NATIONAL
ANIMAL
NUTRITION
PROGRAM

FEED COMPOSITION

Dry Matter Concept vs. Amount As-Fed

FEED INGREDIENTS CONTAIN 6 CLASSES OR CATEGORIES OF NUTRIENTS: CARBOHYDRATES, FATS, PROTEINS, VITAMINS, MINERALS, AND WATER (sometimes referred to as 'moisture'). Animals ingest feeds that contain water *plus* all non-water nutrients supplied by the other 5 categories. This style of feeding is considered the 'as-is' or 'as-fed' basis and represents the practical form of feed that animals are offered each day. The collective weight of all non-water, or dry, nutrients in an ingredient or diet sample is referred to as the 'dry matter' portion, or fraction, of the feedstuff.

Dry Matter

Dry matter (DM) is what remains of an ingredient or diet sample after being dried in an oven.
It is common for nutritionists to work on an **air-dry** basis, which results after a sample has been dried at 55-65°C to the point where the weight of that sample remains constant at ambient conditions. When samples are dried at 105°C for 4-8 hours, this is referred to as an **absolute DM** or **DM-basis** because all free water has been eliminated. Upon elimination of all water from an ingredient or diet sample, the resulting weight represents the collective mass of carbohydrates, fats, proteins, vitamins, and minerals contained therein.

In practical terms, feed ingredients are bought, sold, mixed, and fed to an animal on an "as-is" or "as-fed" basis, which means those feedstuffs contain water weight. In this way, grains and concentrates usually contain around 10% water, while some feedstuffs including grasses, legume pastures, or by-products may contain 70-80% water, which means all non-water nutrients are contained in just 20-30% of the sample weight.

Ingredients and diets used in non-ruminant nutrition (e.g., swine and poultry) generally contain 88-92% DM, so there is typically less emphasis placed on expressing nutrients on a DM basis. However, in ruminant nutrition, differences in water content among feedstuffs can fluctuate widely, even within an ingredient type (e.g., wet vs. dried distiller's grains). This variation in water content among common ingredients makes it difficult to directly compare the concentrations of non-water nutrients (i.e., those contained in the other 5 categories). Therefore, in general, it is best practice for nutritionists to discuss dietary nutrient concentrations on a DM-basis, where the water portion of the ingredient or diet sample has been mathematically eliminated.

Dry Matter Calculation

The percent dry matter of an ingredient, or feedstuff, is often calculated and listed with the analysis of those feeds. Dry matter percent can be calculated very simply by dividing the dried sample weight by the **as-is**, **as-fed**, or **wet** weight and multiplying by 100 to generate percent DM. Note that the dried sample weight must be equal to (if it contained no water) or less than the **wet** sample weight by definition.

Example #1: Dry matter calculation involving Corn grain, dry

(selected from the NANP Feed Composition Database)

As-is/as-fed weight: 100 grams | **Dry weight:** 90 grams

$$\text{DM \%} = \frac{\text{90 g dry weight}}{\text{100 g corn as-fed}} = 0.90 \times 100 = 90\% \text{ DM}$$

By difference, the portion of water weight is: 100 g corn as-fed - 90 g corn DM = 10 g water, which is equivalent to 10% water because we started with 100 g of total corn weight.

Conversion of nutrient composition and amounts between DM and as-is/as-fed and DM bases

Important concepts:

- By definition, the weight of an ingredient or feed sample that contains water will always be greater than the weight of that same sample on a DM basis. Remember, the summed weights of all nutrient categories equals the total sample weight. Samples on an as-is basis contains water weight, whereas samples on a DM basis do not contain water weight.

- The concentration of nutrients or chemical fractions in a feed can appear to change according to the moisture content of the feed. The more water in feedstuffs, the more diluted the nutrients will be on an as-fed basis (i.e., lower nutrient concentrations), which means an animal will have to eat more as-fed (lbs. or kg) of that feed to fulfill its nutrient requirements.

- Feeds with less moisture have less variation in supplied nutrient composition when comparing as-fed and DM bases. This is the reason that swine and poultry industries place less emphasis on ingredient/feed DM, because the primary feedstuffs used by those industries (i.e., corn and soybean meal) generally contain less than 12% moisture and are relatively consistent in nutrient supply.

Nutrient Calculation

Example #2: Calculating nutrient intake using Alfalfa pasture (ALFP)

In this example, we use the known nutrient composition derived from the NANP Feed Composition database and the weight of feedstuff that was fed to calculate the grams of crude protein consumed per day.

Amount fed to the animal on an as-is/as-fed basis: 10 kg per day

Analyzed nutrient values from the NANP Feed Composition database: Actual Dry Matter (DM, %): 20% or 20 g DM in every 100 g ALFP Crude Protein (CP, %) on an as-fed basis: 4%

water/moisture = 80% or 80 g water out of every 100 g of as-is sample weight

DM amount fed, kg = 10 kg ALFP as-is X 0.2(20% DM) = 2 kg DM from the ALFP that was fed

ALFP crude protein (CP) on as-fed basis = 4 g CP in every 100 g of ALFP as-fed or 4% CP
(0.04 in decimal form; this is the analyzed CP value)

To calculate the amount of CP that the animal was fed:

Amount CP fed = 10 kg ALFP as-fed X 4% CP as-fed = 10 kg ALFP X 0.04 = 0.4 kg or 400 g CP fed per day

Conversion of nutrient concentrations between as-fed and DM bases

Using the same example, we can calculate % CP in ALFP expressed on a DM basis.
As calculated above, 10 kg ALFP as-fed provided 2 kg DM and 0.4 kg CP fed to the animal.

$$\text{CP \% in ALFP on as-fed basis} = \frac{\text{0.4 kg CP as-fed}}{\text{10 kg ALFP as-fed}} \times 100 = 0.04 \times 100 = 4\% \text{ CP as-fed}$$

$$\text{CP \% in ALFP on DM basis} = \frac{\text{0.4 kg CP fed}}{\text{2 kg DM from ALFP}} \times 100 = 0.20 \times 100 = 20\% \text{ CP on DM-basis}$$

Notice that the only difference between these calculations was found in the denominator, where the amount of ALFP that was fed represented the feedstuff weight in the presence (as-is basis) or absence (DM basis) of moisture.

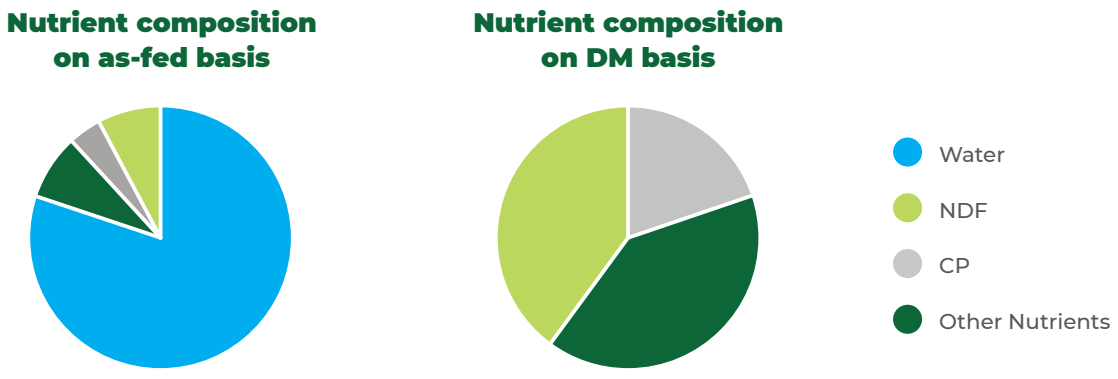
When you understand this concept, there is a shortcut to converting nutrient concentrations between as-is and DM bases and it has to do with the proportion of DM in the sample. In this example, ALFP was 20% DM or 0.2 when expressed in decimal form.

$$\text{CP \% on DM basis} = \frac{\text{4\% CP in ALFP as-fed}}{\text{0.2 (DM \% as decimal)}} = 20\% \text{ CP on DM basis}$$

Assuming neutral detergent fiber (NDF) % = 8% on as-fed basis, we can calculate % NDF on a DM-basis using the short cut.

$$\text{NDF \% on DM basis} = \frac{\text{8\% NDF in ALFP as-fed}}{\text{0.2 (DM \% as decimal)}} = 40\% \text{ NDF on DM basis}$$

Note: the concentrations of nutrients are always larger when expressed on a DM basis as compared to when they are expressed on an as-is/as-fed basis



In this graphical representation of nutrient content, the water slice of the pie is shown in blue, and that slice has been mathematically eliminated when expressing CP, NDF, and other nutrients on a DM basis. In removing the large blue slice, which represents 80% of the pie, all other slices must get larger to make the pie whole again. This is a visual representation of why nutrient concentrations get larger when expressed on a DM basis as opposed to an as-is/as-fed basis.

Example #3: Comparing ingredients of differing moisture content

Corn distiller's grains (wet vs. dried)

This example will highlight the profound influence of water content when comparing nutrient concentrations between ingredients of similar origin. Following is the analyzed nutrient composition of each sample on an as-fed basis:

Nutrient (as-is basis)	Corn dried distiller's grains	Corn wet distiller's grains
Dry matter (DM) %	90	31
Water %	10	79
Crude protein (CP) %	27.9	9.49
Phosphorus (P) %	0.77	0.25

To make a fair comparison of CP and P between dried and wet corn distiller's grains, we first need to convert each nutrient onto a DM basis:

Corn dried distiller's grains

$$\text{CP \% on DM-basis} = \frac{\text{27.9\% CP as-is}}{\text{0.90 (DM \% as decimal)}} = \textbf{31.0\% CP on DM-basis}$$

$$\text{P \% on DM-basis} = \frac{\text{0.77\% P as-is}}{\text{0.90}} = \textbf{0.86\% P on DM-basis}$$

Corn wet distiller's grains

$$\text{CP \% on DM-basis} = \frac{\text{9.49\% CP as-is}}{\text{0.31 (DM \% as decimal)}} = \textbf{30.6\% CP on DM-basis}$$

$$\text{P \% on DM-basis} = \frac{\text{0.25\% P as-is}}{\text{0.31}} = \textbf{0.81\% P on DM-basis}$$

Given the as-is nutrient concentrations in the table, these corn-based ingredients look quite different, but when expressed on a DM basis, it becomes clear that these feedstuffs contain similar concentrations of CP and P. Again, these differences in nutrient concentrations were the result of varying amounts of water weight contained in the as-fed feedstuffs. This is a powerful example of why the mathematical elimination of water weight is a crucial skill for any nutritionist. Only after nutrient concentrations are expressed on a DM basis can nutrient concentrations be fairly compared among samples. In addition to calculating nutrient concentrations on a DM-basis, nutritionists would also want to know how the different ingredients affected intake because both are important when matching dietary input with the animal's nutrient requirements.