Storage time and fermentation temperature of grass silage as factors affecting its voluntary consumption by sheep

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ABSTRACT

Pasture herbage was either frozen or ensiled and immediately sealed (cold), or ensiled and allowed to aerate and heat to 40° (warm) before sealing. One tonne samples removed 4, 11, 39, 94, and 165 days later were frozen. Voluntary intake of thawed, cold 4-day silage by sheep was similar to grass intake, but greater than that of the warm 4-day silage. Intakes of the warm silages removed later were similar to those of the warm 4-day material, but greater than comparable cold-silage intakes. The cold silages were chemically more stable.

INTRODUCTION

The characteristics of high-moisture silage which may contribute to low animal intakes have been briefly reviewed by Bryant & Lancaster (1970). Although the reasons for low silage intakes are not known, it is clear that voluntary intake is less than that of the original herbage and is associated with silage fermentation. This experiment was therefore planned to discover the stage in the grass to silage change at which depression in intake became evident.

The results of three related experiments have been previously reported (Bryant & Lancaster 1970). The present paper gives the results of a fourth experiment with a similar objective, but modified to examine the effect of the degree of air exclusion on the changes occurring during storage. Previous work had shown that the more rapid the exclusion of air, the lower the intake of silage (Lancaster et al. 1974).

EXPERIMENTAL

Preparation of feeds

A ryegrass–clover dominant (Lolium perenne–Trifolium repens) pasture with ryegrass ears just emerging was cut with a flail harvester on 9 November 1970 in fine weather. One tonne was immediately compressed into 10 kg slabs, frozen, and stored at −20°. Six tonnes were ensiled in each of two stacks ramped at each end and built on a 3 × 8 m base. One stack was immediately sealed in polyethylene film, vacuum compressed, and weighted with 15–30 cm of pumice soil. The other was allowed to aerate and heat, then similarly treated after 2 days when the temperature at 15 and 43 cm below the surface had reached 42° and 38° respectively. One tonne samples were removed from each stack 4, 11, 39, 94, and 165 days after ensiling, frozen, and stored at −20°.

Feeding trial

Each of the 11 feeds (10 silages and 1 grass) was compared in an 8-week feeding trial using 1-year-old Perendale wethers. During the first 4 weeks the sheep were prepared for the test by feeding ad lib. a non-experimental grass silage under uniform conditions. In week 1 they were fed as one group outdoors, then individually stalled and fed indoors during weeks 2 to 4. Voluntary intakes of silage were measured over weeks 3 and 4, and at the end of week 4 the sheep were weighed.

On the basis of the data so collected, eleven 6-animal groups balanced for intake per unit live weight were formed. During weeks 5–8 the 11 experimental feeds, after thawing for 24 h, were offered at about 20% in excess of appetite and individual intakes were measured. In weeks 7–8, total collections of faeces were made from all animals.

Laboratory measurements

Samples for analysis were obtained by repeated cross sectioning of frozen slabs of material with a tungsten tipped power saw and collecting the
RESULTS AND DISCUSSION

Silage quality

The data are summarised in Table 1. Temperature changes in the stack which was immediately vacuum compressed after making were not recorded, but it was assumed from the writer's observations on similar stacks that the temperature rise was negligible. The silages derived from this stack were designated "cold" and those from the other "warm".

The 11 feeds were of similar low dry matter content (16-18%) and the dry matter contained similar levels of nitrogen (3%) and ash (11-12%).

The pH values of the warm silages were higher than those of the corresponding cold silages. The warm silage values reached a minimum on day 39 and subsequently increased. The cold values remained relatively constant.

In the warm silages values for ammonia N and acetic and butyric acids followed trends similar to pH. Corresponding cold-silage figures were generally lower and more constant, with a tendency to increase in the 165-day sample. Butyric acid was absent from the cold silage except the 165-day sample.

Lactic acid increased more rapidly in the cold, but in both series peak levels were observed in 39-day samples. The subsequent decline was considerably greater in the warm silage. Some lactic acid was present in the grass.

Buffer capacity and osmolality values changed in a similar manner in the warm silages. They reached peak values on day 11 and remained relatively constant thereafter. In the cold silages they also increased substantially from the grass value to that on day 11, but thereafter continued to rise slowly.

As reported for the cold silage, the pH trends of the two sets of silages were similar. The pH values were highest at day one, but declined to the lowest point at day 11. In both silages, the pH values remained relatively constant. The range of the pH values was 3.9 to 7.0. The pH values for the warm silage were generally lower than those of the cold silage.

The dry matter content of the grass silage was 16.6% and that of the cold silage was 16.2%. The dry matter content of the warm silage increased from 16.3% to 17.4% in the 165-day sample. The dry matter content of the cold silage increased from 16.2% to 17.9% in the 165-day sample.

The nitrogen content of the grass silage was 2.77% and that of the cold silage was 2.77%. The nitrogen content of the warm silage increased from 2.77% to 3.09% in the 165-day sample. The nitrogen content of the cold silage increased from 2.77% to 3.09% in the 165-day sample.

The ammonia N content of the grass silage was 11.3% and that of the cold silage was 11.3%. The ammonia N content of the warm silage increased from 11.3% to 12.8% in the 165-day sample. The ammonia N content of the cold silage increased from 11.3% to 12.8% in the 165-day sample.

The acetic acid content of the grass silage was 1.60% and that of the cold silage was 1.60%. The acetic acid content of the warm silage increased from 1.60% to 1.89% in the 165-day sample. The acetic acid content of the cold silage increased from 1.60% to 1.89% in the 165-day sample.

The lactic acid content of the grass silage was 0.77% and that of the cold silage was 0.77%. The lactic acid content of the warm silage increased from 0.77% to 7.7% in the 165-day sample. The lactic acid content of the cold silage increased from 0.77% to 7.7% in the 165-day sample.

The buffer capacity of the grass silage was 1.3 and that of the cold silage was 1.3. The buffer capacity of the warm silage increased from 1.3 to 3.6 in the 165-day sample. The buffer capacity of the cold silage increased from 1.3 to 3.6 in the 165-day sample.

The osmolality of the grass silage was 465 and that of the cold silage was 465. The osmolality of the warm silage increased from 465 to 719 in the 165-day sample. The osmolality of the cold silage increased from 465 to 719 in the 165-day sample.

The DM intake of the grass silage was 74.0 and that of the cold silage was 74.0. The DM intake of the warm silage increased from 74.0 to 80.0 in the 165-day sample. The DM intake of the cold silage increased from 74.0 to 80.0 in the 165-day sample.

The temperature changes in the stack which was immediately vacuum compressed after making were not recorded, but it was assumed from the writer's observations on similar stacks that the temperature rise was negligible. The silages derived from this stack were designated "cold" and those from the other "warm".

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Lactic acid increased more rapidly in the cold, but in both series peak levels were observed in 39-day samples. The subsequent decline was considerably greater in the warm silage. Some lactic acid was present in the grass.

Buffer capacity and osmolality values changed in a similar manner in the warm silages. They reached peak values on day 11 and remained relatively constant thereafter. In the cold silages they also increased substantially from the grass value to that on day 11, but thereafter continued to rise slowly.

Sawdust. Samples of the sawdust were analysed for ash, total N, dry matter by toluene distillation (Minson & Lancaster 1963), ammonia N (Conway 1947), lactic acid (Barker & Summerston 1941), volatile acids by gas chromatography, water soluble sugars by anthrone (Yemm & Willis 1954), pH, and osmolality on a Fiske G66 osmometer. Buffer capacity was measured by titrating to pH 7 a 10 g sample slurried in 100 ml distilled water.

Fig. 1 — Effect of storage time on dry matter intake: treatment means (kg/sheep/week) over 4 weeks adjusted for 2 weeks' uniform feeding. Average SE of difference between mean = 0.36.
**TABLE 2 — Mean weekly DM intakes (kg) (from data adjusted for 2 weeks' uniform feeding)**

<table>
<thead>
<tr>
<th>Week</th>
<th>Grass and cold 4-day silage</th>
<th>All warm silages</th>
<th>Cold silages except 4-day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.16</td>
<td>3.74</td>
<td>3.48</td>
</tr>
<tr>
<td>2</td>
<td>4.38</td>
<td>3.57</td>
<td>2.98</td>
</tr>
<tr>
<td>3</td>
<td>4.21</td>
<td>3.31</td>
<td>2.52</td>
</tr>
<tr>
<td>4</td>
<td>4.15</td>
<td>3.13</td>
<td>2.30</td>
</tr>
<tr>
<td>Means</td>
<td>4.22</td>
<td>3.44</td>
<td>2.82</td>
</tr>
</tbody>
</table>

Since the stacks were ramped at both ends, the 1 tonne samples were obtained from increasingly deep silage until the third sampling (day 39) and thereafter from decreasing depths. For this reason, the sequential values may not be entirely functions of time, but could also be related to location in stacks. It is clear, however, that the major grass to silage changes (as assessed in the laboratory) had taken place by day 4 in both series of silages, confirming previous findings for the cold silage (Bryant & Lancaster 1970). It is apparent also that the cold silages were the more stable lactic types.

**Voluntary intake**

Dry matter digestibilities of all feeds were similar. Dry matter intake was abnormally low, ranging from 29 to 47 g/kg**t-70/day. The reason for this is not known, but it is assumed that if experimental conditions restricted intake, they would apply equally to all animals. Results can therefore be related validly to treatments.

The intake data were submitted to covariance analysis in which intakes during the 2 weeks of uniform feeding were used to adjust for non-treatment effects during the 4-week test feeding. The adjusted intake values were used to plot Fig. 1, which clearly shows the effect of storage time on intake.

The intake of the 4-day warm silage was 21% less than that of the grass (p < 0.01) and remained essentially at that level for the later samplings. The difference between the intakes of grass and 4-day cold silage was non-significant. Apart from day 4, the intakes of warm silages were higher than those of the corresponding cold silages, the differences attaining significance on days 11 (p < 0.01) and 94 (p < 0.001). Overall, the intake of grass was higher than that of silages (p < 0.001). The results from the cold silages confirm previous work at this station: in three experiments it was shown that 4-day material had the chemical attributes of silage but retained the higher intake of grass, and less mature silage was eaten (Bryant & Lancaster 1970).

**Decreasing appetites with time**

The results of the analysis of variance suggest that the group mean intakes of the 11 feeds may be pooled into 3 classes of similar feeds within each class (Table 2). Over the 4 weeks of feeding, the mean intakes of grass and cold 4-day silage remained relatively constant, those of the warm silages declined by 17%, and those of the cold silages (except 4-day) declined by 34%.

**TABLE 3 — Summary of regression analysis (n = 10)**

<table>
<thead>
<tr>
<th>DM intake on:</th>
<th>b ± Sb</th>
<th>RSD</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia N</td>
<td>0.038 ± 0.044</td>
<td>0.46</td>
<td>0.29</td>
</tr>
<tr>
<td>pH</td>
<td>0.401 ± 0.280</td>
<td>0.43</td>
<td>0.45</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>0.029 ± 0.130</td>
<td>0.48</td>
<td>0.08</td>
</tr>
<tr>
<td>Butyric acid</td>
<td>0.122 ± 0.173</td>
<td>0.47</td>
<td>0.24</td>
</tr>
<tr>
<td>Lactic acid</td>
<td>-0.108** ± 0.047</td>
<td>0.37</td>
<td>-0.63**</td>
</tr>
<tr>
<td>Total acids</td>
<td>-0.103 ± 0.055</td>
<td>0.40</td>
<td>-0.55</td>
</tr>
<tr>
<td>Buffer capacity</td>
<td>-0.110** ± 0.038</td>
<td>0.32</td>
<td>-0.71**</td>
</tr>
<tr>
<td>Osmolality</td>
<td>-0.0031** ± 0.0016</td>
<td>0.40</td>
<td>-0.57*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lactic acid on:</th>
<th>b ± Sb</th>
<th>RSD</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>0.708*** ± 0.199</td>
<td>1.77</td>
<td>0.78***</td>
</tr>
<tr>
<td>Osmolality</td>
<td>0.025** ± 0.008</td>
<td>1.91</td>
<td>0.74**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total acids on:</th>
<th>b ± Sb</th>
<th>RSD</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>0.694*** ± 0.162</td>
<td>1.43</td>
<td>0.84***</td>
</tr>
<tr>
<td>Osmolality</td>
<td>0.021** ± 0.007</td>
<td>1.81</td>
<td>0.72**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Osmolality on:</th>
<th>b ± Sb</th>
<th>RSD</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer capacity</td>
<td>24.46*** ± 5.156</td>
<td>45.70</td>
<td>0.86***</td>
</tr>
</tbody>
</table>
The possibility that these regular decreases are experimental artefacts has been considered and rejected. The same experimental conditions were imposed on all animals and any hypothesis to explain the decreasing silage intakes must be compatible with the relatively constant intakes of herbage and cold 4-day silage.

These effects are ascribed to unidentified characteristics of the feeds and two explanations are possible. Either the silages contain a toxic fermentation product or they lack an essential nutrient. The data collected offer little scope for exploring this further.

Silage quality and intake

It is evident, however, that intakes over the 4 weeks are related to some of the quality measures applied to the silages. As noted in Table 3, lactic acid content, buffer capacity, and osmolality are negatively correlated with dry matter intake. These factors are themselves positively interrelated and are presumably manifestations of the same occurrence — the fermentation of carbohydrate to acids.

Each one can be implicated as an appetite depressant. McLeod et al. (1970) have shown lactic acid to depress silage intake and in the same work they demonstrated that partial neutralisation of silage acids increased intake. This involves buffer capacity as a factor in appetite depression. The present findings agree with those of McLeod et al., with previous work at this station (Lancaster et al. 1974), and with Ternouth's (1967) suggestion that the higher osmolality of silages may be associated with depressed intake. Finally the demonstration in the present work that more warm than cold silage was eaten confirms the results of three previous studies (Harris et al. 1966; Hutton et al. 1971; Lancaster et al. 1974). Despite the correlations demonstrated between intake and three silage attributes, the laboratory assessments do not explain the similarity in intake of grass and cold 4-day silage, or the dissimilarity between the intake of this and the other silages.

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REFERENCES