Hay Preservatives: The Facts

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What are hay preservatives?

Hay preservatives are products that allow the baling of hay at higher moisture contents (16 – 25%) thereby reducing curing times in the paddock, prevents mould growth, minimises heating and reduces likelihood of self-ignition (spontaneous combustion).

How do hay preservatives work?

The various types of hay preservatives work by inhibiting or reducing the growth and activity of bacteria, yeast and moulds in the hay after baling. Their activity produces carbon dioxide, water and heat and if hay moisture content is above the recommended levels, leads to a further build-up in their populations and heating, mould growth, etc. Hay preservatives prevent moulding and so negligible nutritive value is lost. Note that most hay preservatives do not improve the nutritional quality of the forage, but do reduce and/or prevent the decline in quality caused by the micro-organisms

Benefits of using hay preservatives

To gain maximum benefit and effectiveness of hay preservatives it is crucial that the instructions on each product label are followed. This is due to the broad range of preservative types and variation within types due to different concentration levels of active ingredients or bacterial types.

Benefits of using hay preservatives are that they:

- allow the safe baling of hay from slightly above target moisture levels (Table 1) up to 25% moisture depending on preservative type
- allow baling after a shorter curing period which reduces risk of rain damage and sun bleaching. It may also allow baling earlier in a season in certain areas, when fodder is less mature and nutritive value higher
- reduce dry matter and nutrient losses caused by leaf loss and shatter, microbial activity and moulds
- enable longer hours of baling over each day, resulting in more effective machinery operation and efficiency of labour usage
- maintain palatability, hay colour (due to increased leaf retention) and often smells better
- prevent dry matter and quality loss in storage due to reduced microbial activity
- substantially, but not always, reduce risk of spontaneous combustion
- may increase animal intake
- reduce production of mould spores which can affect animal and human health

What moisture contents should hay be baled at for safe storage?

Table 1 shows the recommended moisture contents at which to bale hay to ensure safe storage without the risk of moulding and/or heating hay and the risk of spontaneous combustion. Baling hay at moisture contents slightly above these recommended levels for each bale type may lead to some heating due to the activity of aerobic micro-organisms and possibly some plant respiration. The hay would be expected to eventually cool to the ambient temperature and reach its own equilibrium moisture content based on the local environment.

Table 1. Recommended moisture contents (%) for safe storage of various bale types

Bale Type	Moisture Content Range (%)
Small rectangular bales	16 – 18
Round bales (Soft core)	14 – 16
Round bales (Hard core)	13 - 15
Large rectangular bales	12 - 14
Export Hay	Under 12

However, if hay is baled with moisture contents well above (> 3%) the suggested levels, particularly the large rectangular and round bales, their temperature can increase substantially due to their increased density and/or volume. The warm, moist conditions in this "wetter" hay provides the ideal environment for growth of spoilage microflora such as Bacilli, yeasts, moulds and fungi. These organisms utilise the energy and protein of the hay and can lead to a substantial increase in their respective populations, their activity leading to the increase in bale temperature, mould growth and potential for spontaneous combustion.

How good are the various meters for measuring stem versus dew moisture or stem + dew moisture?

Hay moisture consists of external surface moisture (rain and dew) and internal stem moisture (plant sap). Currently there are no instruments and no Australian or international laboratory standards for measuring the stem and dew moisture separately. Capacitance moisture meters report on the free or dew moisture only and does not take into account stem moisture content and bulk density of the hay being measured. The most common types of moisture meters found on hay balers fall into two measurement methods, conductivity (usually pads or star wheels) and microwave.

Pure water acts as an insulator, and so requires ions (from the uptake of plant mineral salts) to be conductive. For the same moisture content, the conductivity may change depending on plant type, seasonal conditions, atmospheric conditions, soil types etc. The microwave system measures the dielectric of the material (air = 1, dry hay ≈ 2, free water molecules = 80), thus is sensitive to number of water molecules in the hay.

Microwave moisture meters measure both free and stem moisture. The microwave system is claimed to be more accurate than the conductivity method, especially when steam is added to the hay at the pickup of the baler which is becoming more common in the USA and sneaking into Australia. These claims are made by both the Australian manufacturer with 15 years' experience in using microwave in hay and the new (for 2017) USA based microwave moisture meter supplier (using a Danish microwave system).

Work is currently being done to develop an instrument to determine the stem and dew moisture.

What are the types of hay preservatives?

Four main categories of hay preservatives are available; organic acids and their salts, bacterial inoculants, sulphur-based preservatives and ammonia-based additives. Some products may also include enzymes, antioxidants and nutrients.

1. Organic acids and their salts (Buffered acids)

Organic acids act as fungicides by producing an acid environment which is not conducive to mould, yeast or bacterial growth. Two of the main acids used are propionic and acetic and being naturally occurring acids in the rumen, are safe for all types of livestock, including horses. These products are liquid and require spraying equipment to apply the preservative at the hay pick-up area.

However, the organic acids (~pH 1.0) are corrosive on machinery and can be dangerous for operators to use in their pure form. To overcome these problems, "buffered" acids (~pH 6.0), sometimes referred to as "neutralised or pH balanced" acids, have been developed and commonly include salts of propionic, acetic and formic acids. Their pH is about 5.5 to 6 so they are much less corrosive and safer to use but more expensive. Although less effective than the pure acids, there are fewer losses due to volatilisation.

2. Biological products

These are usually silage inoculants which either 1) enhance the fermentation process or 2) are aerobic inhibitors which can reduce the activity of the spoilage organisms. The fermentation enhancers are either bacteria-based or enzyme-based or a combination of each. Most contain lactic acid producing bacteria (LAB) which help the LAB already present naturally on the plants. They promote a good silage fermentation and encourage competition against mould and yeast growth. Many are now sold as being effective as hay preservatives, sometimes at higher bacterial numbers or application rates.

These products can be used in hay with moisture contents up to about 25% moisture. They are best used when plant sugars are high as this is the "food" for the bacteria. Inoculants are generally ineffective on rain-affected hay, probably due to their inability to compete with the rapid increase in hay microflora populations.

Most lactic acid producing bacteria require anaerobic conditions and acidic conditions (under about pH 5.0) to work at their optimum. This situation would probably only occur in the very dense large rectangular bales and densely baled round bales produced by the latest balers. Some non-LAB producing bacteria have improved the visual quality of moist hay (up to 25% moisture) and improved its odour but have not been shown to improve its feed value.

Unfortunately, the effectiveness of biological products is not always as consistent or reliable as some other product types. In general, USA research has shown that this class of microbial products used as hay preservatives do no harm but have shown few benefits.

The aerobic spoilage inhibitors are more effective at reducing heating by reducing growth of moulds and yeasts and hence their activity.

3. Sulphur based preservatives

A sulphur-based preservative is another product type that offers control of microbial proliferation, ideally, up to about 18 – 20% moisture content. Sulphur compounds are widely used in human and animal food sectors as preservatives and work essentially the same way in hay through their oxygen scavenging mode of action.

In fodder, they create an environment within the hay bale that is unconducive to microbial growth stemming mould and yeast development. Sulphur compounds act not only on the actual surface of the particles within baled fodder, but also in the air spaces within the bale.

The application rate in kilogram or litres per tonne is much lower than with acids, and complete coverage of all fodder entering the mouth of the baler is neither possible nor totally crucial when using this product type. Even and consistent application always remains preferable however.

The small application rate may potentially be seen as an advantage when considering the running time that a tank of product can provide between stops in baling to refill. A lower rate of overall moisture being added into bales could also be a potentially advantage.

Sulphur compounds are not acidic, and as such are generally fairly user friendly. However, the sulphur compounds themselves are salts (nowhere as corrosive as acid salts) but wash down of gear post baling is highly recommended.

4. Ammonia-based preservatives

Anhydrous ammonia

Although not commonly used in Australia, anhydrous ammonia, when applied at 1 per cent (dry matter basis) to hay containing up to 30 per cent moisture, has been shown to reduce dry matter losses and prevent heating and moulding. Applying, say 0.8 per cent is much less effective.

However, it is more commonly used to improve the feeding value of cereal straw, mature grass hay and corn stover when applied at 2 to 4 per cent (dry matter basis). The major disadvantage of using anhydrous ammonia is that its application is difficult, and it is a hazardous chemical. Seek information on injecting Anhydrous Ammonia

Urea

Applying urea, which is then converted to ammonia by the bacteria, is simpler than applying ammonia gas. Relatively large amounts (5 to 7%, as baled basis) of urea applied during baling can be effective up to 30 per cent moisture. However, the treated hay must be covered tightly with plastic sheeting as soon as possible after baling.

Use of salt as a hay preservative

Common salt has often been used between layers of moist bales to both preserve the hay and improve its palatability. However, it is ineffective as a preservative unless applied in such amounts as to be physiologically harmful to animals. The salt itself would be detrimental to microbial and mould growth, and being hygroscopic in nature, absorbs moisture in proximity to the salt granules.

The placing of salt between round bales and layers of large rectangular bales will only be effective near the salt itself, possibly having an effect of 1 to 3 cm (guesstimate) into the bale itself. The only way salt may be effective would be if the salt was spread throughout forage in the round bale and large rectangular bales as they were being baled. This would be impractical, be very expensive and difficult to achieve.

Some tips to consider

Hay baled at high moisture contents, even when treated with preservative, should not be mixed with properly cured low moisture hay as the moisture may migrate to the drier hay and allow moulds to grow.

Although hay can be baled up to 30 per moisture content, bale weights will be substantially increased and may exceed the capacity of some equipment. They may become misshapen when being moved, and twine/netwrap may break. Bales will still continue to cure and lose moisture over time and strings/netwrap will become loose.

For most products, the wetter the bale the greater the application rate required to be effective.

Ideally, hay treated with a preservative should be covered if stored outside so that a rain event won't wash out the preservative in the upper layer.

To be fully effective and for best results the preservative must contact as much of the material as possible. It is best applied across the pick up or throat of the baler.

However……

Continuous improvement and innovation for many hay preservative products may mean that a particular product's effectiveness may improve over time or new products are developed so enquire regularly about progress but ensure products are supported by independent robust scientific research by reputable organisations or research institutions, preferably independent of company ties.