots to penetrate into the subsoil, where there is more moisture and micronutrients. More organic matter will also be produced by the additional root growth and more earthworm activity in a larger soil profile will be seen. This deeper soil profile will also weatherproof a crop from excessive moisture by encouraging better drainage as well as from drought by creating capillary action that draws water up into the root profile.

It is crucial to use caution if herbicides are used, particularly those that contain growth-promoting plant hormones *(e.g.,* 2,4-D). They can cause a rapid uptake in nitrates, especially in plants that receive a sub-lethal dose.

Try to harvest or graze forages late in the afternoon. Research has shown that higher sugars are present at that time, and much of the NPN has had a chance to convert to true protein. The sugars are the primary energy source (particularly in ruminants) for the microbes that will ingest rumen ammonia, converting it into high-quality microbial protein.

Nitrates tend to accumulate in the lower parts of the plant, so if there is reason to suspect the crop is laden with nitrogen compounds, raise the header or cutting bar at harvest. Young growing plants usually have higher levels of nitrates when compared to older, more mature plants.

Consider ensiling forages suspected of nitrate contamination. Although making silage tends to create more soluble protein in the forage than is in fresh pasture or dry hay, lactic-acid-producing bacteria are more efficient at reducing nitrates into volatile gasses. Microorganisms reduce nitrate (NO_3) to nitrite (NO_2), which is then rapidly dissipated in the form of nitrogen-oxide gases (NO).

Ensiling feeds has been shown to decrease total nitrate content by 30-70 percent. Allow at least three weeks of fermentation to occur before feeding this silage to livestock. The optimum moisture range for alfalfa hay is 60-65 percent; corn silage, 65-75 percent; oats, barley, sorghum and other cereals, 65-75 percent. Keep in mind however, that nitrate (NO_2) is quite toxic and can cause silo gas poisoning. Levels considered "safe" for human exposure are approximately 10-25 ppm, whereas silo gas levels from nitrate-rich forages can be as high as 4,000 ppm. The danger is exacerbated because NO_2 gas is heavier than air and can concentrate as brownish fog or gas at levels of up to 100,000 ppm. Always use caution around silos that have not been ventilated. Be careful when opening silos, bags or pits and allow for adequate ventilation before working in those areas.

The other side of this coin is that making silage out of grasses and legumes not high in nitrates, but typically high in soluble (rumen-degradable) protein, converts more of that protein into NPN-type compounds. That's why I prefer quality pasture and hay.

Nevertheless, when making silages out of forages rich in soluble protein or suspected of high NPN and/or nitrate levels, use the following additives per ton of silage:

- 10-20 pounds of molasses
- 10 pounds of finely ground calcium carbonate
- 2 pounds of gypsum (calcium sulfate)
- A proven, quality silage inoculant

The calcium carbonate provides a buffer, causing the microbes to work longer and harder to provide higher levels

Table 10: Nitrate Levels in Forages for Cattle

Nitrate-Nitrogen* (ppm)	Recommendations
<1,000 (<0.1 percent)	"Safe" to feed to all cattle (emphasis added)
1,000-1,500 (0.1-0.15 percent)	Safe to feed to non-pregnant cattle. Limit use for pregnant cattle 50 percent to ration dry matter
2,000-3,500 (0.2-0.35 percent)	Should not be fed to pregnant cattle. Can be fed to non-pregnant cattle if limited to 25 percent of total ration dry matter.
3,500-4,000 (0.35-0.4 percent)	Should not be fed to pregnant cattle. Can be fed to non-pregnant cattle if limited to 25 percent of the total ration dry matter.
>4,000 (>0.4 percent)	Do not feed to any class of cattle

****Formula to convert nitrate to nitrate-nitrogen: Nitrate x 0.23***

Source: R.O. Kellems and D.C. Church, Livestock Feeds and Feeding, *4th ed., 1998*

Caveat: I would tend use this chart very conservatively, because, again, I'm interested in the "big picture" of what is stressing that particular herd (i.e. molds, acidosis, other sources of BUN, etc.)

of lactic acid — a great preservative and a source of lower gut energy. Microbes will be able to do this as long as they have a source of quickly available energy, provided here by the molasses. The gypsum supplies sulfur that can be more efficiently used in digestion, as part of the silage matrix, rather than feeding inorganic sulfur directly.

If rain follows a period of drought, delay harvest for three to five days to allow nitrates to be reduced in forages.

In addition, remember that oats and sorghum have a tendency to accumulate higher levels of nitrates than other crops.

Be prepared to foliar feed a crop if essential nutrients such as calcium, boron, phosphorous, magnesium and other trace minerals if the soils aren't up to par, or of there's climatic stress such as drought, inhibiting uptake. Fish and seaweed would also be useful in the foliar "soup" to provide auxins, cytokines and other plant hormones helpful to stressed crops.

Remember that confining animals indoors creates an airborne problem associated with BUN. Atmospheric ammonia is a serious concern in the industrial model of livestock production. Ammonia is primarily produced by the hydrolysis of urea by the enzyme urease, the other by-product being carbon dioxide. The organically bound nitrogen in the manure is the other ammonia source, although the breakdown of manure by anaerobic digestion is a slower process.

To make a point regarding protein quality and how it relates to BUN, research has demonstrated that lowering the crude protein (CP) level in a pig ration while supplementing with synthetic amino acids reduces urea excretion and results in lower ammonia concentrations in the slurry and lower emissions of ammonia in the lagoon.

In a 1997 study conducted by A.J.A. Aarnink at Wageningen University, nitrogen was reduced by 28 percent when crude protein levels in a hog ration were reduced by 3 percent (from 13 to 10 percent) while the diet was supplemented with lysine, methionine, threonine and tryptophan. Other tests indicated a 40 percent reduction of manure nitrogen when crude protein levels were reduced from 18 to 10 percent using synthetic amino acids as supplements.

This clearly demonstrates that, even in monogastric animals, quality protein creates less nitrogenous "waste," which translates into blood ammonia and ultimately ammonia vapor in the urine/manure. Interestingly, ammonia levels are regulated in the United Kingdom in order to protect the respiratory health of workers. Workers are limited to no more than 25-35 ppm for 10 minutes daily. Ammonia levels above 35 ppm require the worker to enter the building with a respirator. Meanwhile, the livestock are supposed to be OK in this environment, 24 hours per day, seven days a week. Table 9 shows the incidence of respiratory symptoms experienced by workers in pig confinement units.

As an aside, another interesting, but tragic, bit of trivia is that up to 1990 more Scottish pig farmers died of lung diseases than did Scottish coal miners!

Research from the Royal Veterinary and Agricultural University of Denmark has demonstrated that even extremely short durations of exposure to ammonia can be harmful to livestock. Exposure to 50 ppm ammonia for 20 minutes per day on only four occasions seriously impacted the performance (feed conversion and rate of gain) of pigs between 37 and 90 kilograms liveweight. Other experiments demonstrated that atmospheric ammonia delayed puberty of pigs at as low as 20 ppm.

Keep in mind that if ammonia levels are elevated in the atmosphere, oxygen levels are simultaneously suppressed. Oxygen (O_2) outdoors approximates 20-21 percent of total gases. At that level, viruses can only travel 5-6 inches before they're oxidized out of existence.

Dropping O_2 levels by 1-2 percentage points allows that same virus to travel 500-600 feet before being neutralized. Imagine the filthy, immuno-suppressive incubation chambers in which most of the civilized world's livestock are being raised, with an environment where the oxygen level is 17-18 percent, while the air ammonia level is 25-50 ppm! A real alarm goes off in my head when I walk into a barn in the winter and the olfactory sensor device known as my nose detects a very distinct presence of ammonia. I'm instantly suspicious that feeding practice and/or feed quality is problematic.

Is there any wonder that as industrial agriculture takes over the production of milk, meat and eggs, removing animals from the soil, fresh grass and herbs, sunshine and oxygen-rich air (so that they can be "more efficiently managed") that the sale and use of feed-grade antibiotics and vaccines is skyrocketing? Just what is it that folks are eating these days when they scramble some eggs, fry some bacon, and chase it with a glass of pasteurized, homogenized milk?

Needless to say, the ecologically sensitive farmer who has his or her livestock primarily outside where there's little or no ammonia, oxygen-rich air, fresh grass and legumes, and sunshine has placed no extra burden on the respiratory organs, liver, lymph or immune systems of the animals. These animals are happy and productive, not needing a plethora of drugs and vaccines, and they create a better bottom line for the farm and a wholesome, health-supporting, real food for customers.

FEEDING SUGGESTIONS

Always test your forages for nitrate levels if there have been conditions conducive to the formation of nitrates in feeds. While you're at it, have the water tested as well. In areas of the country where there is intensive conventional crop production, nitrates have now become the norm instead of the exception. The EPA has determined that 10 ppm is the "safe" limit for human consumption. There is controversy as to what levels are safe for livestock. The variable amounts of feed-related nitrate that the animal consumes affects how much nitrate it can tolerate in the water, and vice versa. In addition, ruminants are more tolerant of nitrates than monogastric animals. To be accurate, one has to determine not only the amount of nitrate, but also the level of stress from all sources in order to make conclusions as to how much nitrate in the water an animal can tolerate. Are acid-forming feeds involved? Any molds or mycotoxins? What are the ammonia levels (or oxygen levels) in the barn?

Remember, if the liver is "taking a hit" from any source or sources, its ability to remove all toxins is compromised. I've looked at dairy herds where the owner was understandably alarmed that their drinking water contained 45 ppm of NO_3-N (nitrate-nitrogen). On the other hand, I've had trouble convincing other owners that at least a part of their livestock's health issues were coming from drinking water containing 100 ppm. Frankly, if nitrates get too much above 20 ppm for ruminants and 10 ppm for monogastrics, I want to survey all the stressors in the operation and then make a judgment. Remember that nitrate levels in water can fluctuate depending on rainfall (or lack thereof), the depth of the well, and the amount of water in that vein. So if there's a problem, you may want to test periodically (at least once to twice a year) to make sure the water quality doesn't worsen. Based on a study published in the May 2001 issue of *Epidemiology,* I'm skeptical that there are "safe" levels of nitrate-nitrogen in water. That study shows that levels as low as 2.46 ppm may triple the risk for bladder cancer.

Refer to Table 10 and feed according to the recommendations if your feeds are suspected of being high in nitrates.

Provide a soluble source of energy such as blackstrap molasses either free choice or to be included in the ration at no more than 5 percent of the total. Cattle will easily consume 1-2 pounds/head per day if the ration is high in NPN. Make sure that this source of molasses does not contain any urea or NPN, as many lick tanks do. Blackstrap molasses is an excellent source of many bio-available minerals including copper, iron, zinc, calcium, etc.

I often will provide nutritional non-swelling clay (montmorillonite), which has the ability to absorb ammonia in the gut. This also provides a buffering property as well as numerous micro/ macro nutrients.

In the case of nitrates, feed an additional 30,000 IU of vitamin A supplement per 1,000 pounds of body weight daily.

Make sure the sulfur intake is adequate. Remember the 10:1 nitrogen-to-sulfur ratio in the forages (see last month's installment). For both ruminants and monogastrics, the sulfur deficit will have to be made up with methionine. I also like to see a free-choice sulfur supplement containing the following minerals: sodium sulfate, 30 percent; Dynamate (sul-po-mag), 25 percent; magnesium sulfate, 15 percent; calcium sulfate, 15 percent flowers of (elemental) sulfur, 10 percent; and salt, 5 percent. Provide sulfur-rich plants such as garlic (but not for lactation ruminants if you're selling the milk), horseradish, watercress, wheat bran and the mustard family, especially turnips, the greens of which are high in vitamin A.

Since BUN levels are bound to be high, providing magnesium is important because BUN can depress this element in the blood. Conversely, magnesium is necessary to reduce elevated levels of BUN. I would supply a free-choice mixture containing: dolomitic limestone, 60 percent; magnesium oxide, 35 percent; magnesium sulfate (Epsom salts), 10 percent; salt, 5 percent. This magnesium mixture also provides the benefit of buffering any acidosis (low pH) that may be present in the gut. In addition to properly grown grasses and legumes, feed supplements rich in magnesium are wheat bran, wheat germ, soybeans, pumpkin seeds and oats.

Considering that the liver and kidneys are going to be under additional stress to metabolize, detoxify, and eliminate this runaway nitrogen, certain herbs and other vitamin and mineral supplements would be advisable. The liver uses glutathione to assist in detoxification, which, in turn, requires sulfur-bearing amino acids (methionine/cystine).

Selenium is also necessary, and the preferred supplemental form is selenium-enriched yeast, which is more bio-available and less of a toxic risk than sodium selenite. Many stockmen, especially cattlemen, are mimicking their European counterparts by feeding two to four times as much selenium as is legally allowed in the United States, resulting in improved performance and resistance to disease. Be careful to insure that your forages are not grown on a soil with excessive selenium levels if you plan on supplementing selenium.

The feeding of choline is also quite beneficial, but ruminants require protected choline to prevent degradation in the rumen. Niacin and thiamin (vitamin B_1) are also indicated, as are biotin and vitamin B_{12}. All of the above are conducive to optimum liver health. Needless to say, this all starts to add up in cost and economically challenge the stockman faced with treating an entire herd or flock with these additional supplements.

Herbs for the liver, which can be available on the farm and quite effective, consist of chicory, burdock (leaf, root and seed), dandelion root, milk thistle, peony root, horseradish, rosemary, fennel and various mints.

Apple cider vinegar is also indicated, as it is liver detoxifying and activating. Approximately eight ounces per 1,000 pounds of body weight daily is recommended. Mixing the vinegar with the molasses and wheat bran and then supplying the herbs at approximately two to three handfuls of fresh herbs per 1,000 pounds of body weight daily are helpful.

To assist with the kidneys, kelp meal is excellent (at least four ounces per 1,000 pounds of body weight daily), parsley, dandelion leaf, radish, corn silk, cleavers (bedstraw), celery seed and small amounts of juniper berries.

Needless to say, BUN, whether from feeding excess protein, poor-quality protein, or forages high in nitrate can be economically devastating and cause untold amounts of suffering for livestock and frustration for the stockman. It is a relatively easy problem to prevent, if one first recognizes it as a soil fertility issue. Allowing livestock to have access to many diverse species of perennials, woody plants and miscellaneous wild herbs is clearly critical as well. Offering inexpensive free-choice supplements at all times will also provide additional buffering mechanisms that can help livestock neutralize feedstuffs, which may be harboring such culprits as NPN/nitrates, mold toxins and acid-forming concentrates.

Jerry Brunetti is managing director of Agri-Dynamics, which specializes in products for farm livestock and pets, and consults on a wide variety of other issues. He can be reached at Agri-Dynamics, P.O. Box 735, Easton, Pennsylvania 18044, phone (610) 250-9280, e-mail <jbrunetti@agri-dynamics.com>, website <www.agri-dynamics.com>.