Understanding and Reducing Mold Growth in Hay

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An ideal hay should contain maximum digestible energy and protein to meet the needs of high producing livestock. Several factors can reduce an ideal hay lot into an average or fair lot. One of the most frustrating factors that results in downgraded hay is mold. Not only is it generally less acceptable to livestock, but it can also be less nutritious and cause animal and human health problems. This paper will provide a brief overview of how mold growth occurs, its effect on hay quality, and potential solutions. Most of the information will relate to molding in alfalfa hay.

Mold Growth in Hay

The potential for hay molding starts even in the standing crop. The plant leaf and stem surfaces are mainly covered with bacteria which help protect the living plant from fungal infection and yeasts which have been suggested to have a protective role against the effects of visible light. Remember that some fungi cause diseases in the living plant like root and crown rots and leafspots, but other fungi can grow and multiply on cut and baled hay causing mold.

Once the standing crop is cut then the moisture content of the plant rapidly decreases. The predominate bacteria and yeast populations present on the standing crop are no longer competitive as the moisture content decreases. A new group of microbes can start multiplying which consists of new species of bacteria, some yeasts and an increased presence of fungi. These organisms feed off sugars and organic acids exudates from the plant during the drying process. There are over 10 main groups or genera of fungi that can be found in a hay windrow. The faster the crop dries down the less dry matter losses occur in the windrow from the growth of these fungi. Dustiness in hay without the visual presence of mold is usually a result from fungi growing in the windrow.

Once hay is baled a new group of microbes (mainly fungi and yeasts) start to multiply, especially when the moisture content is between 20% and 30%. These new fungi outcompete the windrow fungi because they can grow at the lower moisture levels and higher temperatures that occur in a hay bale. Three of the main groups or genera of fungi that start to grow in storage are *Aspergillis*, *Fusarium* and *Penicillium*. Several of the specific fungi that grow during bale storage (e.g. *Aspergillis flavus)* are known to produce mycotoxins, but usually mycotoxin production is very low or non-existent under the low moisture conditions of a hay bale. Although mycotoxins can be produced by certain fungi during hay storage, they are much more common problems in forage stored under higher moisture conditions (haylage and silage) or in grain fed to livestock.

It is important to remember that temperatures within a bale almost always rise following baling due to natural plant reactions and the increase in bacteria populations, but in dry hay the temperature never gets high enough to cause heat damage. Although bale temperatures usually decrease after two weeks, in moist hay they can reach over 150 degrees, causing excessive heat damage and even the risk of fire. It is important to remember that while moldy hay and heat damaged hay often go together, fungi alone cause little heat damage.

Each type of fungi has their own ideal temperature and moisture level where they grow best, but none grow well at low moisture levels (<15%). It is probably not that important to know the specific

genus and species of fungi that can grow within a hay bale, since it is difficult to predict which one will predominate at any given time. The most important management decision is to have the windrow at a low enough low enough moisture level at baling so that no fungi will have a very good chance to grow.

It is often impossible to prevent at least some mold growth from occurring. The following sections will discuss the effect of mold growth on hay quality. Let me give you a few definitions first though. In hay, mold growth is comprised of mycelium and spores. Mycelium are the stringy growth structure of fungi and spores are the reproductive or seed like structures. Although the spores can cause to respiratory problems in humans and horses, the main concern in cattle is the total amount of mycelium and spores combined or the total fungal biomass. (Note: white mold in a hay bale is mycelium and dustiness is from the tiny spores.)

Mold and Hay Quality

For any of you that have bought or sold hay in Wisconsin you are probably familiar with the "A Standard Guide to Evaluate Hay" developed by the Wisconsin Forage Council. Part of the visual description involves writing down how the hay was cured using a range of descriptive terms such as: no discoloration, slight discoloration, slight musty odor, slight white mold and heavy white mold. Although these visual descriptions are not very precise they are extremely important because there are no easy chemical or NIR tests to measure moldiness. The traditional method to describe mold levels has been through spore counts, but often does not reflect the amount of mycelium present (or white mold as it is usually called). There are a couple of chemical tests that can be used to determine the total amount of mycelium and spores by measuring the cell wall components of fungi (i.e. glucosamine and chitin). Each unit of glucosamine represents about 10 units of total fungal biomass. Although these tests are quite accurate, they are not commonly used except by researchers. Results from glucosamine tests show that even hay "put up" under the best of conditions often contains 1 to 2% total fungal biomass, but severely molded hay may contain up to 10% total fungal biomass. Not only do animals not like eating mold, but there can be a tremendous loss of other nutrients in the molding process.

As stated above, standard chemical and NIR measurements of forage quality provide little indication of moldiness. In fact, two hay lots can have almost the same RFV and one be moldy and the other not. Until easier measurement techniques are developed for mycelium and spore levels, visual descriptions of moldiness will continue to be very important.

The most common complaint about moldy hay by dairy and beef producers is the loss of palatability or livestock "turning off" feed. No one is exactly sure if this is due to taste, dustiness, or loss of feed quality, but all three are likely factors. Although there have been limited feeding studies with moldy hay, the following two examples from University of Manitoba research provides some insights. Four-month-old Holsteins heifers were used in a study with alfalfa hay at three different approximate levels of total fungal biomass (1.7%, 3.2 % and 4.3%). Remember that hay harvested and stored under ideal conditions can contain 2% total fungal biomass. In this study, the young heifers could eat as little or as much as they wanted. Intake was 40% lower for the heifers that were fed hay containing high levels of total fungal biomass.

In a related study, weaned Angus calves were fed alfalfa hay that contained approximately 3.7%, 4.3 % and 5.4% total fungal biomass. In this study, intake was the same at each level of hay moldiness. There was also no difference in animal stress level between the alfalfa hay lots offered. The results of these

two studies may not surprise you. You have probably had moldy hay that your livestock consumed with no problem or other moldy lots that they avoided.

Mold and hay quality is a very difficult issue because the presence of mold does not necessarily mean that the feed quality is lower. It is doubtful if mold ever results in higher quality, but it may or may not cause lower feed quality. More commonly though, the presence of mold indicates other problems. For example, heavily molded hay was likely put up moist and because of this probably has more heat damage. In a worst-case scenario, moisture levels were high enough that mycotoxin producing fungi could grow and produce mycotoxins.

So, while mold is not always a negative it is never a positive. There are several proactive things that you can do to reduce mold growth and there are several possible solutions that researchers are working on for the future.

How to Prevent Mold Development

So how does one go about reducing mold growth in hay? As stated earlier in the paper, fungi are always present in the windrow and in the bale, so they can never completely be eliminated. The best way to reduce the amount of mold growth though is do put up dry hay. Now you are probably thinking, "I knew that already". Yes, I guess everybody knows that, but it is much easier said than done. That is why mower conditioners were invented and why equipment manufacturers are still trying to perfect the perfect combination.

Hay desiccants such as potassium or sodium carbonate offer chemical alternatives for a faster dry down. This works by partially dissolving the waxy cuticle on the alfalfa stem allowing it to dry down faster, but effectiveness varies with climatic conditions.

Another mold prevention strategy is to use a hay preservative. This limits microbial growth that contributes to heating and as well as inhibit mold growth when hay is baled at higher moisture levels. Thus, hay can be baled sooner with less concern for heat or mold damage. The most effective preservatives are organic acids like propionate and acetate and their derivatives such as sodium diacetate. Another preservative in anhydrous ammonia that can be injected to hay bales after harvest. Anhydrous ammonia is only recommended for lower protein grass hay though, because adding it to high protein alfalfa hay can result in severe livestock health problems. Dan Undersander provided a good review on both desiccants and preservatives in the summer 1998 issue of the Wisconsin Forager available at http://www.uwex.edu/ces/forage/wfc/summer98.htm. It is important to remember that preservatives must be added at recommended rates and the chances for storage damage increases when higher moisture hay is stored. You may want to read a recent article in the February 2000 Hay & Forage Grower (p. 4) on preservatives, but also make sure that you read the follow-up letter to the editor in the March 2000 Hay & Forage Grower (p. 30).

Bacterial inoculants provide another method to potentially reduce mold growth. Earlier in this paper I mentioned the bacteria present on the plant surface inhibit fungi infecting the living plant. There are also naturally occurring fungi that can inhibit the growth of fungi in the windrow and after baling. The idea behind use of bacterial inoculants is to dose the plant with adequate amounts of these beneficial bacteria, so that they inhibit the mold causing fungi and outcompete the bacteria that contribute most to heating. In some cases, bacterial inoculants have shown very good results, but in other cases they have not significantly reduced molding.

Potential Solutions in the Future

It may never be possible to eliminate molding in hay completely, but there may one day be alternatives to preservatives for safely baling higher moisture hay. Alfalfa cultivars that show less tendency to mold would provide the most practical and economical solution.

Research has been conducted over the last 6 six years at the University of Manitoba to determine the feasibility of developing mold resistant cultivars. Screening 22 cultivars for mold growth indicated that there were no differences in currently available cultivars, but other research has identified individual plants that consistently show less mold growth in laboratory studies. In field studies using mini hay bales the most resistant plant showed significantly less molding in comparison to susceptible plants. At present several resistant plants have been identified and will be used for further research. A screening procedure has also been developed that can be used by other plant breeders to screen for resistance to mold growth in alfalfa. While there is little chance that totally mold-resistant cultivars will be developed, this research offers hope that cultivars may one day be developed that can be baled at higher moisture levels with reduced risk of molding.

Current breeding efforts by leading seed companies may indirectly lead to cultivars that show reduced tendency to mold. For example, companies are attempting to produce alfalfa cultivars with higher rumen bypass protein and other cultivars that either eliminate or reduce the chances for bloat. These types of cultivars may have thicker leaf cell walls, which would likely reduce the chances for mold causing organisms to grow. Another avenue to reduce bloat and to improve bypass protein is to introduce tannins into alfalfa. If tannins are successfully introduced into new cultivars, then they would likely inhibit the growth of mold causing fungi.

If you are interested in the possibility of cultivars with less tendency to mold, then I encourage you to talk to your local seed company. Tell them to follow up on some of this recent research because you want to be able to buy seed of alfalfa cultivars that you can bale at higher moisture levels without worrying about molding.

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Recent research on breeding for mold resistance is contained in a University of Manitoba thesis by Vivian Babij and in two articles published in the Canadian Journal of Plant Science: 1) Wittenberg, Smith et al. 1998. Screening methodology for post-harvest fungal resistance in alfalfa. Can. J. Plant Sci. 78:481-488 and 2) Kimbeng, Smith et al. 2000. Alfalfa resistance to post-harvest *Aspergillis* species: response to selection. Can. J. Plant Sci. 80: 755-763.