NebGuide

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Research-Based Information That You Can Use

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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 the nutrient profile and weight of feeds between these different expressions.

Introduction

How does one compare the protein value of hay to haylage? How does one 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 lbs of dry matter daily, but you're feeding nearly 50 lbs! 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 fractions—water and dry matter. While water is physiologically critical, the nutrients (energy, protein, minerals, and vitamins) are found in the dry matter fraction, so it is important to know what percentage of the feed is associated with dry matter. Although the quantity of dry matter in a feed will not change, the amount of water present may change, and this will determine the dry matter percentage. Figure 1 attempts to illustrate this concept using colored dots. Brown dots represent dry matter and blue dots represent water. On an "as-fed basis", there are 20 total dots with 12 brown dots and 8 blue dots. Thus, the percentage of brown

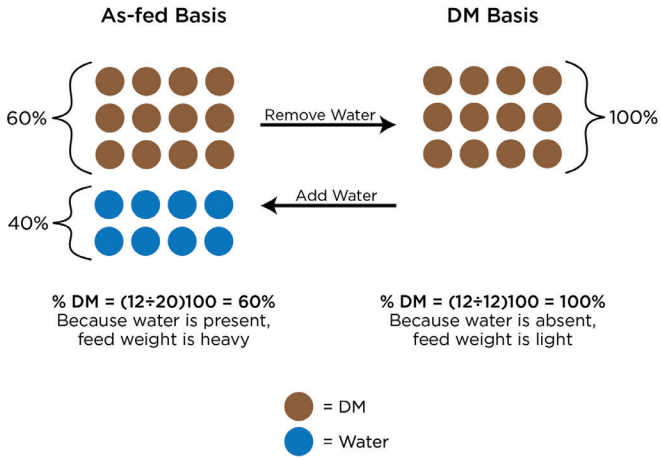

Figure 1. As-Fed vs. Dry Matter

dots (i.e., DM) equals (12 ÷ 20)100, which is 60%. If the blue dots, representing water, are removed, 12 brown dots remain. Now, the percentage of brown dots equals (12 ÷ 12)100, which is 100%. This would represent the dry matter percentage of feeds, expressed on a "dry matter basis". The dry matter percentage of a feed, expressed on a dry matter basis, is always 100%.

As-fed, feeds including fresh forages and silages may contain significant amounts of water. Others, however, may appear and feel dry, but still contain 10–12% water. If feeds are allowed to air-dry, such as sun-cured hay, approximately 10% water will remain. To determine actual dry matter percentage, feed samples must be placed in a special

oven set to 105°C (221°F) that will remove all moisture through evaporation. 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% 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% dry matter (10% moisture). Thus, nutrient expressions conducted on an air-dry basis assume the presence of 10% 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. To illustrate this concept, in Figure 2, three of the 12 brown dots (from Figure 1) have been colored green to represent units of crude protein. On an "as-fed basis" (with water), the percentage of green dots (representing protein) equals (3 ÷ 20)100, which is 15%. When the blue dots, representing water, are removed, the 3 green dots remain in addition to 9 brown dots (dry matter, but not protein). Thus, the percentage of green dots (protein), expressed on a "dry matter basis" (no water) equals (3 ÷ 12)100, which is 25%. Through this illustration, one can see that the number of green dots (protein) did not change from an "as-fed basis" to a "dry matter basis", but the percentage of green dots (protein) became more concentrated as the blue dots (water) were removed.

All nutrient conversions from one basis to another can be set up using equivalent ratios as shown in Figure 3. 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% dry matter is assumed. When nutrients are expressed on an air-dry basis, 90% dry matter is assumed. To properly determine as-fed dry matter percentage values, the feed must be appropriately tested.

Figure 2. As-Fed vs. Dry Matter, Nutrients

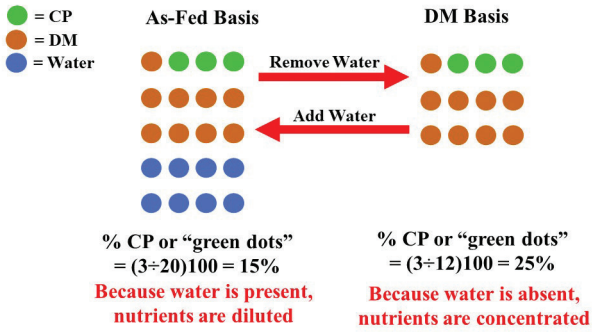

Figure 2. As-Fed vs. Dry Matter, Nutrients

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

Figure 3. Setting up Equivalent Ratios for Nutrient Conversions

Conversion of feed nutrients from an as-fed to dry matter basis—An Example.

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

2. On the left or known side of the equation, 10% CP is associated with 50% DM (as-fed). On the right side of the equation, X represents the unknown CP percentage value. The associated dry matter percentage value is 100% because 100% is always assumed when nutrients are expressed on a dry matter 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 = 1000 (1st step is to cross-multiply)

   Step 2—divide by the value in front of X. X = 1000 ÷ 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 crude protein increased from 10 to 20% because all water is removed. The protein fraction of the ingredient is more concentrated.

5. Alternative solution. The known crude protein value could be divided by its dry matter percentage value expressed as a decimal.

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

Conversion of feed nutrients from a dry matter to as-fed basis—An Example.

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

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

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

3. To solve for X . . .

   Step 1—cross multiply. 100X = 6882 (1st step is to cross-multiply)

   Step 2—divide by the value in front of X. X = 6882 ÷ 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% 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 dry matter 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)

Conversion of feed nutrients from an air-dry to dry matter basis—An Example.

1. Assume the label of a commercial protein supplement indicates the feed should have a minimum of 36% CP. What is the crude protein percentage of the supplement when expressed on a dry matter basis?

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

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

3. To solve for X . . .

   Step 1—cross multiply. 90X = 3600 (1st step is to cross-multiply)

   Step 2—divide by the value in front of X. X = 3600 ÷ 90 = 40% CP on a dry matter basis (100% DM)

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

5. Alternative solution. The known crude protein value could be divided by its associated dry matter 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 com-

mon to evaluate dry matter intake as an indicator of health and performance, but the feed that is placed in the bunk may contain 10 to 50% 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. This will result in a larger number because water is now included in the weight.

Conversion of weight from as-fed to dry matter basis—An Example.

1. On an as-fed basis, a feedlot finishing ration is 60% dry matter. If the cattle consume 40 lbs of the ration, how much actual dry matter is consumed?
2. The conversion is from an as-fed (water included) to a dry matter (water removed) basis. Thus . . .

   40 lbs as-fed * 0.60 = 24 lbs dry matter

Conversion of weight from dry matter to as-fed basis—An Example.

1. A ration was formulated on a dry matter basis that consisted of 45% dry rolled corn (87% DM), 35% wet distillers grains (36% DM), 15% alfalfa hay (89% DM), and 5% supplement (90% DM). How much of each ingredient must be added to the mixer to make 1 ton (2000 lbs) of mixed feed?
2. To simplify, rather than evaluating the ration formulation on a percentage basis, assume it is a formulation to mix 100 lbs of dry matter (45 lbs dry rolled corn, 35 lbs wet distillers grains, 15 lbs alfalfa, and 5 lbs supplement).
3. Because ingredients differ in dry matter, the conversion is from a dry matter (water removed) to an as-fed (water included) basis. Thus, each ingredient must be divided by its corresponding dry matter percentage to determine the amount of that particular ingredient that is needed, as-fed.

Dry Rolled Corn:	45 lbs DM	÷ .87	= 51.72 lbs as-fed
Wet Distillers Grains:	35 lbs DM	÷ .36	= 97.22 lbs as-fed
Alfalfa Hay:	15 lbs DM	÷ .89	= 16.85 lbs as-fed
Supplement:	5 lbs DM	÷ .90	= 5.55 lbs as-fed
Total	100 lbs DM		171.34 lbs as-fed

4. Because ingredients differ in dry matter, ingredient proportions differ on an as-fed basis compared to a dry matter basis. For example, wet distillers grains makes up only 35% of the ration on a dry matter basis, but nearly 57% of the ration on an as-fed basis due to this ingredient having a lower dry matter. To calculate the relative proportion or percentage of feed ingredients in the ration 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 lbs as-fed	÷ 171.34	* 100	= 30.19% as-fed
Wet Distillers Grains:	97.22 lbs as-fed	÷ 171.34	* 100	= 56.74% as-fed
Alfalfa Hay:	16.85 lbs as-fed	÷ 171.34	* 100	= 9.83% as-fed
Supplement:	5.55 lbs as-fed	÷ 171.34	* 100	= 3.24% as-fed
Total	171.34 lbs as-fed			100%

5. Once ingredient percentages are determined on an as-fed basis, mixes for any amount can be calculated. To mix one ton (2000 lbs) of this feed, simply multiply each as-fed ingredient percentage times 2000.

Dry Rolled Corn:	30.19% as-fed	* 2000	= 603.8 lbs as-fed
Wet Distillers Grains:	56.74% as-fed	* 2000	= 1134.8 lbs as-fed
Alfalfa Hay:	9.83% lbs as-fed	* 2000	= 196.6 lbs as-fed
Supplement:	3.24% as-fed	*2000	= 64.8 lbs as-fed
Total	100%		2000 lbs 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 in a mixed ration. 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.

Calculating Dry Matter of a Mixed Ration—An Example.

1. One ton (as-fed) of feed was mixed. Feed ingredients included 1150 lbs corn silage (35% DM), 115 lbs molasses (30% DM), 350 lbs corn gluten meal (90% DM), 120 lbs soyhulls (90% DM), 215 lbs ground corn (88% DM), and 50 lbs of a mineral/vitamin premix (100% DM).

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

Corn Silage:	1150 lbs as-fed	* .35	403 lbs DM
Molasses:	115 lbs as-fed	* .30	35 lbs DM
Corn Gluten Meal:	350 lbs as-fed	* .90	315 lbs DM
Soybean Hulls:	120 lbs as-fed	* .90	108 lbs DM
Ground Corn:	215 lbs as-fed	* .88	189 lbs DM
Mineral/ Vitamin Premix:	50 lbs as-fed	* 1.00	50 lbs DM
Total	2000 lbs as-fed		1100 lbs DM

3. Overall dry matter percentage of the mixed feed = 1100 lbs DM ÷ 2000 lbs as-fed * 100 = 55% DM

4. In contrast, a simple arithmetic average of the dry matter values (corn silage = 35%, molasses = 30%, corn gluten meal = 90%, soybean hulls = 90%, ground corn = 88%, and mineral/vitamin premix = 100%) without accounting for differences in quantities would return an average dry matter value of 72%. This is erroneous because wet feeds make up a significantly greater percentage of this ration 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.

This publication is a revision of Feed Dry Matter Conversions, 2011, NebGuide G2093, by Bryan Reiling.

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