DEPARTMENT OF
PRIMARY INDUSTRIES

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What Happens to Hay When it Heats?

The heating of hay results in losses of dry matter, digestible nutrients and energy as a result of a complex chain of biological activities. Palatability will also decline as dust from mould spores develop. If heating continues, chemical reactions can begin, possibly leading to haystack fires due to spontaneous combustion.

Introduction

Immediately after baling the internal bale temperature rises as a result of plant respiration, enzyme activity and microbes associated with the plant in the pasture or crop. Heating usually continues for a few days and then decreases. This temperature decrease is then often followed by a further prolonged period of heating that can last several weeks and is due to the respiration of microorganisms (aerobic bacteria, yeasts and moulds) during storage.

In hay baled at the correct moisture content, this heating will also subside, resulting in minimal losses. The temperature decline is dependent on the drying or storage conditions and the type of bale. It stabilises when the interior bale temperature is in equililbrium with ambient (surrounding air) temperature. See Agriculture Note: AG1356: *Haystack fires (Spontaneous combustion).*

Heating is largely avoided if the forage is extremely dry at baling (under 15% moisture), but this increases field losses during the harvest operations because the material is very brittle leading to leaf shatter. These losses are minimsed by baling at slightly higher moisture levels, but increase again if baled too wet.

Each type of bale should be baled at the recommended moisture contents to ensure safe storage and minimal losses during harvest. See Agriculture Note: AG1356: *Haystack fires (Spontaneous combustion).*

Baling above the recommended moisture contents will cause plant respiration and enzyme activity to continue, and increase due to the production of extra moisture and heat from this activity. This mix of water and warmth will encourage rapid mould and yeast growth. Eventually the interior of the stack or offending wet bale or bales can become so hot that charring can occur. After this stage, heat build up can increase rapidly and chemical reactions can lead to the release of inflammable gases which can self ignite on exposure to oxygen.

It is difficult to accurately predict what will happen when hay begins to heat because of the complex interactions involved. The temperature reached depends on the type of crop, its maturity and moisture content, the density, volume and storage system of the fodder, the bacteria and fungi present and the external conditions of atmospheric temperature, humidity and air movement. Exposure to further rain also increases the risk of excessive heating.

Effects of heating on hay

Heating of hay causes losses of dry matter (DM) and nutritive value. The ideal conditions (heat and moisture) in heating hay results in mould growth which further increases losses as well as reducing the hay's palatability due to production of mould spores. Lastly, there is always danger of a haystack fire due to spontaneous combustion.

The amount of heating dictates the extent of losses.

The effect of heating on DM losses

Heating hay will always result in some degree of dry matter loss because the end result is that carbon dioxide, water and heat are given off. Table 1 shows the effect of moisture content at baling on DM losses in lucerne after six months storage

Table 1. Effect of moisture content at baling of lucerne on dry matter losses after 6 months storage

Moisture Content (%)	DM Loss (% of original content)
11 - 20	5
20 - 25	8
25 - 34	11

Source: Rotz and Abrams, 1988

Many experiments have reported losses of this order but the actual DM losses will vary according to crop storage

conditions, bale type, ambient temperature, relative humidity, etc.

Rule of Thumb to estimate DM loss

A rule of thumb useful in estimating yield loss of round bale hay is that 1% of original yield will be lost for each 1% moisture that is lost as stored hay reaches its equilibrium storage moisture. For example, when hay is baled at 20% moisture, and then dries to 14%, dry matter loss will be approximately 6%.

The effect of heating on nutritive value

The hotter the hay becomes, the larger the losses in nutritive value. Early reseach in Victoria measured the extent of losses as stack temperatures increased (Table 2). The most serious effects on feeding value are substantial losses of digestible protein and energy.

Table 2. Nutrient losses caused by heating of hay

Maximum stack temperature	Loss of digestible protein (%)	Loss of energy (%)
Up to 45°C	Nil	5-10
45° to 55°C	10-30	5-15
55° to 70°C	30-80	15-30
70° to 75°C	100	40-70

Source: Simmons & Simpendorfer (1979)

Protein level is important because it is needed in feeding for milk and meat production and growth of young stock. Heating can be particularly damaging because the protein fraction becomes indigestible. Equally important, energy losses reduce the hay's value for animal maintenance and production feeding.

Heating of hay beyond about 38° C causes “browning” reactions or caramelisation and is sometimes referred to as Maillard reactions. The end result is plant sugars “bind” with the amino acids, with the extent depending upon the degree of heating. Simply put a proportion of energy and protein combine and this becomes unavailable to stock.

At feeding out, farmers mistakenly believe their hay is very palatable due to the sweet odour (hence the term caramelisation) and due to the animals’ vigour at consuming it. Stock will not perform as expected. This hay is like children eating lollies still wrapped in plastic.

Testing for heat damaged hay

The extent of heat damage can be estimated in most feed testing laboratories by measuring the amount of unavailable protein. This is measured and reported as acid detergent insoluble nitrogen as a percentage of dry matter (ADIN %). Hay bales which have turned brown from heating will have also converted its nitrates to nitrites, and these are ten times more toxic than nitrates. When supplementing fresh crop or pasture which also has high nitrate levels, it is advisable not to use caramelised hay.

Mould in hay

Hay palatability is reduced when it has been baled too moist and/or moisture increases due to excessive sweating or rain falls on the hay, because favourable conditions (moisture, nutrients, warmth) allows mould growth. These moulds produce spores and when disturbed will produce a spore ridden dust (Figure 1). These further reduce the nutritive value of hay by using the nutrients (mainly energy and protein) for their own growth and reproduction.

Although not a common occurrence in Australia, this mouldy dust can cause “Farmer’s Lung”, an infection in the lungs, when inhaled in large quantities in enclosed areas such as a fully enclosed hay shed.

Figure 1. Spore ridden dust from mouldy hay

Acknowledgements

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This Agnote was developed by Frank Mickan, Farm Services Victoria/Dairy, Ellinbank . October 2008

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