RETURN TO START

Alfalfa Protein

Many alfalfa hays and haylages grown in Alberta have crude protein levels above 20%. In fact, high protein levels have been the primary objective of alfalfa growers for many years. However, in the past few years, we have come to recognize that the high degradability of alfalfa protein demands changes in the way that we handle the crop and in the way that we formulate and deliver alfalfa-based rations.

Protein Degradability

In typical lactating rations, 60-75% of the crude protein is broken down (*degraded*) by rumen microbes. Some ration ingredients, such as urea, contain protein which is degraded completely and very rapidly. Bypass protein sources, including corn gluten meal and meat meal, are degraded slowly, allowing part of their protein to *escape*, or *bypass* the rumen. The degradability of canola and soy protein lies between that of urea and bypass protein sources. Relative degradabilities are illustrated in figure 1.

The crude protein in alfalfa hay is very degradable - estimates range from 74 to 79%. When alfalfa is put up as wet silage (more than about 70% moisture), the fermentation that occurs in the silage often results in the breakdown of protein, further increasing its degradability.

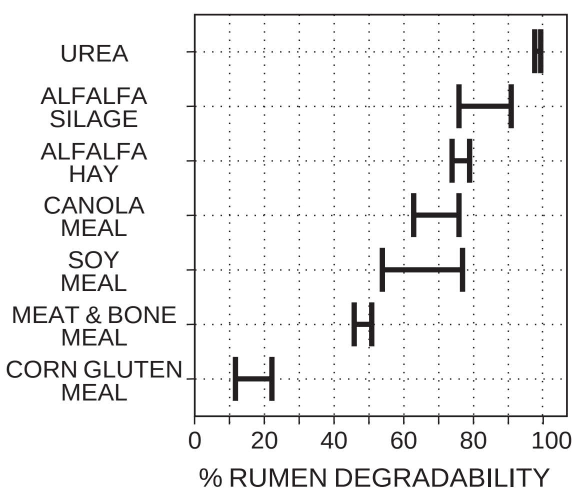

Figure 1 : Rumen degradability estimates for the crude protein in common feed ingredients.

Dry haylages (less than about 50% moisture) often heat in storage. The same problem occurs in wet hays. Heating can produce heat-damaged protein, measured in the feed lab as *acid detergent insoluble nitrogen* (ADIN) or *acid detergent fibre* (ADF) *insoluble protein*. Heat damaged protein is considered undegradable in the rumen, but if the degree of heating is high enough, heat-damaged protein may also be indigestible in the small intestine. Most feed labs report an adjusted crude protein value if heat-damaged protein is greater than about 9% of total crude protein.

Reducing protein damage in the crop

Alfalfa is one of the most difficult crops to preserve as silage. Before discussing why, let's consider what is supposed to happen in storage :

- the crop is ensiled and packed, either under its own weight (in an upright) or with a tractor (in a bunk, pit or pile). The objective of packing is to exclude as much oxygen as possible, to reduce *aerobic* (oxygen-requiring) spoilage to a minimum.
- aerobic bugs (including yeasts, moulds and some bacteria) consume the remaining oxygen, along with *fermentable carbohydrates* in the crop. They produce acids which start the process of lowering pH. Heat is a byproduct of carbohydrate breakdown.
- when most of the oxygen has been consumed and the pH has been lowered to about 5.5 (from about 6.0 when the crop was harvested), a group of *anaerobic* (without oxygen) bugs takes over the fermentation. If there are enough of them and if there is enough fermentable carbohydrate left in the crop, they'll produce enough acid to take the pH down to about 4.0-4.5.

Now, let's look at what can go wrong with this process, particularly as it applies to alfalfa silage :

- if the crop is too dry, it will not pack well and will retain a lot of oxygen. Aerobic bugs will survive for an extended period of time, breaking down carbohydrates and producing excessive heat and heat-damaged protein.
- if the crop is very wet and well-packed, the life of aerobic bugs is quite limited. However, high moisture (greater than about 70%) favours the

growth of a type of bacteria called *Clostridia* which break down protein. *Clostridia* prefer a pH range of about 5.0-5.5, so if the anaerobes can take over and get the pH below 5.0 quickly, protein damage can be minimized.

- the wetter the crop, the more acid that must be produced to lower pH. This is simply because the acid is diluted in a larger volume of water.
- alfalfa crops often contain very limited amounts of fermentable carbohydrate. If the anaerobic bugs run out of carbohydrates to ferment, they may be unable to produce enough acid to get the pH down below 5.0. *Clostridia* will contiue to multiply and break down protein.
- alfalfa contains natural buffers which resist changes in pH. Therefore, the amount of acid that must be produced to lower pH to the 4.0-4.5 range is greater than for most other crops.

With this background in mind, here are a few recommendations for reducing protein damage in alfalfa silages :

- put the crop up at a moisture level of 50 - 70%;
- pack well and seal quickly to minimize the amount of oxygen available for aerobic spoilage;
- use a silage inoculant containing anaerobic, lactic acid producing bacteria. Used correctly, this will guarantee that there are enough bugs present to ferment the available carbohydrates. In addition, these bacteria are more efficient at lowering pH than native species found on the crop.
- consider mixing a source of fermentable carbohydrate with the crop before ensiling, to supplement the limited amount in the alfalfa. Ground wheat or barley are practical choices.

Formulating alfalfa-based rations

A common strategy for formulating high alfalfa rations has been to simply supplement with high bypass protein sources. Although this approach may look reasonable when balancing the ration on paper, it is expensive and results in inefficient use of the alfalfa.

The high degradability of alfalfa protein means that it is rapidly broken down in the rumen, releasing large quantities of ammonia over a short period of time. Rapid ammonia release is further increased when feeding silage that has been subject to protein breakdown or when a large amount of alfalfa is consumed in a single meal.

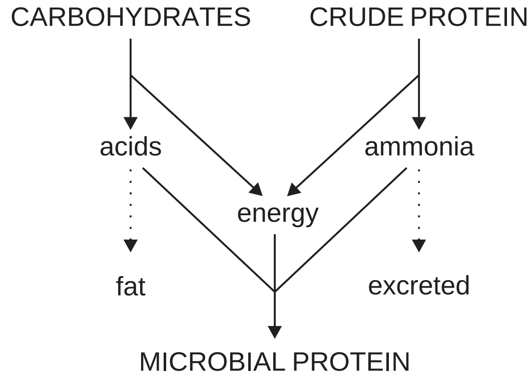

Figure 2 : Acids and ammonia are produced from the breakdown of carbohydrates and crude protein and are used to make microbial protein. Excess ammonia is excreted; excess acids yield body fat.

While rumen microbes degrade crude protein, they also use the breakdown products to produce *microbial protein*. But, in order to use these breakdown products, the bugs also require fermentable carbohydrates. When ammonia is produced in large quantities very rapidly, then the bugs need large quantities of rapidly-fermentable carbohydrates at the same time, in order to capture the available ammonia. This process is illustrated in figure 2.

Rapidly fermentable carbohydrates can be supplied by supplementing alfalfa-based rations with ingredients such as molasses and ground wheat. Feeding large amounts of these in a single meal (slug feeding) is not advised. They work most effectively when mixed with the alfalfa.

If the ammonia produced from the rapid degradation of alfalfa protein is not captured, then microbial protein production is restricted. Using high bypass proteins is intended to make up for this deficit. Another approach is to use proteins of intermediate degradability (such as canola or soy protein) to stimulate microbial protein production, reducing dependence on expensive bypass ingredients. An added bonus of this approach is that, by stimulating rumen microbial activity, the ammonia produced from the breakdown of alfalfa protein is more likely to be utilized.

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