Cooked Hay!

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Unfortunately, over recent years the difficult hay making seasons has resulted in the term, "cooked" hay, to be bandied around by farmers, contractors and fodder merchants. Sometimes this cooked hay eventuated into spontaneous combustion, that is, self ignited into haystack fires.

Cooked hay is really hay that has heated to varying degrees. The heating arises from too much free moisture in or on the hay and also from plant sap and cell moisture. This moisture allows some plant respiration but mainly microbial activity by bacteria, moulds and yeasts all of which use the plant sugars to produce carbon dioxide, water and heat. This sugar is a major nutrient of the hay.

The digestibility of forages is reduced in heating hay, largely due to the oxidation or "utilisation/burning" of the sugars caused by the microbial activity to provide energy for them, not your animals (Table 1). In the short term (less than 60 days), the concentration of crude protein (CP) may increase because of preferential oxidation of the sugars. As the sugars are "used" by the microbes, the proportion of CP and fibre left behind increases hence their percentage content increases, but not the absolute amount of CP or fibre.

Table 1. Effect of Moisture Content on Dry Matter Loss and Quality changes on Hay during Storage.

Moisture content (%)	DM Loss (%)	Quality Changes
Less than 15	None	None, but if too dry at baling, energy and protein losses due to leaf shatter
15 – 20	1 – 5	Moisture evaporates to equilibrium level Slight loss of digestibility or energy. CP not affected
Greater than 20	Over 5	Significant losses of digestibility or energy (> 5% units), substantial loss of green colour, substantial decrease in protein digestibility due to heat-damaged protein

Source: M. Collins, University of Kentucky

An Agnote on the Department of Economic Development, Jbs, Transport and Resources (DEDJTR) website, AG1357: "What happens to hay when it heats?" provides a more detailed breakdown in losses of nutritive value and DM under Australian conditions.

However, the long-term effect of spontaneous heating during bale storage is to decrease CP content as it also then starts to be broken down (Table 1). Crude protein can be reduced by at least 0.25 percentage units per month of long-term storage because of volatilisation of ammonia and other nitrogenous compounds.

Maillard or non-enzymatic browning reactions occur in hays that have heated. During Maillard reactions, carbohydrates are degraded in the presence of amines or amino acids to yield polymers that are largely indigestible in ruminants. That is, the sugars and components of CP "combine" and become largely unavailable to cattle. Figure 1 shows a

round bale of hay which has undergone such severe heating and browning reactions that it was near the point of spontaneous combustion. The hotter the hay becomes, the greater the extent of browning reactions.

Heat-damaged protein is determined by quantifying the N remaining in forage residues after digestion in acid detergent and called an Acid Detergent Insoluble Nitrogen (ADIN) test. Moisture content, forage type and the magnitude and duration of spontaneous heating all affect the amount of heat damage that may occur to forage proteins.

Moisture plays a critical role by firstly having a catalytic effect which is why silages are more susceptible to heat damage than forages conserved as hay. Secondly, the moisture and consequent microbial activity within the hay at baling stimulates spontaneous heating, which subsequently increases the probability of heat damage.
All forages have some indigestible protein that is inherently unavailable to livestock, but this fraction is generally small in most standing forages or unheated hays.

Concentrations of ADIN in unheated lucerne can range between 3 and 6 percent of total N. Typically, the indigestible protein in unheated pasture hays represents a higher percentage of the total forage N, and may exceed 20 percent of total N in hays.

Grass hays are typically more susceptible to heat damage than lucerne or other legumes. Nutritionists usually consider lucerne hay to be seriously heat-damaged when concentrations of ADIN exceed 10 percent of total N.

Most hays are baled with some moisture to reduce plant shatter at baling which does result in bales warming slightly but also serves to dry out the hay by evaporating some of the remaining moisture. Depending on the environmental climate, bales will reach equilibrium moisture content, eg. 15% moisture, and dry no further. The wetter or mistier the climate, the higher is this equilibrium moisture content.

Hay users need to know that hay which has “cooked” to the extent of looking brown in the middle of the bale or stack and/or has a caramel-like smell has lost most of its nutritive value. Don’t let the cattle fool you. They will love it due to the hay’s sweetness or increased palatability but animal performance will be well below that indicated by their willingness to consume it. Yes, there may be some animal production benefit but the more the hay has “cooked”, the less they will produce.

Figure 1. Bale with severe browning reaction