Dairy Nutrition and Mineral Needs on a High Forage Diet

Karen Hoffman, USDA-NRCS

At first blush, it may seem that dairy nutrition for organic herds, or those who feed a high forage diet, would not be that different from "normal". In reality, however, there are some significant differences in the approach a nutritionist needs to take when developing a feeding program for these herds. It requires a shift in thinking from complexity to simplicity that is not typical for most nutritionists, who are constantly trying to keep up with the latest knowledge of all the intricacies of physiological, microbiological, and metabolic processes in the dairy cow.

About dairy nutritionists:

The typical dairy nutritionist's "path to knowledge" about the proper feeding and management of dairy cows usually starts in a college classroom. Of course, for those who grow up on dairy farms, or who participate in 4-H or FFA, there are some fundamentals that come along as part of inherent knowledge and experience. The formal instruction piece of the education, where the real complexities of the science are taught, usually involves sitting in a lecture hall with other college freshmen.

The course is usually called "Animal Science 101", and the students who take the course range from pre-vet students to those who want to go home to the family farm. There are many who end up somewhere in the middle, as dairy nutritionists, cooperative extension educators, agricultural sales reps, and so on. A few go on for advanced degrees and become college professors, perhaps teaching the very same courses they started taking as freshmen.

In Animal Science 101, or the equivalent, the basics of physiology and nutrition are taught. This includes the structure of the ruminant animal's digestive system – the four compartments of the rumen, reticulum, omasum, and abomasum. The functions of those compartments, as well as the intestines, liver, pancreas, and other glands and organs are explained. All eventual nutritionists learn early on that the rumen, and to an extent the reticulum, is a large fermentation vat with millions of bacteria, protozoa, and fungi. The purpose of the fermentation vat is to digest the fiber from the forages a ruminant eats, because the enzymes and acids in the other parts of the gut cannot breakdown or utilize the fiber. Thus, it is a symbiotic relationship between ruminant animal and micro-organisms – they work together so both can live. It is also how ruminants evolved to survive on a planet that grows many types of plants.

An understanding of fiber is taught – that it is made up of three primary components called cellulose, hemicellulose, and lignin. These components make up the cell walls of plants, and there are certain bacteria in the rumen that work to break down those cell walls by digesting the cellulose and hemicellulose. Lignin is almost completely indigestible by the bacteria, and is usually not discussed for long. Once the bacteria break down the cellulose and hemicellulose, it allows other bacteria access to the inside of the plant cells, where proteins, sugars, starches, and other nutrients are found. The fiber-digesting bacteria make compounds that the animal can use, called volatile fatty acids (VFA's), and the other bacteria use the cell contents to either reproduce themselves or to create a variety of other compounds for the animal to use. Undigested feed, bacteria, water, and the other compounds flow out of the rumen and into the rest of the digestive system for further digestion and absorption.

From there, Animal Science 101 covers the other nutrients that are needed by both the animal and the rumen bugs, but that have to come from feeds such as grains or other supplements. These are

protein, energy compounds, and minerals, and there needs to be a proper balance of these for the animal and rumen bacteria to grow, reproduce, and make milk.

These are the basics of dairy nutrition, and over the remaining college years there are more courses that future nutritionists take to increase their knowledge and understanding of the dairy system. These may include courses in soils, forage and crop management, and perhaps even some farm business management courses. They take advanced dairy nutrition courses as well, and learn some of the more complex concepts of dairy nutrition such as rates of digestion and passage of feeds from the rumen, protein fractions, amino acid requirements, and mineral interactions. They may take other physiology courses such as immunology, endocrinology, or reproductive biology to enhance their knowledge of how nutrition influences other aspects of animal health and performance.

These young dairy nutritionists then head out into the world and many of them become employed by feed companies, supplement manufacturers (i.e. minerals and other additives), or pharmaceutical companies, among many career opportunities. They learn even more through on-farm experiences helping dairy farmers to make more milk through feeding programs that are incredibly complex. After all, it is expected that cows should produce ever increasing amounts of milk, and the farmers will look elsewhere for purchased inputs if the nutritionist can't make them milk. They attend company-sponsored seminars to teach them how to make nutrition even more byzantine by using the company's products. They sell a broad range of expensive grain ingredients, additives, and the like that all promise to boost milk production.

Often there is little consideration given to the profitability of these complicated rations, or of the effects on the cows' health and well-being. The nutritionists become salespeople quite rapidly, and after a period of time lose their ability to remember the simplicity of what they learned in Animal Science 101. In addition, Universities sponsor conferences, or their Cooperative Extension Educators do, to promote the use of more and more complicated knowledge about balancing rations down to the smallest decimal point of the smallest nutrients. We use computer programs to model what is happening to, with, and in the cows, without accounting for the fact that cows don't know how to use a computer, read a printout, or ever agree to eat and produce the exact amount of milk we have balanced the ration for. Dairy cows become reduced to a technological item used for company profits, rather than animals with individual needs, behaviors, or personalities.

This is both a harsh reality and a radical thought, that perhaps we have become too "techie" when it comes to feeding cows. Fortunately, we have a way to recapture the basics we once learned in Animal Science 101, and to apply them to farms that are looking for a simpler and more profitable method of dairy farming – organic.

Keeping it Simple:

Organic dairy production quickly takes us back to the basics, as it requires cows to live, eat, and make milk in their natural environment. Pasture is a requirement in organic production, and that is both the most natural environment for her to live in and the most natural feed for her to eat. Of course, in the winter she cannot be on pasture, so stored forage needs to be fed. On organic farms, it is usually dry hay and either baleage or haylage. All of these forages can be consumed in large amounts, given the right quality. All of these forages can be digested by the cow, as that is what she and her rumen microbes evolved to do.

The reaction of most nutritionists when faced with a pasture diet or a high forage diet based on hay is to try to complicate the ration. The quality of pasture is too high, so it must be complicated and we need to feed all kinds of fiber, bypass protein, and fats to keep milk production high. A hay based diet is too low in quality, so we need to get some corn silage or alfalfa haylage in the diet to ensure the cow makes a lot of milk, and then supplement with a complex grain mix and lots of minerals. There's a good reason many organic herds don't utilize a nutritionist and take a "D-I-Y" approach. Remember, if you stick with the basics, it's really not so hard.

First, eliminate the idea that organic dairy cows need to produce a lot of milk for the farmer to be happy. There are organic farms that have high production, so it is possible, but assume that production is not the goal. The goal is to have healthy cows on a high forage diet with a minimum of purchased inputs. Although the organic milk price is higher than conventional, it doesn't mean that costs of production are irrelevant. Organic grain prices are very high (currently), and the feed to milk price ratio is actually tighter than in conventional. Many organic dairy farms are trying to OPTIMIZE milk production based on the quality of forage they have and supplement with smaller amounts of grain to maintain body condition or breeding performance. They are concerned about minimizing stress, and maintaining the immune system, as there are fewer options for treating sick cows. A high forage diet does this for most farms, and can also be profitable with less grain fed, and less milk produced.

There are some tangible benefits of high forage diets that nutritionists don't typically think about. One of these is rumen pH, and most of the time we're worried about it being too low because we feed high levels of grain or silages that are chopped too fine. Fresh grass has a neutral pH, and the particle length is usually well over an inch. Although the NDF level is usually low, it is offset by these characteristics of the forage. Further, a dry hay or baleage-based diet is also neutral to only slightly acidic, and has long particle length as well. This reduces the chances of sub-acute rumen acidosis (SARA) from occurring, even when grain is fed separate from forage. Some studies have shown that there is an increased inflammatory response in cows with SARA, which may affect overall immune system response when challenged.

Corn for silage is a difficult crop to grow organically, so many organic dairy farms do not have corn silage to feed and rely mainly on hay-based forages. However, those who do grow and feed corn silage are fairly judicious in the amount they feed, as they do not want to cause rumen upset due to the acidic nature of this feed. Many of them only feed enough to keep the silage fresh as it's fed out, or reserve most of it for feeding as an energy source during the grazing season.

Thus, the basic principle of high forage intakes on organic dairy farms is to grow, harvest, and store the highest quality pasture or hay crop. The first indicator of forage quality to look at is the NDF level, as it is an excellent tool to use to predict intake. The following table shows some typical forage qualities for pasture and hay crops.

Forage	**% Protein**	**NE_l, Mcal/lb** (Energy)	**% NFC**	**% ADF**	**% NDF**
	goal	**goal**	**goal**	**goal**	**goal**
Managed pasture: spring & fall	>25	0.68	17	25	<45
Managed pasture:	>20	0.64	15	30	<50

summer					
Dry hay – grass/mixed legume	13-18	0.52-0.61	15-20	35-42	50-60
Dry hay – alfalfa	20-22	0.55-0.58	22-25	33-35	42-47
Grass/legume haylage or baleage	16-18	0.49-0.58	18-22	32-38	49-55
Alfalfa haylage/ baleage	21-23	0.55-0.61	22-28	30-35	37-45

Note the column for NDF is shaded, and all the nutrients are listed as goals. Forages that meet these goals are generally well-suited for organic rations, as they will allow cows to achieve a high intake and provide other nutrients for production. The contribution of nutrients from forages also reduces the amount of nutrients that will need to be supplied by grain.

Cows on well-managed pasture can eat up to 1.4% of their body weight in NDF, and approximately 1.1 to 1.2% when fed stored forages. Thus, if the NDF value of the forage is known, it is relatively easy to predict how much of that forage the cows should eat. Here are two examples:

Pasture-based – forage NDF value of 43.6% and cows weigh 1200 pounds
1200 lbs x 1.4% = 16.8 lbs of NDF
16.8 lbs NDF ÷ 43.6% = 38.5 lbs pasture DMI

Baleage-based – forage NDF value of 52.3% and cows weigh 1200 pounds
1200 lbs x 1.2% = 14.4 lbs of NDF
14.4 lbs NDF ÷ 52.3% = 27.5 lbs baleage DMI

There's a difference of almost 11 pounds in potential dry matter intake from these two forages, simply based upon NDF! The 11 pounds of intake may end up being compensated for through grain supplementation – the question next is what the percent forage is in the total diet.

If we use the benchmark of total dry matter intake near 3.5%, these cows can potentially eat 42 pounds of dry matter. The cows on pasture then can eat a diet that is 90% forage, and on baleage the diet will be 65% forage.

These calculations should be the basis of formulating the rest of the diet, and ensuring that the cows are fed adequate protein and energy. The cows on pasture are likely to be meeting their protein needs, so energy will be the main nutrient to feed. The mental challenge for most nutritionists will be that the ration may not be balanced for a specific level of milk production, rather the high forage diet may determine how much milk can be produced. It is almost like thinking in reverse. Of course, if the farmer feels he needs to ship more milk than what the high forage ration will support, more grain can be fed to achieve that. Forage should not be less than 55 or 60% of the diet, however. The bottom line is these diets should lead to good animal health, and adequate profits for the farm, which may be the most important outcomes.

Minerals:

There are three main sources of minerals in the world – rocks, soil, and water bodies – at least in the beginning. Most of the time when nutritionists consider minerals, it is in the form of those mined from rock sources that are added into grain mixes or other supplements. Organic management requires that any mineral supplement or pre-mix be approved by the farm's certifier. The list of approved supplements is constantly changing, and different certifying agencies accept different supplements. Salt must be from a naturally mined source, and approved minerals do not contain anti-caking agents, such as yellow prussiate of soda.

In an organic dairy, minerals are more important to maintain healthy animals. A mineral imbalance, either in excess or in deficit, will weaken the immune system contributing to other health problems. The major minerals required include calcium, phosphorus, magnesium, potassium, sodium, chlorine, and sulfur. They all play key roles in various metabolic processes, as well as in the structure and function of different tissues and body fluids. Trace minerals include cobalt, copper, iodine, iron, zinc, manganese, molybdenum, and selenium, and are important for the function of enzymes and hormones in the body. Since they support immune function, an imbalance could have a negative health impact.

The primary vitamins are Vitamin A, D, and E, and are important for immune cell function and many metabolic pathways. Usually these vitamins are supplemented to meet the animal's requirements, however this is somewhat based on confinement feeding strategies. The advantage of grazing in an organic system is that the precursor of Vitamin A is ß-carotene, which is plentiful in the green chlorophyll of fresh pasture, and Vitamin D is synthesized by the skin when exposed to sunlight. Thus, during the grazing season, a reduction in vitamin supplementation may be appropriate (except for Vitamin E, which needs to be supplemented year-round), but vitamins should be increased again upon returning to winter confinement feeding.

Plants take up minerals from the soil as well, and thus become a source for herbivores, carnivores (who eat herbivores), and omnivores (who eat almost anything). It seems that these minerals are sometimes given less attention from nutritionists, because the focus is on adding minerals that are "deficient" in forages. Typically the focus is on calcium, phosphorus, magnesium, and potassium, and then trace minerals and vitamins are added via a "pre-mix" or through a trace mineral salt. The trace minerals from forage are not typically assessed or used for balancing the diet to any great extent.

A goal of most organic farms is to have soils that are well mineralized. This means the soil is at the proper pH, has high organic matter content, and that it has all the minerals plants need to grow. When the soil is balanced in this way, it is easier for the plants to take up both major and trace minerals, which then make them available for animals in a more natural, easily utilized form. The process of creating well-mineralized soils can be very long term, so in the short term animals need to be supplemented with those they cannot obtain from forages.

There are also plants that take up minerals from water bodies, though we rarely consider those unless we are thinking of fish or shellfish as a food for ourselves. However, aquatic plants such as kelp and other algae are a good source of various major and minor minerals, vitamins, and other antioxidants. These nutrients are easily assimilated by the body because they are in the natural plant form rather than from rock. Kelp is regarded as being too high in iodine, but many organic dairy and livestock farms use kelp as a supplement with very few problems related to iodine. Some research has shown that kelp helps to boost the immune system and may reduce the

incidence of pinkeye in pastured animals. It is approved for use in organic herds by the National Organic Program standards.

Those who feed kelp as a supplemental source of minerals either feed it free-choice or include it in a grain mix or TMR. When fed free-choice, animals usually eat it readily and consume large amounts of it initially. After a period of time, however, they decrease their intake of kelp to a much smaller amount daily. It is thought that they reach a point where they have eaten enough to correct any mineral imbalances that may have existed before they were offered kelp. Most dairy nutritionists have been taught that animals do not have "nutritional wisdom", and cannot balance their own diets through a free-choice mineral program. Please see the attached fact sheet, "Mineral Nutrition: Are animals nutritionally wise?" from the BEHAVE project at Utah State University (www.behave.net). This fact sheet provides an excellent overview of why the research that has been conducted on nutritional wisdom did not show that animals have the ability to balance their own diets, and recent research does.

One other influence on intake of kelp (as well as other feeds) may be what is known as a transient taste preference – they initially like how it tastes, and it doesn't make them feel sick – so they consume a lot of it. Over time, however, they develop a transient taste aversion – they have eaten so much that it no longer tastes as good as it did at first – so they reduce their consumption rate and only eat it in small quantities on a more periodic basis.

If animals do have nutritional wisdom, and they do, then it explains in part why the mineral program of most organic dairies works so well. As stated above, minerals are an important component of maintaining the health and immune status of organic dairies. Natural sources such as forages grown on mineralized soils and kelp are considered to be key sources of minerals. Trace mineral salts are also fed free-choice on most of these farms, although they do include an "insurance policy" of minerals by including some in the grain mix. The strategy works well because minerals and other micro-nutrients are provided in a variety of forms, and some is by human design while others are by nature's design.

Summary:

Organic dairy nutrition is all about a return to the basics of our knowledge and on-farm practices. Feeding them what they were designed to eat – lots of forage – and allowing them to produce a healthy and profitable level of milk based on those forages, is the best strategy long term. The remaining nutrients they need can be supplemented with smaller amounts of grain and free-choice natural supplements to meet mineral, vitamin, and other needs.