Exercise 3
Adjusting for Moisture Content in Feedstuffs
20 Points

Introduction:

Feedstuffs vary tremendously in their moisture or water content. For example, alfalfa silage may have 65% moisture, while alfalfa hay may have only 12% moisture. The moisture content of feedstuffs is of relatively small nutritional value to the animal; however, the amount of moisture affects the concentration of other nutrients (protein, energy, etc.) contained within the feed. Therefore, to consider the nutritional value of the feed, the concentration of nutrients should be considered as if the feed had all of its water removed. This expression of nutrient concentration is termed "dry matter basis", or simply "DMB". For example, the expression of the protein content of the feed’s dry matter (DMB) is a more accurate expression of the feed’s nutritive value than if the protein content was expressed as a concentration with the water in the feed (or on an "as fed basis"). Importantly, a nutrient concentration of a feed is greater when expressed on a DMB than when expressed on an as fed basis. This is because the water contained in the feed acts to dilute the concentration of the nutrients, therefore the nutrient concentration with the water removed is greater than with the water included.

Conversely, when pricing feed or placing a value on feed, the water content must be considered very closely. Obviously the livestock producer purchasing feed does not want to pay for the water present in the feed. It is the dry matter which contains the nutrients that the feed buyer is willing to pay for. This exercise is designed to teach the students skills necessary to properly evaluate feeds that differ in moisture and nutrient concentration.

Finally, an important dry matter conversion skill to acquire is to convert ingredient percentages in a ration from a DMB to an as fed basis. You should remember from Exercise 1 that an animal’s nutrient requirements are expressed on a DMB. For example, to say that the protein requirement for a growing lamb is 13% DMB is to say that the DM in the ration should contain 13% protein. Because of this, the DMB nutrient concentrations of feed ingredients are used to balance rations to meet the requirements of animals. The result of this formulation is a list of ingredients and their required ration percentage on a DMB. It is then necessary to convert these ingredient percentages from a DMB to an as fed basis.

Objective:

The objective of this exercise is to teach the student to: 1) convert nutrient concentrations of feeds from an as-fed basis to a DM basis and vice versa, 2) evaluate the nutrient value ($/nutrient) of feeds on the basis of moisture content and nutrient content, and 3) to convert a ration from an DM basis to an as-fed basis.
**Nutrient Concentrations:**

Consider that the following bar represents a sample of alfalfa. This particular hay contains 15% water and 85% dry matter. Also, the hay is 18% protein (as fed) leaving 67% for the other dry matter constituents:

<table>
<thead>
<tr>
<th>Component</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>15%</td>
</tr>
<tr>
<td>Protein</td>
<td>18%</td>
</tr>
<tr>
<td>Carbohydrate Ash Lipid</td>
<td>67%</td>
</tr>
</tbody>
</table>

Total Dry Matter = 85%

When the water is removed (the 15% from the bar), there remains a bar which is comprised strictly of dry matter. Of the original 100 part bar, 85 parts remain and of the remaining 85 parts, 18 parts are protein and 67 parts are the other dry matter constituents:

<table>
<thead>
<tr>
<th>Protein</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbohydrate Ash Lipid</td>
<td>67</td>
</tr>
</tbody>
</table>

Total Dry Matter = 85 parts

Now the protein component of the bar is 18 parts per 85 rather than the 18 parts per 100 when water was a component of the bar. Therefore, the protein content of the sample on a DMB is:

\[
\frac{18}{85} \times 100 = 0.2118 \text{ or } 21.18\%
\]

The following equation can be used to calculate the nutrient content of a feed on either a dry matter or an as fed basis:

\[
\text{Known Nutrient Concentration} = \frac{\text{Unknown Nutrient Concentration}}{\text{Known Dry Matter Content}} \times \text{Desired Dry Matter Content}
\]
In our example if we know that a feed is 18% protein as fed and has 15% water (85% DM), and we want to know what the protein content is on a dry matter basis, this is how we can use this equation:

\[
\frac{18}{85} = \frac{x}{100} \quad x = 21.18\% \text{ protein (DMB)}
\]

Alternatively, if we have a feed which 20% protein on a dry matter basis and the feed contains 20% water, (80% DM) and we want the protein content of the feed on an as fed basis, this is how the equation is used:

\[
\frac{20}{100} = \frac{x}{80} \quad x = 16\% \text{ protein (as fed)}
\]

It is important to remember when performing these exercises that the as fed nutrient concentration is **ALWAYS** less than the dry matter basis nutrient concentration. If you have used the equation and this is not the case, then you have used the equation incorrectly.

**Adjust Feed Costs to Equal Dry Matter Content.**

Because feeds differ in their dry matter content, it is desirable to adjust feeds to an equal dry matter content. For example we want to determine the value, or fair price, for high moisture corn (dry matter content = 75%) when the fair market value for conventional corn (dry matter content = 88%) is $210/ton. Because these feeds differ only in dry matter content, it is sufficient to establish prices for the two feeds that are proportional to their dry matter content:

\[
\frac{210}{88} = \frac{x}{75} \quad x = $178.98/ton of HMC
\]

This is to say then that when “conventional” or “dry” corn is $210/ton, high moisture corn is worth $178.98/ton given these dry matter conditions. Importantly, if everything else is equal, the feed having the greatest dry matter content is always more valuable. Remember, **do not pay for water**.

**Calculate Cost per Nutrient Provided.**

In most situations feeds which are to be compared economically may differ in dry matter content as well as in the nutrient content of the dry matter. In these situations it is best to determine the cost per amount of nutrient each feed provides. The equation for determining the cost per nutrient provided is as follows:

\[
\$/\text{nutrient} = \frac{\$/\text{ton of the feed}}{\text{nutrient content in the feed}}
\]
For example, the cash market value of alfalfa hay (88% dry matter and 18% protein on a dry matter basis) is $160/ton and your neighbor has hay that is 86% dry matter and 16% protein on a dry matter basis. The neighbor is willing to sell the hay for $144/ton because of its lower dry matter and protein content. Is this a good price? The calculation necessary first requires that the protein content be converted to an as fed basis because the price per ton of hay is expressed on an as fed basis:

Step 1: Adjust CP% to as fed basis

Alfalfa 1: \[
\begin{align*}
\frac{18}{100} &= x \\
\frac{88}{88} &= x = 15.84\% \text{ CP - As fed}
\end{align*}
\]

Alfalfa 2: \[
\begin{align*}
\frac{16}{100} &= x \\
\frac{86}{86} &= x = 13.76\% \text{ CP - As fed}
\end{align*}
\]

Next the cost per amount of protein provided can be calculated:

Step 2: $/nutrient = \frac{$/ton of the feed}{nutrient content in the feed}

Alfalfa 1: \[
\begin{align*}
\frac{160}{.1584} &= \frac{1010.10}{\text{ton CP}} = \$0.505 \\
\frac{1}{10} &= \text{lb CP}
\end{align*}
\]

Alfalfa 2: \[
\begin{align*}
\frac{144}{.1376} &= \frac{1046.51}{\text{ton CP}} = \$0.523 \\
\frac{1}{10} &= \text{lb CP}
\end{align*}
\]

This example demonstrates that although the neighbor's hay is priced lower, the cost per pound of protein provided is still greater than the typical cash market hay ($0.523 vs $0.505 per pound of protein). The neighbor then asks what you feel is a fair price for his hay. The above calculation indicates that you should be willing to pay $1010.10 per ton of protein (Alfalfa 1). Therefore, you insert this value in the Alfalfa 2 equation and solve for the $/ton:

\[
\frac{x}{.1376} = \frac{1010.10}{\text{ton CP}} \\
x = 138.99/\text{ton of Alfalfa 2}
\]

You will be willing to pay the neighbor $138.99/ton of his hay given that the cash price of 18% protein, 88% dry matter hay in your area is $160 per as fed ton.
**Convert ration ingredient percentages from DMB to as fed basis:**

As explained in the introduction, when a ration is balanced the calculated ingredient proportions or percentages are initially expressed on a DMB, which then need to be converted to an as fed basis so that the ingredients can be weighed and the ration prepared. A typical ration for a lactating dairy cow may consist of 55% forage and 45% concentrate on a DMB. This obviously does not tell you how much of each as fed ingredient to weigh to prepare a given amount of the ration. The forage is a mixture of silage and hay with a DM content of 50% and the concentrate is a mixture of grain and protein and mineral supplements and has a DM content of 90%. The conversion of the ration to an as fed basis is as follows:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Ration %, DMB</th>
<th>DM content</th>
<th>As fed amount</th>
<th>Ration %, As fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forage</td>
<td>55</td>
<td>.50</td>
<td>55/.50 =110</td>
<td>110/160 = 68.75</td>
</tr>
<tr>
<td>Concentrate</td>
<td>45</td>
<td>.90</td>
<td>45/.90 = 50</td>
<td>50/160 = 31.25</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>XXX</td>
<td>160</td>
<td>100</td>
</tr>
</tbody>
</table>

Then if you need to feed your herd 1000 pound of ration you would mix 687.5 pounds of the forage with 312.5 pounds of the concentrate.
1. A feed sample (Feed A) weighs 160 g fresh (as fed). After drying at 100 C in an oven for 24 hours the sample weighs 144 g. What is the dry matter (DM) percent of the feed?

2. Feed A was analyzed to have 18% protein, as fed. What is the crude protein percentage of the feed on a DM basis?

3. A second feed (Feed B) is 80% DM and has 17% crude protein, as fed. Which feed is a better source of crude protein (which has more protein on a DM basis)?

4. Feed A costs $140 per ton and B costs $132 per ton (as fed). What is the cost per pound of crude protein for each of the feeds? Provide your answer to the 3rd decimal place ($\cdot\cdot\cdot/\text{lb of CP}$)
5. The fair market value for alfalfa hay which is 86% DM is $142 per ton. Calculate the value of equivalent alfalfa haylage which is 46% DM.

6. Compare the cost per pound of crude protein provided by regular soybean meal (SBM) which is $335 per ton, 50% protein-DMB, and 92% DM with dehulled SBM which is $360 per ton, 54.5% protein-DMB, and 93% DM.

7. Compare the cost per pound of TDN provided by alfalfa hay which is $142 per ton, 58% TDN-DMB and 86% DM with barley which is $234 per ton, 82% TDN-DMB and 91% DM.

8. What is the cost per Mcal of ME of grass hay which is $110 per ton (as fed), 88% DM, and 1.9 Mcal of ME/kg (DMB)?
9. For practice, perform the following conversions from as fed basis to DM basis or vice versa. Always show all of your work!

A. What is the Ca content of grass silage on a DM basis if the as fed analysis is 0.32% Ca and the DM content is 38%?

B. How many megacalories (Mcal) of metabolizable energy (on DMB) is in barley, which is 92% DM and has 3.1 Mcal/kg on an as fed basis?

Convert the answer to Mcal/lb (2.2 lb = 1 kg).

C. If soybean meal is 48% protein on an as fed basis, what is its protein content on a DM basis if its DM content is 92%?

D. You have your choice of alfalfa hay, which is 16.5% protein as fed and 89% DM, and alfalfa silage which is 6.8 % protein and 34% DM. Which has the best protein content?

What lesson do you learn in the example above about the importance of understanding nutrient concentrations on a DM basis?
10. Given the following lactating cow ration and ingredient percentages on a DMB, what are the as fed ration percentages of the ingredients?

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Ration %, DMB</th>
<th>DM Content %</th>
<th>Ingredient %, As Fed</th>
<th>Ration %, As Fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass Hay</td>
<td>82</td>
<td>88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley</td>
<td>12</td>
<td>92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein Supplement</td>
<td>6</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If the cows weigh 1230 pounds and should consume 2.2% of their body weight in DM, how much of the supplement (as fed weight) will you want them to consume (lbs/head/day)?

How much barley (lbs/head/day)?