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Feed Dry Matter Conversions

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> Nutrient profiles and weights of feed may be expressed on a dry matter, as-fed or air-dry basis. This NebGuide will explain each expression and how to convert between the different bases.

Introduction

How do you compare the protein value of hay to haylage? How do you compare the energy content of dried versus high-moisture corn? If a recommended ration is provided on a dry matter basis, and it contains feeds that vary significantly in moisture content, how much of each ingredient needs to be fed? Your nutritionist said the cattle should consume 24 lb of dry matter daily, but you're feeding nearly 50 lb. How can that be? The answer to each question is associated with developing an understanding of dry matter and associated dry matter conversions.

Simplistically, feeds consist of two major portions — water and dry matter. While water is physiologically critical, the nutrients (energy, protein, minerals, and vitamins) are found in the dry matter portion, so it is important to know what percentage of the feed is dry matter. Some feeds, including fresh forages and silages, contain significant amounts of water. Others, however, may appear and feel dry, but still contain 10-12 percent water. If feeds are allowed to air dry (eg., hay), approximately 10 percent water will remain. To determine actual dry matter percentage, feed samples must be placed in a special oven set to 105°C that will evaporate off all moisture. Once actual dry matter percentages of different feeds are known, nutritional comparisons can be conducted and rations properly evaluated.

Nutrient Profile Conversions

The nutrient composition of feeds is commonly expressed as a percentage or quantity per unit of weight (Mcal/lb, kcal/lb, g/lb, etc.) using one of the following bases: 1) dry matter, 2) as-fed, or 3) air-dry. The dry matter basis assumes no water is present — 100 percent dry matter. This expression of nutrient composition is commonly used to compare forages and other feeds that may differ significantly in dry matter content. The as-fed expression represents feed as it would be fed to the animal, including water. When feeds are allowed to air dry, most feeds eventually equilibrate to 90 percent dry matter (10 percent moisture). Thus, nutrient expressions conducted on an air-dry basis assume the presence of 10 percent water. Nutrient profiles shown on feed tags are expressed on an air-dry basis.

Because nutrients are found in the dry matter portion of feeds, the physical quantity of nutrients will NOT change when water is added or removed. However, the percentage of nutrient present in the feed will change if water is added or removed. The denominator used to calculate nutrient percentages is total feed weight, including water that may be present. When water is removed, the physical quantity of nutrients will remain unchanged, but the percentage of that nutrient in the feed will increase because it becomes more CONCENTRATED with the removal of water. Similarly, if water is added, the physical quantity of nutrients will not change, but the percentage of that nutrient in the feed will decrease because it is DILUTED with water (*Figure 1*).
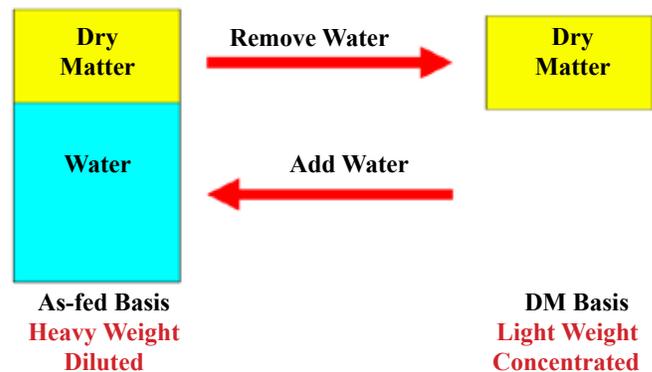

Figure 1. Dry Matter Conversions

All nutrient conversions from one basis to another can be set up using equivalent ratios as shown in *Figure 2*. The known nutrient value for a given dry matter expression (dry matter, as-fed or air-dry basis) is placed over its associated and known dry matter percentage to establish the ratio on the left side of the equation. On the right side, the unknown nutrient value is placed over its associated and known dry matter percentage. Remember, when nutrient profiles are expressed on a dry matter basis, 100 percent dry matter is assumed.

$$\frac{\text{\% nutrient (A)}}{\text{\% DM (A)}} \; \mathbf{=} \; \frac{\text{\% nutrient (B)}}{\text{\% DM (B)}}$$

Figure 2. Setting up Equivalent Ratios for Nutrient Conversions

When nutrients are expressed on an air-dry basis, 90 percent dry matter is assumed. To properly determine as-fed dry matter percentage values, the feed must be appropriately tested.

Example: Conversion of feed nutrients from an as-fed to dry matter basis

1) Assume haylage was analyzed to provide 10 percent crude protein (CP), as-fed. The haylage contained 50 percent water (50 percent dry matter (DM)). What is the CP percentage when expressed on a DM basis?

2) On the left or known side of the equation, 10 percent CP is associated with 50 percent DM (as-fed). On the right side of the equation, X represents the unknown CP percentage value. The associated DM percentage value is 100 percent because 100 percent is always assumed when nutrients are expressed on a DM basis. Thus:

$$\frac{10\% \text{ CP}}{50\% \text{ DM}} \; = \; \frac{X\% \text{ CP}}{100\% \text{ DM}}$$

3) To solve for X:

   Step 1 – cross multiply: 50X = 1,000
   Step 2 – divide by the value in front of X: X = 1,000 ÷ 50 = 20% CP on a DM basis (100% DM)

4) Remember, the quantity of nutrients in the feed did NOT change, but the percentage of CP increased from 10 to 20 percent because all water is removed. The protein fraction of the ingredient is more concentrated.

5) Alternative solution. The known CP value could be divided by its DM percentage value expressed as a decimal.

   10% CP ÷ 0.50 = 20% CP on a DM basis (100% DM)

Example: Conversion of feed nutrients from a dry matter to as-fed basis

1) Assume high-moisture corn (74 percent DM) was analyzed to provide 93 percent total digestible nutrient (TDN) on a DM basis. How much TDN does the corn provide, as-fed?

2) On the left or known side of the equation, 93 percent TDN is associated with 100 percent DM (DM basis). On the right side of the equation, X represents the unknown TDN percentage value. The associated as-fed DM is 74 percent.

$$\frac{93\% \text{ TDN}}{100\% \text{ DM}} \; = \; \frac{X\% \text{ TDN}}{74\% \text{ DM}}$$

3) To solve for X:

   Step 1 – cross multiply. 100X = 6,882
   Step 2 – divide by the value in front of X: X = 6,882 ÷ 100 = 68.8% TDN on an as-fed basis (74% DM)

4) Remember, the quantity of nutrients in the feed did NOT change, but the percentage of TDN decreased from 93 to 68.8 percent because water is typically added when nutrients are expressed on an as-fed basis. The TDN is diluted.

5) Alternative solution: The known TDN value on a DM basis could be multiplied by the as-fed dry matter percentage value, provided it is expressed as a decimal.

   93% TDN (DM basis) * 0.74 = 68.8% TDN (as-fed)

Example: Conversion of feed nutrients from an air-dry to dry matter basis

1) Assume the label of a commercial protein supplement indicates the feed should have a minimum of 36 percent CP. What is the CP percentage of the supplement when expressed on a DM basis?

2) On the left or known side of the equation, 36 percent CP is associated with 90 percent DM (air-dry basis), which is the assumed DM percentage for feed labels. On the right side of the equation, X represents the unknown CP percentage value expressed on a DM basis (100 percent dry matter). Thus:

$$\frac{36\% \text{ CP}}{90\% \text{ DM}} \; = \; \frac{X\% \text{ TDN}}{100\% \text{ DM}}$$

3) To solve for X:

   Step 1 – cross multiply: 90X = 3,600
   Step 2 – divide by the value in front of X: X = 3,600 ÷ 90 = 40 percent CP on a DM basis (100% DM)

4) Again, the quantity of nutrients in the feed did NOT change, but the percentage of CP increased from 36 to 40 percent because water is removed when nutrients are expressed on a DM basis. The protein is more concentrated.

5) Alternative solution: The known CP value could be divided by its associated DM percentage value, provided it is expressed as a decimal.

   36% CP (air-dry basis) ÷ 0.90 = 40% CP on a DM basis (100% DM)

Weight Conversions

While it is common and beneficial to compare nutrient profiles on a dry matter basis, producers must work with and mix feed on an as-fed basis. For example, a ration may be formulated on a dry matter basis, but the actual feed ingredients must be mixed on an as-fed basis. It's also common to evaluate dry matter intake as an indicator of health and performance, but the feed that is placed in the bunk may contain from 10 to 50 percent water.

When feeds are expressed on a dry matter basis, all water is removed. While the nutrients are very concentrated, the total weight is light (small) in absence of water. When water is added back or as feed expressions are converted from a dry matter to an air-dry or as-fed basis, the weight should increase or become heavier. For simple weight conversions, multiply or divide by the associated as-fed dry matter percentage, expressed as a decimal. Multiplication by a percentage less than 100 expressed as a decimal will result in a smaller number, which is expected when converting weights from an as-fed (water included) to a dry matter (water removed) basis. To convert weights from a dry matter to an as-fed basis, divide by the as-fed dry matter percentage value, expressed as a decimal.

Example: Conversion of weight from as-fed to dry matter basis

1) On an as-fed basis, a feedlot finishing ration is 60 percent DM. If the cattle consume 40 lb of the ration, how much actual DM is consumed?

2) The conversion is from an as-fed (water included) to a DM (water removed) basis. Thus:

$$40 \text{ lb as-fed} * 0.60 = 24 \text{ lb DM}$$

Example: Conversion of weight from dry matter to as-fed basis

1) A diet was formulated on a DM basis that consisted of 45 percent dry rolled corn (87 percent DM), 35 percent wet distillers grains (36 percent DM), 15 percent alfalfa hay (89 percent DM), and 5 percent supplement (90 percent DM). How much of each ingredient must be added to the mixer to make 1 ton (2,000 lb) of mixed feed?

2) To simplify, rather than evaluating the diet formulation on a percentage basis, assume it is a formulation to mix 100 lb of DM (45 lb dry rolled corn, 35 lb wet distillers grains, 15 lb alfalfa, and 5 lb supplement).

3) Because ingredients differ in DM, the conversion is from a DM (water removed) to an as-fed (water included) basis. Thus, each ingredient must be divided by its corresponding DM percentage to determine the amount of that particular ingredient that is needed, as-fed.

Dry Rolled Corn:	45 lb DM ÷ 0.87	= 51.72 lb as-fed
Wet Distillers Grains:	35 lb DM ÷ 0.36	= 97.22 lb as-fed
Alfalfa Hay:	15 lb DM ÷ 0.89	= 16.85 lb as-fed
Supplement:	5 lb DM ÷ 0.90	= 5.55 lb as-fed
Total	100 lb DM	171.34 lb as-fed

4) Because ingredients differ in DM, ingredient proportions differ on an as-fed basis compared to a DM basis. For example, wet distillers grains make up only 35 percent of the diet on a dry matter basis, but nearly 57 percent of the diet on an as-fed basis. To calculate the relative proportion or percentage of feed ingredients in the diet as-fed, take the amount of as-fed feed ingredient required divided by the total as-fed quantity of feed.

Dry Rolled Corn:	51.72 lb as-fed ÷ 171.34 * 100	= 30.19% dry rolled corn, as-fed
Wet Distillers Grains:	97.22 lb as-fed ÷ 171.34 * 100	= 56.74% wet distillers grains, as-fed
Alfalfa Hay:	16.85 lb as-fed ÷ 171.34 * 100	= 9.83% alfalfa hay, as-fed
Supplement:	5.55 lb as-fed ÷ 171.34 * 100	= 3.24% supplement, as-fed
Total	171.34 lb as-fed	100%

5) Once ingredient percentages are determined on an as-fed basis, mixes for any amount can be calculated. To mix 1 ton (2,000 lb) of this feed, simply multiply each as-fed ingredient percentage times 2,000.

Dry Rolled Corn:	30.19% as-fed * 2,000	= 603.8 lb as-fed
Wet Distillers Grains:	56.74% as-fed * 2,000	= 1134.8 lb as-fed
Alfalfa Hay:	9.83% as-fed * 2,000	= 196.6 lb as-fed
Supplement:	3.24% as-fed * 2,000	= 64.8 lb as-fed
Total	100.00%	2,000 lb as-fed

Calculating Dry Matter of a Mixed Ration

Because feeds may differ significantly in dry matter content, a simple arithmetic mean of ingredient dry matter percentages will often provide erroneous results. The total pounds of dry matter provided by the as-fed ingredients must be determined. Then, total pounds of dry matter must be divided by the total pounds as-fed. Effectively, this provides a weighted average of the ingredient dry matter percentages.

Example: Calculating Dry Matter of a Mixed Ration

1) One ton (as-fed) of feed was mixed. Feed ingredients included 1,150 lb corn silage (35 percent DM), 115 lb molasses (30 percent DM), 350 lb corn gluten meal (90 percent DM), 120 lb soyhulls (90 percent DM), 215 lb ground corn (88 percent DM), and 50 lb of a mineral/vitamin premix (100 percent DM).

2) To determine the amount of dry matter provided by each ingredient, multiply the amount of each ingredient in the diet (as-fed) by its percent dry matter.

Corn Silage:	1,150 lb as-fed * 0.35	= 403 lb DM
Molasses:	115 lb as-fed * 0.30	= 35 lb DM
Corn Gluten Meal:	350 lb as-fed * 0.90	= 315 lb DM
Soybean Hulls:	120 lb as-fed * 0.90	= 108 lb DM
Ground Corn:	215 lb as-fed * 0.88	= 189 lb DM
Mineral/Vitamin Premix:	50 lb as-fed * 1.00	= 50 lb DM
Total	2,000 lb as-fed	1,100 lb DM

3) Overall DM percentage of the mixed feed = 1,100 lb DM ÷ 2,000 lb as-fed * 100 = 55% DM

4) A simple arithmetic average of the DM values would have been 72 percent DM; an erroneous value. In this diet, a significantly greater percentage of the diet is associated with wet feeds than dry feeds.

Summary

When converting nutritional profiles and feed weights, it is important to always evaluate the question or problem. Should the final answer have a larger or smaller number? As a rule of thumb, when converting from an as-fed to dry matter basis, nutrient concentrations will increase, but weight will decrease. When converting from a dry matter to as-fed basis, water is added so nutrient concentrations will be diluted or decrease, but weight will increase. Then, it's a matter of arithmetic. Multiplication by a percentage less than 100 expressed as a decimal will yield a smaller number, whereas division by a percentage less than 100 expressed as a decimal will generate a larger number. The decimal is always the dry matter percentage of the feed.

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