

Nutrition 101: The grass roots of nutrition

Trent L. Lartz, DVM

Ridgeview Animal Consulting, Shippensburg, PA 17257

Key words: bovine, nutrition, nutrients

Introduction

The dairy cow is an impressive animal, but to keep her healthy, we must provide a perfect balance of nutrients for her to consume. Her needs can be broken down into categories of essential nutrients that are common to all mammals:

- water
- energy
 - carbohydrates
 - protein
 - fats
- vitamins
- minerals

Water

Water is the most essential nutrient, so dairy cows must have free access to a high-quality water supply at all times. Approximately 71 to 73% of a cow's non-fat body weight is water. Water helps to break down the feed she eats, transports nutrients, helps chemical reactions occur, and helps maintain a normal body temperature.

Cows drink 2 to 3 times more water than the amount of feed consumed. Water intake increases during times of hot weather and increasing milk yields. While most of the water comes from the water a cow drinks, some is found in the feed she consumes. Corn silage, for example, is commonly 65 to 70% water.

Energy

Cows need energy to produce milk, grow, maintain body structure and function, and maintain pregnancy. Energy is available from 3 dietary sources: proteins, carbohydrates, and fats. Fats provide the most energy per pound of feed, with protein and carbohydrates next.

The maintenance requirement of a cow is the energy needed just to maintain her body. This requirement must be met before any growth, milk production or pregnancy can occur.

Energy is measured in calories. Not all energy that a cow eats will be utilized as usable energy. Some of it is indigestible, and some will be wasted. Gross energy is the total amount of energy ingested by the cow. That, minus the energy that is lost in the cow's feces is digestible energy. For example, forages are less digestible than grains, meaning more of their energy is lost in the feces. After accounting

for the energy lost in urine or gases, such as methane, we have the metabolizable energy (ME). Finally, some energy is lost as heat during chemical reactions that occur, and the ending amount of energy with everything considered is net energy.

In the end, it is the net energy that a cow can use for her maintenance, growth, pregnancy, and lactation. This is important to understand in finding the most efficient and economical diet to feed a cow.

Carbohydrates

Carbohydrates are the primary component found in livestock feeds and are a source of energy. They are made up of carbon, hydrogen and oxygen, and are the main energy compound in plants. Plant tissues are high in carbohydrates such as starch, cellulose, and hemicellulose. When a cow consumes carbohydrates, the ruminal microorganisms release enzymes that break them down into monosaccharides or "simple sugars." The monosaccharides are then converted by the microorganisms into volatile fatty acids, which are absorbed across the ruminal and small intestinal walls to be utilized as energy.

Protein

Protein is found in the highest concentrations of any nutrient, except water, in all animals. Thousands of different proteins have many different functions in a cow's body. Proteins provide structural components of muscle, hooves, bones, and blood. Several hormones are proteins, like insulin and bovine somatotropin. Additionally, the enzymes important in digestion, absorption, and metabolism are all proteins.

Proteins are made up of long chains of amino acids that have been linked together. Amino acids contain carbon, hydrogen, oxygen, and nitrogen, and some other compounds, and are known as the "building blocks of proteins." Combinations of these elements form 22 different amino acids, and various combinations of those amino acids are bonded to form various types of proteins. Enzymes secreted by the abomasum, pancreas, and small intestine break these bonds to separate the amino acids and allow them to be absorbed by the cow. Proteins cannot be absorbed until these bonds of the amino acids are broken.

Amino acids can be divided into 2 groups; essential and non-essential. The difference is that essential amino acids are not produced by the cow, so she needs to get these from the diet. Non-essential amino acids are produced by cells in the cow and are not needed in the diet.

The essential amino acids are: arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.

Each protein made by the cow requires a specific combination of amino acids. If an amino acid is in short supply, it cannot be replaced by another without completely changing the protein that is made. The amino acid supplied in the smallest amount required for protein synthesis is known as the first limiting amino acid, because it limits the amount and type of protein that can be made. In dairy rations, lysine and methionine are the most common limiting amino acids because common feeds like corn, corn silage, and soybean meal are relatively low in these amino acids compared to the quantities needed for milk production.

Fats

Fats, or lipids, are high in energy, and are found in many common feedstuffs. Oilseeds, like cottonseed or whole soybeans, or animal fats, are common sources of fat in a cow's diet. Fat is a very important part of a dairy ration because of the amount of energy needed for high milk production. It is also essential for absorption of fat-soluble vitamins. Fats can be classified as either saturated or unsaturated, which is determined by the chemical structure. A saturated fat is fully saturated with hydrogen atoms and does not contain double bonds between carbon atoms. Unsaturated fats contain double bonds, so they do not have the maximum number of hydrogen atoms. During rumen fermentation, most of the unsaturated fats are converted to saturated fats, which is why most of the fat found in milk and muscle is saturated fat.

Vitamins

Vitamins are essential for sustaining health. Each vitamin has many functions. They are needed for normal growth, and enable many critical processes that occur. Some play a role in absorption and metabolism of carbohydrates, proteins, fats, and minerals. The major storage site for vitamins is the liver. Most vitamins are bound to specific proteins. Vitamins are divided into 2 categories, water-soluble and fat-soluble.

Water-soluble vitamins are not stored in body tissue, but they are synthesized by the rumen microbes to meet her nutritional requirements. Many water-soluble vitamins function primarily as cofactors for enzymes. A cofactor is a substance that is required for an enzyme to function properly.

There are 4 fat-soluble vitamins: vitamins A, D, E, and K. They can be stored in large volumes in the cow's body fat for months. This means providing too much of these vitamins can lead to toxicity. Vitamins A, D, and E are commonly supplemented in lactating cow diets.

Minerals

Minerals can be divided into 2 classes, macrominerals and microminerals. Macrominerals are present in cows in

larger proportions – greater than 100 parts per million. Microminerals are found in smaller quantities – less than 100 parts per million. Like vitamins, minerals play a variety of important roles, and need to be fed in just the right amounts to prevent either deficiency or toxicity.

Feedstuffs

“Feedstuffs” is a common term for things we feed to cows. There are basically 3 categories: forages, energy concentrates, and protein supplements.

Forages

Forages include the stem and leafy parts of a plant and are generally higher in fiber. They are more bulky, and provide less digestible energy than concentrates. Common forages include baled hay, haylage, and corn silage. The value of different forages is routinely determined by sending samples to a forage analytical laboratory. The most common analyses run on these samples are:

- dry matter – the amount of material left after the water is removed from the feed;
- crude protein – total protein, as determined by the amount of nitrogen in the feed;
- crude fat – total fat;
- crude fiber – total fiber, as determined by the amount of less-digestible carbohydrates in the feed (hemicellulose, cellulose and lignin);
- ash – inorganic materials, including minerals; and
- nitrogen-free extract – readily available carbohydrates.

Another common test gives more accurate information about the feed's fiber and how well it will be digested – the neutral detergent fiber (NDF) and acid detergent fiber (ADF). The NDF includes the cell walls, while the ADF includes the cell contents. NDF commonly reflects a feed's bulk and can determine how much a cow can fit in her rumen. ADF is closely associated with the digestibility of feed.

Energy Concentrates

A cow will get energy from feedstuffs that contain readily available carbohydrates, fats, and oils. Known as “high-energy” feedstuffs, these components contain greater than 70% total digestible nutrients and are high in net energy. High-energy feed generally has low protein content, less than 20% crude protein. The energy concentrates in a ration are commonly referred to as “grains.” Cereal grains come from plants that are grown primarily for their seeds, which we harvest as grain. This includes things like corn, wheat, oats, barley, rye, and sorghum. Other items in an energy concentrate can be molasses, whey, beet pulp, citrus pulp, bakery waste, or potatoes. Fats and oils can be added to a cow's diet to boost her energy intake.

Protein Supplements

Protein supplements are generally defined as having 20% or more crude protein. The predominant plant protein source fed is soybean meal. Corn gluten meal and distillers grains have become more popular over the past several years. Manufactured non-protein nitrogen such as urea is also added as a supplement. This should be supplemented in small amounts because it will reduce the palatability of a ration.

Balancing a Cow's Diet

In its simplest form, you can think of balancing a ration as ensuring the nutrient requirements are equal to the feed

nutrients. A ration that is not balanced will be either in surplus or deficiency, which can negatively affect the health of the animal. As veterinarians, we can make observations about the health and performance of the animals to determine if there may be a nutritional component that may be hindering their health or performance.