CFAES

Factsheet # AS-Y-5-22

Nutrient Classification

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Introduction

In human nutrition, the food pyramid or “my plate” initiative encourages us to think about balancing the food groups that we consume. But have you ever considered the balance of nutrients required by the animals that you raise? Animals also require a balanced diet that consist of six nutrient classes: water, carbohydrates, lipids, protein, vitamins, and minerals (Figure 1). Each nutrient class meets unique requirements for the survival, growth, reproduction, and health of your animals (Pond et al., 2004). Nutrient classes differ from feedstuff classes. While feedstuff classes (such as silages, roughages, concentrates, additives) are used to identify ingredient types on feed tags, nutrient classes describe how feeds fit into the nutrient requirements for the animal.

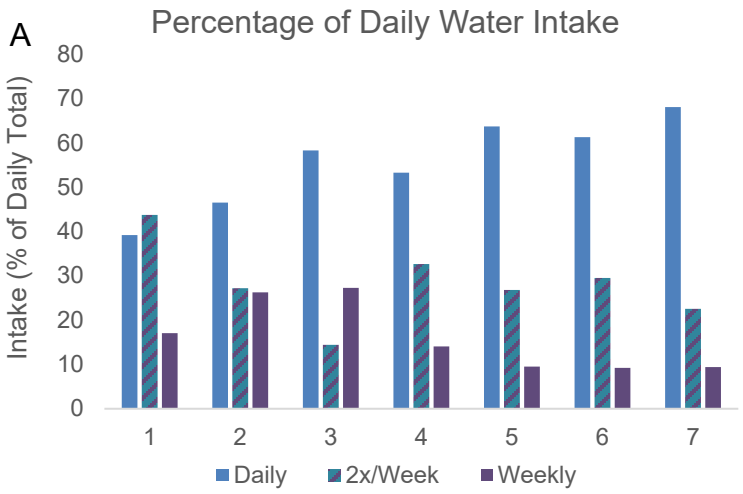

Figure 2 (adapted from Jermolowicz and Wenner, 2022). Sheep offered water from buckets cleaned daily, biweekly, or weekly preferred to consume water from the buckets cleaned most frequently (A). After a week without cleaning, all buckets were cleaned yet sheep refused to drink from the buckets that were previously dirty (B).

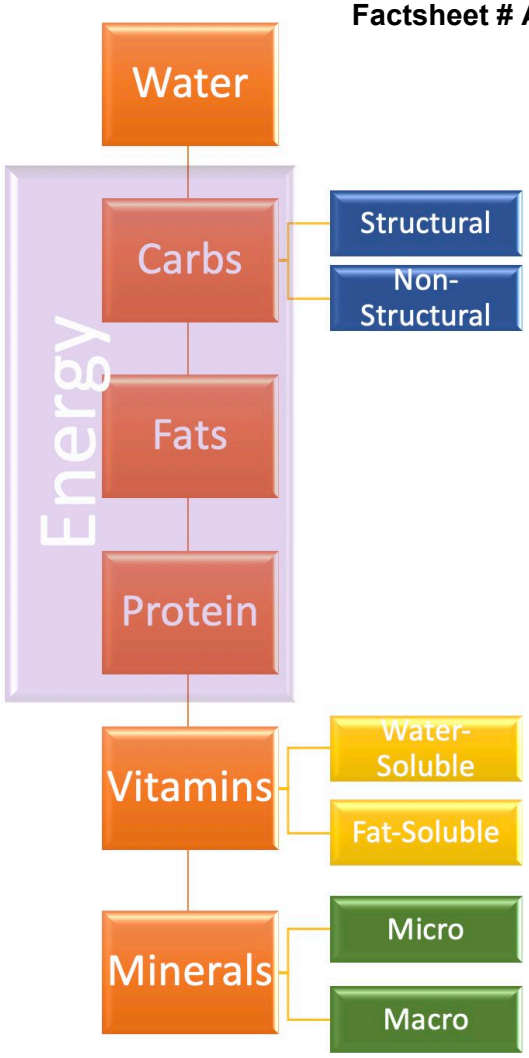

Figure 1. Nutrients can be classified into one of six categories or classes (in orange). Carbohydrates (Carbs) can be further broken down into structural or non-structural carbohydrate sources.

Water

Commonly called the “most essential” or more likely the forgotten nutrient, water is essential to life. Water helps maintain body temperature, supports muscle accretion, lubricates joints, and helps mix digesta for breakdown and absorption. Animals consume a varying amount of water related to their size, diet, housing conditions, and physiological demands. For example, a lactating dairy goat will consume more water than most market goats due to her increased demand for water needed for milk production. Alternatively, animals housed with effective cooling during the summer will consume less water than those in hotter, more stressful conditions. There are limited data on the importance of clean water for animal intake, but a recent study demonstrated that

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Figure 3. Ruminant papillae absorb energy from microbes that ferment carbohydrates – both structural and non-structural to volatile fatty acids.

cows could detect as little as 0.005% manure contamination in their water and will consume more water if it is cleaner (Schütz et al., 2019). Data from sheep corroborate a preference for clean water and that a pattern develops in response to their previous experiences with clean water (Jermolowicz and Wenner, 2022; Figure 2). We also know that if animals drink more water, they will likely consume more feed dry matter and potentially grow faster (Brew et al., 2011). To improve your animal's growth, prioritize clean and fresh water!

Carbohydrates

This broad nutrient class can sometimes confuse people because of the breadth of feedstuffs that typically provide carbohydrates to a diet. People often think of the sugars in soft drinks or the starch in breads and cereals. However, carbohydrates can also include complex sugars that are much less tasty and fiber that provides little energy value to non-fermenting animals. Everything from byproduct roughages to hays and silages, from corn starch to molasses – it is all contained within the carbohydrates nutrient class. Structural carbohydrates typically imply fiber; whereas, nonstructural carbohydrates would include starches and sugars.

In all species, carbohydrates provide the bulk of energy in most livestock animal diets. Foregut fermenters (such as ruminants, i.e., cows) and hindgut fermenters (such as a horse or rabbit) consume a combination of fiber and starch that have a mixed fate of microbial fermentation to volatile fatty acids (VFA) and digestion in the small intestine. The many papillae in the rumen (Figure 3) increase surface area for VFA absorption by ruminants. Non-ruminant, non-hindgut fermenting animals, such as a pig or chicken, rely heavily on nonstructural carbohydrates like starch and sugar to provide consistent energy for growth and performance.

Lipids

Lipids (or fats) are the most energy dense nutrient class. When your animal starts to store fat, you can see that fat takes up a lot of space, but each pound of fat has more than 2 times as many calories (energy) as a pound of carbohydrates or protein. Fats are essential to life; for example, they fuel the heart, support cell membrane integrity, and are used to build hormones that regulate the body. Dietary lipids are especially important for the absorption of vitamins A, D, and E as fat-soluble vitamins.

Addition of lipids in the diet is common in companion animals for flavor but in livestock species our typical goal is the increase of energy density for the diet. This means that with more fat in the diet, each bite will provide an increased number of calories. Ruminants rely on microbes to ferment fiber (and other nutrients) to generate energy but some of those microbes are very sensitive to fat, especially unsaturated fats. Thus, ruminants specifically have a limit to how much fat should be included in their diets.

Proteins

Proteins are built from combinations of building blocks called amino acids. The order of amino acids and the combination of them dictates the structure and function of the proteins. Therefore, most animals don't strictly have a protein requirement but rather a requirement for amino acids. Feedstuffs can vary not only in how much crude protein they have but also in the make-up of that protein, i.e., some proteins have more of the "rare" or limiting amino acids whereas others have less valuable amino acids. Soybean meal is the standard protein feedstuff by which others are compared because it provides the most balanced source of limiting amino acids.

Ruminants are a bit of an anomaly when it comes to protein requirements. The microbes that grow in the rumen build their own protein and are fairly indiscriminate as to the source of their nitrogen to build that protein. When those microbes die and pass downstream, they are digested to provide a high-quality protein to the animal. We can supplement ruminants with non-protein nitrogen sources, such as urea, to partially meet their protein requirement and save money versus actual protein feedstuffs.

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Vitamins

Animals require vitamins in two primary categories: water-soluble and fat-soluble vitamins (Figure 1). Fat soluble vitamins A, D, E, and K are required across animal species while water-soluble vitamins are often only required by non-ruminants. Ruminant microbes build their own B-vitamins and when they die, they pass downstream and are digested to provide those B-vitamins to the animal. Unique to guinea pigs, vitamin C (water soluble) is also required, while for the non-ruminant rabbits, coprophagy leads to the consumption of microbial-derived B-vitamins in the feces.

When identifying feedstuffs for an activity, it is uncommon to have vitamins on the table. This is because vitamins are required in very small amounts and are typically mixed together into a premix.

Minerals

Minerals can also be sub-divided into two categories: macrominerals and microminerals (Figure 1). A common misconception is that macrominerals are larger than microminerals. However, the terminology actually reflects how much mineral needs to be included in the diet of an animal. Macrominerals (such as calcium, phosphorus, and magnesium for bone health) are generally included in the diet as a percent of the total daily intake. Whereas microminerals are only needed in very small amounts – typically parts per million or parts per billion. This is why microminerals are commonly called trace minerals.

Figure 4. Whole cottonseed provides significant quantities of fat, carbohydrates, and protein. However, whole cottonseed is typically added as a source of fat to increase the energy density in ruminant diets. Thus, although it is relatively high in fiber, we would classify whole cottonseed into the fats nutrient class since we feed it for the fat content.

Again, it is uncommon to see minerals as a standalone feedstuff in an identification activity. The small amount required by animals makes it difficult to weigh each mineral ingredient separately, so they are weighed in large batches to create a mix (premix) for adding to an animal ration, such as a trace mineral blend.

Summary

All six of these nutrient classes contain one or more of the approximately 40 essential nutrients required for animals. It is common that a single feedstuff can provide nutrients contained within more than one nutrient class. However, we often assign a feedstuff to a single nutrient class, and this can be a confusing process. When assigning a feedstuff to a nutrient class, it is essential to first consider what nutrient classes are represented by the majority of the feedstuff. An example of this process is illustrated in Figure 4, where a high fat feedstuff (cottonseed) is classified into the lipids category even though the lint and hulls add considerable fiber. It is important to remember that if there are two or more nutrient classes exceeding 15 to 20% of the content, ask ”What is the ***primary reason*** you are feeding the feedstuff?” The primary nutrient class supplemented in the diet by the addition of the feedstuff is the appropriate nutrient class to assign.

References

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