Stabilization of wet hay by preservatives

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Introduction
In hay stacks with more than 20% moisture microorganisms are able to grow, predominantly different “storage-fungi” of genus Aspergillus and bacteria of genus Micrococcus. Their metabolism leads to losses and finally to deterioration. Wet hay preserving additives have to inhibit the development of the microflora in hay stacks. Vegetable, microbial and technical factors influence the effect of an additive (fig. 1).

Fig. 1: Causing factors upon the effect of hay preservatives

Acid preservatives
Propionic acid was the first additive for hay stabilization, which was examined on broad practical scale in the 70ties. Propionic acid and also its derivatives could prevent a rise of temperature but in spite of it the hay deteriorated (fig. 2). Due to its volatility the stabilizing effect stays in practice unsatisfactory. A conversion into less volatile, neutral compounds like ammonium-propionate or ammonium-bis-propionate has not improved the preservative effect particularly due to lack of a safe technique for application.

Fig. 2

Other acids and their salts had a small growth inhibition effect of hay microorganisms, too. It seems to be especially the undissociated part of an additive that is effective against moulds in hay (see also paper 1b; U. Küntzel: Conservation of unusual substrates). Because the hay-pH is mostly higher than 6 the undissociated part of acids is too small.

Ammonia
Ammonia (NH₃) is the best investigated preserving additive. Normally, the application is in the form of anhydrous NH₃ under pressure i.e. as liquid NH₃. Growth inhibition of hay microorganisms in laboratory tests could be achieved by 0.75% soluble NH₃ (fig. 3).

Fig. 3: Growth of hay-microorganisms in vitro
In practice the large affinity with water leads to NH₃-solution and solution-heat is set free. This causes a temperature rise up to 80°C (fig. 4) and water evaporation and release of NH₃.

Fig. 4:

![Temperature diagram for hay bales](image)

Without cover this free NH₃ disappears. Under seal sheet, the water condenses and again the NH₃-gas dissolves. The heat turned out to be the most important factor for NH₃-distribution in hay; covering of the stacks is, therefore, necessary.

53% of the NH₃-dose are bound with hay and 47% stay in solution. Less than 1% of the dose is free NH₃. The minimal inhibition concentration (mic) of 1.6% liquid NH₃ was calculated and confirmed in practical experiments (fig. 5).

Fig. 5:

![Moulds and yeasts in NH₃-treated hay](image)

Ruminants consume the NH₃-treated hay without difficulty in spite of the strong NH₃-odour (table 1).

<table>
<thead>
<tr>
<th>Nature of Feed</th>
<th>Dairy Cattle</th>
<th>Alfalfa</th>
<th>Fattening Cattle</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM intake (kg/day/head)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control hay group</td>
<td>10.2 (100)</td>
<td>11.7 (100)</td>
<td>9.6 (100)</td>
</tr>
<tr>
<td>NH₃-hay group</td>
<td>8.5 (81)</td>
<td>11.4 (97)</td>
<td>11.5 (120)</td>
</tr>
<tr>
<td>Milk performance (kg/day)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control hay group</td>
<td>15.8 (100)</td>
<td>21.7 (100)</td>
<td>10.0 (102)</td>
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<tr>
<td>NH₃-hay group</td>
<td>13.0 (82)</td>
<td>21.4 (99)</td>
<td></td>
</tr>
<tr>
<td>Live weight gain (kg/day)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control hay group</td>
<td></td>
<td></td>
<td>0.53 (100)</td>
</tr>
<tr>
<td>NH₃-hay group</td>
<td></td>
<td></td>
<td>0.25 (100)</td>
</tr>
</tbody>
</table>


Urea

The conservation effect of urea is based on its solution in water and the following breakdown to NH₃ in the presence of the enzyme urease. The necessary urea dose for wet hay stabilization is determined by the solved part of urea, the degree of urea hydrolysis and the amount of NH₃ which is going into solution. 56.7 parts of NH₃ arise from 100 parts urea. Here, the soluble portion of NH₃ seems to be constant, but depends on the moisture content of the hay. Accordingly, the calculated mic-dose of hay with 24% moisture is 7% urea but wet hay with 30% moisture only needs 2.4% urea.

The technique for urea application is still unsatisfactory; no feeder are offered on the market. Apparently, it is possible to feed ruminants with urea-treated wet hay without problems.

References