Proper Hay Storage Tips

Colin Hill

- With the rain behind us, we can finally get out to put up hay. However, with the moisture we have had, it is important to insure hay moisture levels are correct before baling to prevent hot hay quality loss and the chance of fire.

- The moisture of dry hay at baling is critical to hay quality during storage and can be the difference between high quality hay and trash. Small square bales should be baled at less than 22 percent moisture, and round bales should be less than 18 percent moisture before baling. Hay baled with more than 22 percent moisture should not be put into storage for at least thirty days, especially if hay will be stacked several layers deep.

- Safe storage temperatures are less than 120 degrees, above this excessive molding and heating occurs, fire danger begins at an internal temperature of 170. Bale temperature usually peaks four to seven days after baling, and can increase rapidly if conditions are favorable.

- For bales stored outside, barn fire danger is lost, but quality remains an issue. Excessive heating and molding can cause the loss of as much as one-third of the feeding value of hay bales at 28 percent moisture. Outside storage combined with loss of feed value due to poor digestibility can result in a loss of total feed during storage of around 25 percent which results in a 25 percent loss of the initial investments like land, fertilizer, time, and fuel.

- Following some general guidelines when storing dry hay outside can reduce storage losses. Always store bales on a well-drained area, some farmers place bales on poles or crushed rock to minimize losses on the bottom of bales. Use a minimum of three feet between bale rows for air circulation, and always place bale rows going north to south.

Avoid storing bales under trees and in the shade of buildings, if space is available, store some of the bales inside, especially the higher quality hays that should be used near the end of the feeding period.

- Investing in a hay moisture tester and a bale thermometer can improve hay quality and remove guesswork and stress from haymaking. See Extension publication G4575 or contact Colin Hill, University Missouri Extension in Taney County at (417) 546-4431 for more information.

"Cut Late and Baled Early"

Low-Quality Forage Utilization in Ruminant Animals

Randy Wiedmeier

It’s been quite a spring! We’ve had record precipitation but I’m not complaining. My neighbors who have lived in the Ozarks for generations continue to remind me that we are only 10 days from a drought. However it has been risky weather for making hay. My Grandpa would classify this year as “Cut Late and Baled Early” regarding hay making. With the abundance of rain many producers have had to postpone cutting their hay until much of the forage was more mature than preferred. And as unsettled as the weather has been, there has been a tendency to bale before the hay is adequately dry. So many of us will be dealing with forages of lower quality than normal this year, lower in crude protein (CP) and energy (NEm). Most livestock nutritionists describe Low-Quality Forages as being below 6% CP and also containing less than .45 Mcal NEm/lb of DM. Much of our hay will likely meet those criterion this year.

I thought it would be beneficial to review some principles of low-quality forage utilization by ruminant farm animals using a couple of examples. The parameters of these examples are as follows:

<table>
<thead>
<tr>
<th>Feed</th>
<th>Crude Protein % of DM</th>
<th>Net Energy Mcal/lb. DM</th>
<th>Value $/lb. DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tall Fescue Hay</td>
<td>5.0</td>
<td>.44</td>
<td>.04</td>
</tr>
<tr>
<td>Protein Supplement</td>
<td>30.0</td>
<td>.92</td>
<td>.10</td>
</tr>
<tr>
<td>Energy Supplement</td>
<td>15.0</td>
<td>1.00</td>
<td>.08</td>
</tr>
</tbody>
</table>

1200 lb. beef cows in the last third of pregnancy
The following table illustrates the effects a **Protein Supplement** would have on the utilization of **Low-Quality Tall Fescue Hay**:

<table>
<thead>
<tr>
<th>Protein Suppl. Intake lbs. DM/day</th>
<th>0.0</th>
<th>1.0</th>
<th>2.0</th>
<th>3.0</th>
<th>4.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein from Suppl., lbs./day</td>
<td>0.0</td>
<td>.30</td>
<td>.60</td>
<td>.90</td>
<td>1.20</td>
</tr>
<tr>
<td>NEm from Suppl., Meal/day</td>
<td>0.0</td>
<td>.92</td>
<td>1.84</td>
<td>2.76</td>
<td>3.68</td>
</tr>
<tr>
<td>Hay Intake, lbs. DM/day</td>
<td>18.0</td>
<td>19.2</td>
<td>20.8</td>
<td>21.3</td>
<td>21.5</td>
</tr>
<tr>
<td>Hay NEm Content, Mcal/lb. DM</td>
<td>0.44</td>
<td>.47</td>
<td>.49</td>
<td>.51</td>
<td>.51</td>
</tr>
<tr>
<td>NEm from Hay, Mcal/day</td>
<td>7.92</td>
<td>9.02</td>
<td>10.19</td>
<td>10.86</td>
<td>10.97</td>
</tr>
<tr>
<td>Protein from Hay, lbs./day</td>
<td>0.90</td>
<td>0.96</td>
<td>1.04</td>
<td>1.07</td>
<td>1.09</td>
</tr>
<tr>
<td>Total NEm Intake, Mcal/day</td>
<td>7.92</td>
<td>9.92</td>
<td>12.03</td>
<td>13.62</td>
<td>14.65</td>
</tr>
<tr>
<td>NEm Requirement, Mcal/day</td>
<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Status</td>
<td>-5.08</td>
<td>-3.06</td>
<td>-9.7</td>
<td>+.62</td>
<td>+1.65</td>
</tr>
<tr>
<td>Total Protein Intake, lbs./day</td>
<td>.90</td>
<td>1.26</td>
<td>1.64</td>
<td>1.97</td>
<td>2.29</td>
</tr>
<tr>
<td>Protein Requirement, lbs./day</td>
<td>1.92</td>
<td>1.92</td>
<td>1.92</td>
<td>1.92</td>
<td>1.92</td>
</tr>
<tr>
<td>Status</td>
<td>-1.02</td>
<td>-.66</td>
<td>-.28</td>
<td>+.05</td>
<td>+.37</td>
</tr>
</tbody>
</table>

Remember this is an example. The numbers in Table 1 will change with different forage and protein supplement types. However, the principles will remain constant. The following are a few of these principles we can glean from Table 1:

- As the amount of protein supplement consumed increases (0 to 4.0 lbs. /day) the intake of the low-quality hay increases (18.0 lbs. DM to 21.5 lbs. DM). It’s important to remember that low-quality forages are low in protein and in energy relative to animal (cows in this example) requirements. The low protein content of these forages is not only below animal requirement but is also starving the microorganisms that inhabit the ruminal compartment of the stomach for needed protein. Thus their activity is diminished. The problem with that is most of the energy of these low-quality forages is associated with Fiber and fiber utilization can be accomplished only by these microorganisms. They ferment the plant fiber and then share a portion of the energy with the cows. Adding protein to the diet increased the activity of the ruminal microorganisms and thus increased the rate and extent of fiber utilization, allowing increased hay intake.

- As the amount of protein supplement offered increases, the effect on forage intake subsides. Note that increasing supplement from 3.0 to 4.0 lbs. /day increased hay intake only slightly.

- Protein supplementation increased the energy (NEm) content of the hay from .44 Mcal NEm/lb. with no supplementation to NEm with supplementation. This is roughly eq. .51 Mcal NEm/lb. equivalent to an increase of 44 % TDN to 51% TDN. This was due to the increased activity of the microorganisms in the rumen.

**Low-Quality Tall Fescue Hay:**

- Protein supplementation increased both the intake of the hay and its available energy content. So the energy intake from the hay was increased from 7.92 Mcal of NEm without supplementation to 10.97 Mcal of NEm with supplementation.

- Note that protein and energy requirements of the cows were not met until they were receiving **3.0 lbs. of protein supplement** per day. Feeding 4.0 lbs. of protein supplement was not necessary unless the cows were required to increase body condition. Another source of supplementation for ruminants like cattle that are consuming low-quality forage is cereal grains like corn or barley. Grain supplements are usually much cheaper than protein supplements but have a much different affect or low-quality forage utilization. This is illustrated in table 2.

**Good quality tall fescue**
Table 2:

<table>
<thead>
<tr>
<th>Grain Suppl. Intake, lbs./day</th>
<th>0</th>
<th>2.0</th>
<th>4.0</th>
<th>6.0</th>
<th>8.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein from Suppl., lbs./day</td>
<td>0</td>
<td>.30</td>
<td>.60</td>
<td>.90</td>
<td>1.20</td>
</tr>
<tr>
<td>NEm from Suppl., Mcal/day</td>
<td>0</td>
<td>2.0</td>
<td>4.0</td>
<td>6.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Hay intake, lbs. DM/day</td>
<td>18.0</td>
<td>17.5</td>
<td>16.8</td>
<td>15.9</td>
<td>14.7</td>
</tr>
<tr>
<td>Hay NEm from Hay, Mcal/day</td>
<td>.44</td>
<td>.43</td>
<td>.425</td>
<td>.417</td>
<td>.40</td>
</tr>
<tr>
<td>NEm from Hay, Mcal/day</td>
<td>7.92</td>
<td>7.53</td>
<td>7.14</td>
<td>6.63</td>
<td>5.88</td>
</tr>
<tr>
<td>Protein from Hay, lbs./day</td>
<td>.90</td>
<td>.88</td>
<td>.84</td>
<td>.80</td>
<td>.74</td>
</tr>
<tr>
<td>Total NEm Intake, Mcal/day</td>
<td>7.92</td>
<td>9.53</td>
<td>11.14</td>
<td>12.63</td>
<td>13.88</td>
</tr>
<tr>
<td>NEm Requirement, Meal/day</td>
<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Status</td>
<td>-5.08</td>
<td>-3.47</td>
<td>-1.86</td>
<td>-.37</td>
<td>+.88</td>
</tr>
</tbody>
</table>

- As the amount of grain-type supplement increased, the intake of the low-quality hay decreased from 18.0 lbs. /day without supplementation to 14.7 lbs. /day with 8.0 lbs. /day grain supplement. So the opposite effect of protein supplementation.
- Also notice that the energy content of the hay decreased as grain supplementation increased. Again, the opposite effect of protein supplementation.
- These are termed Associative Effects, in which the utilization of a mixture of feeds in an animal’s diet is different than what would be expected by adding the contributions of the individual components. Regarding supplementation of low-quality forages, Protein supplementation resulted in a Positive Associative Effect as the utilization of the hay was increased. Grain Supplementation resulted in a Negative Associative Effect.
- The negative associative effect of grain supplementation on low-quality forage utilization can be explained by impacts on microorganism in the rumen. The starches in cereal grains are rapidly fermented in the rumen, which causes a fairly rapid increase in rumen acidity. The microorganism that fermented fiber (fibrolytic) decrease their activity when in acidic conditions. Thus the rate and extent of fiber fermentation decreases. Also some fibrolytic rumen microorganisms can ferment either fiber or starch but prefer starch when available. So they Substitute starch for fiber and forage utilization decreases.
- Table 2 shows that the cows had to be fed 8.0 lbs. /day of grain supplement before their protein and energy requirement were met.
- So is supplementing cattle or other ruminants being fed low-quality forages with cereal grain supplements to be avoided? Keep in mind that the cows’ requirements can be met by feeding a fairly large amount of cereal grain and the low-quality hay. Actually the reduction in hay intake can be an advantage if the Supply of hay is limited. Also keep in mind that our objective is to feed the cow herd through the winter with the least expense. Let’s estimate the cost of the protein

Table 3:

<table>
<thead>
<tr>
<th>Feed</th>
<th>Lbs./cow/day</th>
<th>$/lb.</th>
<th>$/cow/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein Supplement</td>
<td>3.0</td>
<td>.10</td>
<td>.300</td>
</tr>
<tr>
<td>Low-Quality Hay</td>
<td>21.3</td>
<td>.04</td>
<td>.852</td>
</tr>
<tr>
<td>Diet Cost</td>
<td></td>
<td></td>
<td>$1.152</td>
</tr>
<tr>
<td>Grain Supplement</td>
<td>8.0</td>
<td>.08</td>
<td>.64</td>
</tr>
<tr>
<td>Low-Quality Hay</td>
<td>14.7</td>
<td>.04</td>
<td>.588</td>
</tr>
<tr>
<td>Diet Cost</td>
<td></td>
<td></td>
<td>$1.228</td>
</tr>
</tbody>
</table>

- Either diet will supply the cows with amounts of protein and energy required. But with the feed price estimates used in this example the Protein Supplemented diet will save about $.08 /cow/day.

Cautions: The objective of this article was to review some of the basic principles of low-quality forage utilization in ruminant animals (cattle). The value of feeds, etc., changes from farm to farm and from year to year. But the principles here in will help illustrate important factors that should be considered. Only protein and energy requirements were considered in this article. Mineral and vitamin concentrations in most low-quality forages are well below the requirements of most producing animals. Thus careful supplementation of these nutrients is also needed.

Don’t Become a Victim of a Hay Bale Fire

Bob Schultheis

The wet weather this haying season is challenging forage producers to put up hay dry enough that it will keep without damage. Fires that damage or destroy hay and barns cost area farmers thousands of dollars each year for building replacement, feed replacement, poor animal performance, and loss revenues from hay sales.
Proper harvesting and storage practices will reduce the possibility of hay fires and reduce the associated costs. Hay fires usually occur within four to 10 weeks after baling, depending on storage and climatic conditions and on the moisture content of the forage.

You can reduce fire and mold risk by baling small square bales at 18 to 22 percent moisture content and large round bales at 14 to 18 percent moisture content. The large round bales must be baled drier because they have three times less surface area per pound of hay to give up their moisture (see Figure 1).

![Figure 1. Comparison of bale surface area to pounds of hay in the bale](image)

Higher moisture levels increase microbial activity and also results in loss of dry matter and usable protein, which can reduce the feeding value of the hay by as much as one-third.

Heating in hay bales will occur to some extent in all forages over 15 percent moisture content, with a typical peak in temperature 4 to 7 days after baling. It takes 15 to 60 days for the hay temperature to decline to non-damaging levels, depending on outdoor humidity, density of the bales, and amount of rain the bales soak up. The longer it takes for the hay temperature to decline, the more damage is done to the hay. For safe storage of hay inside a barn, the bale temperature should be below 120°F. New hay that is stacked in the field or placed in a barn should be checked at least twice a day for abnormal heating. Make sure the barn roof and any plumbing does not leak, and that surface water cannot run into the barn.

If the hay temperature reaches 130°F, move the hay to allow increased air circulation and cooling. If the temperature climbs above 160-175°F, call the fire department and be prepared to inject water to cool hot spots before moving the hay. Don't open the barn door if the hay is smoking. The added oxygen can cause the hay to burst into flames.

Hay temperature can be easily checked using a compost thermometer. These can range in price from $30 to $170. For versatility and durability, I recommend a thermometer with a 36" long stem that is 5/16" to 3/8" in diameter and measures from 0 to 200°F. An example can be found at [http://www.amazon.com/REOTEMP-A36FR-D43-Compost-Thermometer-Response/dp/B002Q13MA6/ref=sr_1_1](http://www.amazon.com/REOTEMP-A36FR-D43-Compost-Thermometer-Response/dp/B002Q13MA6/ref=sr_1_1). If you prefer to build your own, use a 3/8-inch diameter pipe with a pointed tip screwed to the end and holes drilled in it. A thermometer can then be inserted into the pipe and retrieved and read after 10-15 minutes.

If your hay got hot but didn’t burn, it likely suffered significant protein damage. So when doing forage testing for nutritional quality, be sure to include the test for “available protein.” The cows may like the hay because it is caramelized brown, but it will have very low nutritional value. More information on forage testing is available at [http://extension.missouri.edu/webster/pres-2009-01-15.aspx](http://extension.missouri.edu/webster/pres-2009-01-15.aspx).

Two MU guides that are very helpful in putting up good quality hay are G3151 Using a Microwave Oven to Determine Moisture in Forages and G4575 Making and Storing Quality Hay.

**Motorists Often the Losers in Crashes with Farm Machinery**

*Bob Schultheis*

During summer hay harvesting season, farm machinery navigating over public roads is heavy, especially on rural roads. And that creates danger for highway accidents. Years ago, with large cars and small tractors, the farmer was usually the loser in a collision. Now many farmers have larger tractors and there are more smaller, lighter-weight cars on the highways. More motorists now come out on the losing end.

**These are some highway safety tips for motorists:**

- Slow down on roads where farm equipment might be found. Tractors travel at less than 25 mph, so the motorist has less time to react and take avoidance measures. Reaction time may be as little as 5 seconds, especially on blind hills and curves. Texting while driving on rural roads can be fatal.
- To avoid a sideswipe collision, watch for wide machinery when passing.
- Plan extra travel time to destinations when traveling on rural roads. Be patient. The farmer has as much right to use the road as the motorist.

**These are some highway safety tips for farmers:**

- Make sure the rear of the tractor and each piece of equipment is marked with a Slow-Moving Vehicle (SMV) sign and that it’s in good visible repair. The triangular, red and orange SMV sign should be mounted, with the point up, between 4 and 6 feet above the ground (see Figure 2). Upgrade older signs with new retro-reflective and fluorescent tapes to improve visibility.
- Turn on lights and warning flashers, if the tractor has them, to improve visibility. Use turn signals or hand signals when turning.
- If moving equipment on curving roads, roads with blind hills or roads lined with trees or high weeds, send an escort vehicle ahead to warn oncoming traffic.
- Stay alert and pull over to the shoulder where possible to let any buildup of traffic pass.


If you have questions on this topic or other engineering concerns, you can reach me at the Webster County Extension Center in Marshfield by phone: 417-859-2044, by email: [schultheisr@missouri.edu](mailto:schultheisr@missouri.edu), or go to our website at [http://extension.missouri.edu/webster](http://extension.missouri.edu/webster).
Feeding Value of Hay May be Altered in 2015
Ted Probert

In last month’s newsletter Sarah talked about concerns with forage quality of hay baled late due to poor haying conditions. The take home message from that discussion is that advanced plant maturity negatively affects forage quality. When we did get into the hay fields much of this year’s hay was made under less than ideal drying conditions resulting in some hay being baled at a higher than optimal moisture content. This situation sets the stage for some additional issues that can alter the feeding value of hay.

One problem that can arise in hay baled too wet is mold. Just about all hay contains some trace amounts of mold but hay that is high in moisture content provides an environment in which mold growth can flourish. Moldy hay will predictably be lower in nutrient content than it was before mold growth began. As the fungi grow they utilize the forage’s energy and protein – nutrients that we would rather see used by livestock. Additionally, moldy hay will typically be less palatable than clean hay, leading to lowered intake and a further reduction of nutrients available to the animals consuming it.

A second concern when feeding moldy hay is the possibility of the presence of toxins. Horses are among the most sensitive of livestock to mycotoxins derived from moldy feedstuffs, with respiratory and digestive upsets being of major concern. Cattle, generally speaking, are less sensitive to moldy hay. It is possible, however, for mycotoxins to lead to abortions in pregnant animals. The best strategy for utilizing hay that contains mold would be to feed it to classes of livestock other than horses or pregnant females, dilute it with good hay as much as possible, and supplement as needed.

Another situation that can arise from hay baled with a higher than optimal moisture content is heat damage. Hay that is baled dry (16%-18% moisture or less) does not support microbial growth. By contrast, higher moisture levels in harvested forages create an environment that promotes microbial growth. If we are making silage this is a good situation. The microbes soon deplete available oxygen and the result is a stabilized high moisture forage product, i.e. silage. A high moisture hay package, on the other hand, cannot eliminate oxygen and in such an environment aerobic microorganisms continue to grow. Soluble carbohydrates from the forage are consumed by aerobic microorganisms, producing carbon dioxide and heat. Some types of bacteria, known as thermophilic bacteria, actually grow at temperatures in excess of 120 degrees. This microbial induced heating of the forage produces some undesirable qualities in hay.

Protein is one of the nutrients affected by excessive heating of hay. Crude protein (CP) often is assumed to be completely digested by ruminants but we know a certain amount of CP is unavailable. Usually the unavailable protein content of a forage is of little concern, but in some conditions it can be a problem. The level of unavailable protein can become significant in hay that becomes too hot during storage. The resulting forage turns brown to black depending on severity of overheating, and it has an odor that ranges from sweet to caramel-like to tobacco-like. The smell and taste can enhance palatability of overheated forage and cattle may readily consume it. In this case though, acceptance is not an indicator of quality. When forages overheat during the curing process some of the protein becomes bound to the fiber component and is rendered nutritionally unavailable to livestock. It is important to note that heat damage is not an “on” or “off” situation, but exists in degrees. Hay can be minimally damaged or severely damaged. The degree of heat damage and resulting protein unavailability can only be determined through testing the forage. With testing, damaged protein can be discounted and rations can be balanced accordingly.

Protein is the nutrient most commonly talked about in discussions on heat damaged hay but it is not the only nutrient affected. The carbohydrate profile of forages is also altered with heat damage. Neutral detergent fiber (NDF) concentration can increase significantly in heat damaged hay. In actuality, NDF is not being generated but cell solubles such as sugars are being utilized (and therefore lost) by microbes as a food source. As the microbes consume nutrients contained in the forage, heat is produced and energy density of the feedstuff (expressed as TDN or Net Energy) decreases. This leaves us with a higher fiber, lower energy forage.

As mentioned earlier, the true nutrient losses incurred through heat damage can only be determined through forage test results. TDN or Net Energy values indicated on the test report should be fairly straight forward. Unavailable protein may be expressed in one of several ways. Terms such as acid detergent insoluble crude protein (ADICP), acid detergent fiber crude protein (ADF-CP), acid detergent insoluble nitrogen (ADIN), heat-damaged protein (HDP) and insoluble crude protein (ICP) are all used in the industry to indicate unavailability and they all mean basically the same thing. Also included on the test report will be adjusted crude protein (ADJ CP). This is the value that should be used in ration formulation in place of CP.

If you have questions concerning heat damage to forages or utilization of forage test results feel free to contact your local extension office.

Hay harvested from the same field, same cutting – sample on the left shows significant heat damage – sample on the right was properly cured and has no heat damage.