



## What happens when hay heats

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*The heating of hay is the result of a complex chain of biological events and chemical reactions. Heating can be a result of the presence of excess surface moisture (rain, dew, flood water, etc.) trapped inside hay at baling. It can also occur when the plants are too green (internal moisture) at baling or a combination of both.*

### Introduction

Initial heating occurs because living processes continue for some time after plants are cut. This heat may dissipate within days, depending on the drying or storage conditions, or may continue to rise over a period of weeks. Even though higher temperatures and higher humidity may favour fungal, bacterial or other biological activity, the stack may stabilise at that stage without more heating. However, the increased heat may in turn trigger off more changes until charring occurs, or until there is a build-up of heat and chemical distillation of inflammable gases which can 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 degree of heating 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 wind. This assumes further rain is out of the equation.

### What happens when hay heats?

Research shows that the extent of heating is determined by a number of critical situations and temperature at that time, compounded by humidity. Different organisms are able to survive and cause the rise in temperatures at various stages of heating.

The initial heating is due to respiration of the plant material and bacteria activity and can often raise the temperature to about 45°C. This heating may then continue up to about 65 -70°C when organisms (fungi, bacteria) which actually live at the higher temperatures become active and generate heat through digestion.

Then heat mites can appear at this stage, foraging for heat resistant fungal spores before the fodder dries out. Hay stacks often cool down after this period when food for the organisms is used up and their activity diminishes. This will occur if the heat is able to be quickly conducted to the outside of the stack, eg. by loosely stacked bales.

Chemical reactions are responsible if the temperature continues to rise above the changeover point of 70°C. Once the stack reaches this temperature, a rapid rise to the spontaneous ignition point (fire) of 200°C can be expected if enough oxygen is available, or up to 280°C if oxygen is limited eg. tightly stacked bales.

### Effects of heating on hay quality

Heating is undesirable, not only because there is danger of fire from spontaneous combustion but heating also impairs or severely reduces the nutrient value of the hay (See Table 1). Probably the most serious effects on feeding value are losses in protein digestibility and energy content. Protein level is important because protein is needed in feeding for milk and meat production and growth of young stock. Heating can be particularly damaging because the protein becomes indigestible. Energy losses reduce the hay's value for maintenance and fattening.

Heating is likely to damage the nutrients whenever hay with a moisture content of more than 25% is stored.

**Table 1. Nutrient losses caused by heating of hay**

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

Source: Simmons & Simpfordorfer

### Indications of a heating haystack

When stored in a shed, there are often tell tale signs that a stack is heating significantly. Steam condensation on the steel roof, mould growth on and inside bales, acrid fumes and hot and humid air at the top of the stack are indicators of heat generation from inside the stack.

### Finding the temperature of a stack

Push a crow-bar well into the stack, leave it for approximately two hours, then extract it and feel it with your hands.

The temperature is up to 50°C if you can handle the bar without discomfort. The temperature is up to 60°C if you can only touch the bar for a short time. The temperature is

up to 70°C if you can touch the bar only briefly. The temperature is above 70°C if the bar is too hot to handle. An alternative is to push a small open ended pipe into the stack and lower a small thermometer inside to the opposite end of the pipe. However, if the stack is near ignition point, using this open end pipe technique may be very dangerous as this may now allow air into the inner air-depleted section of the stack. It may suddenly catch fire! A small volume of wet hay surrounded by dry hay can cause spontaneous heating, so rake and dry hay as evenly as possible. Most fires resulting from spontaneous ignition start between two and seven weeks after storage, but later fires have occurred in stored hay that has become wet by flooding.

### What to do if the stack is too hot

Be very wary of walking across the top of a stack suspected of being very hot. It may be so hot and air deficient in the middle of the stack that it has become extremely hot, leading to charred bales which can collapse inwards with the extra weight on top. The sudden access to air will often result in spontaneous combustion and sever consequences.

For the same reason, if an extremely hot stack is being pulled apart to allow it to cool down, it may suddenly catch alight as bales are removed thus allowing air to enter. Always be careful when removing bales and always have a fire cart on hand.

Space the bales out so that plenty of air can circulate around them to dissipate the heat. Spreading wet bales from the paddock over the tops of other stacks or equipment shed floor may be an option to avoid excessive heating.

### Moisture contents for baling hay

To minimise the likelihood and danger of hay heating, it should be baled below specific moisture contents. Due to their large volume to surface area round bales should be baled at a lower moisture content than small rectangular bales, but due to their high density and volume, large rectangular bales should be even drier! Table 2 indicates the suggested baling moisture contents for each type of bale.

**Table 2. Suggested moisture contents (%) for safe storage of various forms of hay**

Bale type	Moisture content range of (%)
Small rectangular bales	18 - 20
Round bales	14 - 18
Large rectangular bales	Under 14

Hay with a moisture content slightly above the suggested levels will usually heat to some extent, then eventually cool to the ambient temperature. The temperature will rise substantially if hay is baled with moisture contents well above (> 3%) the suggested level, particularly the large

rectangular bales. “Dry” hay which has subsequently become moist with dew or rain, then trapped if stacked into tight confines, eg. hayshed, before drying will also often lead to heating. How much will depend on the factors mentioned earlier.

### Guide to moisture content of hay

The following is a guide to judging moisture from the appearance and handling characteristics of the hay.

Moisture content	Observation
50% to 60%	Little or no surface moisture. Leaves are limp. Juice shows on stems or leaves if rubbed or pressed hard.
40% to 50%	No surface moisture. Parts of leaves are brittle. Moisture may be seen in stems twisted in a small bundle, but the hay is still tough.
30% to 40%	Leaves begin to rustle. No show of moisture unless rubbed very hard. Moisture shows in stems scratched with a fingernail or less easily, when twisted in the hands. Losing toughness.
25% to 30%	The hay rustles. A bundle twisted in the hands snaps with difficulty; it shows little sign of moistness. Thick stems may show moisture if scraped or split open with a fingernail.
20% to 25%	The hay rustles readily; stems snap when twisted. Leaves may shatter. There are few moist stems. Nodes or joints are shrivelling. The bark on stems can't be raised with a fingernail.
15% to 20%	The hay fractures easily. Bundles snap easily when twisted. It is difficult to see any moistness. Leaves shatter readily.

*The previous version of this note was published in November 1999.*

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