Changes in Quality of Alfalfa Hay Treated With a Preserver

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ABSTRACT

A bacteria based preserver was tested on high moisture alfalfa hay. The point of application of the hay preserver was at the baler. Evaluations of hay quality included hay temperature in storage and chemical analyses of core samples of the bales. All treated bales stayed cooler than the controls. After one month in storage, hay baled at a moisture range of 18 to 23% was higher in quality than hay baled at a moisture range of 30 to 35%. There was no significant difference in quality estimates between the high moisture bales indicating that the preserver was not effective at the high moisture range studied.

INTRODUCTION

The cattle industry in Hawaii is dependent on grazing large areas of pasture land and on imported feed to supply the required source of protein and energy for the animals. In 1984, more than 30 thousand tons of alfalfa products were imported to the State as supplemental feed. Farmers attempting to produce hay in Hawaii are plagued by wet weather when the crops are processed. Nutritive value of hay dried in swath or windrows may be considerably reduced when rained upon or exposed to moist environments for long periods of time. Also, the very humid weather in many areas of Hawaii makes it difficult to store high quality baled hay without some degradation in quality over time due to mold and bacterial activity.

Artificial drying and storage systems relying on fossil fuels for energy are relatively expensive to install and maintain. Hence, there is a need to explore other methods of reducing field drying time and producing high quality hay that will store well.

During the past several decades, considerable work has been done using different chemical substances to preserve and improve the quality of high moisture hay. Reports on use of bacteria based preservers are lacking in the literature. Sheaffer and Clark (1975), in a laboratory study, found that application of propionic acid and ammonium isobutyrate on high moisture alfalfa-timothy hay significantly lowered storage temperatures and increased in vitro digestible dry matter. Lower acid detergent fiber values were also reported at higher application rates. Mueller et al. (1976) sprayed Chemsor (80% propionic acid and 20% acetic acid) and ammonium isobutyrate on alfalfa windrows to evaluate the preservation of high moisture hay. There was a lack of consistency associated with estimated nutritional quality of chemically treated hay in this study. In most cases, however, chemically treated hays were at least equal to heat-cured hays in acceptability and performance in animal evaluations.

Ghate et al. (1979) reported that high moisture hay treated with urea developed less mold and browning than untreated 21.8% moisture (w.b.) bromegrass hay after six weeks in storage. They also reported a urea breakdown of 42 to 65% during storage. Use of sulfur dioxide as a preservative for high moisture hay was investigated by Harrison (1983). Large round bales were used to evaluate temperature increase in bagged and unbagged bales. Bagging was helpful in reducing temperature rise, dry matter loss and fiber content. A more effective preservative or a higher rate of application than 1% of the dry matter was recommended.

Koegel et al. (1983) conducted ammonia treatment tests on large and small hay packages to evaluate temperature-time history, dry matter loss and presence of mold. The importance of covering the bales after ammonia treatment was pointed out in this study. Alfalfa up to 50% moisture content (w.b.) was preserved with ammonia in covered bales. A study was thus designed to investigate the use of a hay preserver, which was a concentrate of living bacteria and enzymes rather than a chemical substance, for baling high moisture hay. The main objective was to evaluate changes in nutritive value of "preservative" treated high moisture alfalfa hay during storage.

PROCEDURE

Alfalfa in the half-bloom stage of maturity was harvested with a mower-conditioner and windrowed in preparation for baling and addition of the hay preserver at different moisture levels. Field moisture of forages in windrows was determined with a resistance-type hay moisture detector at scheduled intervals. Baling began
when moisture reached the 30 to 35% range and the 18 to 23% range (w.b.). Baling was accomplished by means of a Heston baler which produced rectangular bales approximately 76 cm long by 46 cm wide and 36 cm high.

The hay preserver used was a soluble concentrate of living bacteria and enzymes obtained from Germain's Seeds, Fresno, California. The manufacturer’s literature described the bacteria as producing lactic acid and other substances that counteract the growth of harmful bacteria and mold in the baled hay. The preservative was applied at rates of 2 ounces and 3 ounces per 10 tons of the wet hay. The dilution rate used was 1 ounce of concentrate per 37.5 liters (10 gallons) of non-chlorinated water. Each treatment consisted of 8 bales replicated three times. The solution was applied to the hay with a baler-mounted pump system. The system included a 94 liter (25 gallon) tank and three flat spray (Teejet 8001) nozzles mounted on a boom placed over the hay pick-up conveyer. Spray was applied as hay moved to the top of the pick-up conveyer and just prior to entering the baling chamber. Following treatment, each 8 bale replication was barn-stored in stacks of two tiers with 4 bales per tier.

The experimental design was completely randomized and means were separated using the Duncan Multiple Range tests.

QUALITY DETERMINATIONS

Measures of hay quality used in this study were storage temperature, crude protein, fiber components and in vitro digestible dry matter. Average temperature within each stored hay stack was measured with thermocouples placed in the four middle bales in each stack. Temperatures were taken once daily for the first month and monthly for the last two months. Samples were taken with a core sampler in each stack after one month and then at the end of 3 months in storage for chemical estimation of quality. Dry matter and crude protein (CP) were determined according to the method described in A.O.A.C. (1980). Fiber components were measured as neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose (HM) according to the procedure of Goering and Van Soest (1970). In vitro digestible dry matter (IVDDM) was determined by the method outlined by Nelson et al. (1969).

RESULTS AND DISCUSSION

Temperature

Average temperatures of the hay stacks for the first 30 days of storage are plotted in Figures 1 and 2. For the low moisture hay (18 to 23% range), the temperatures of the bales dropped after two days in storage for all three treatments. This may be more a reflection of the ambient conditions at that time rather than any treatment effect. However, for the next three weeks in storage, bales treated with the preserver stayed cooler than the control. This is especially significant considering the fact that the average moisture content of the preserver-treated hay was higher than the control. The average moisture contents were 18%, 20.6%, and 22.2% (w.b.) respectively for the control, 2 ounce preserver and 3 ounce preserver treatments. Usually higher moisture content hay (above 20%) creates favorable conditions for microbial heating.

![Figure 1](image1.png)

**Figure 1** Average temperature noted in alfalfa hay baled and treated with a hay preserver (low moisture treatments).

![Figure 2](image2.png)

**Figure 2** Average temperature noted in alfalfa hay baled and treated with a hay preserver (high moisture treatments).

The temperature profiles for the high moisture treatments (30 to 35% range) are presented in Figure 2. All treatments heated during the first week of storage. However, the amount of heat generated by microbial fermentation in the treated bales was much lower than that in the untreated hay as evidenced by the temperature plots. Hence, the bacteria added were somewhat effective in controlling the growth of harmful microorganisms. Temperatures then steadily declined for the next three weeks. All treatments reached about the same temperature after a month in storage except for the high moisture untreated sample which took a longer time to attain ambient conditions. Also, the higher application rate of the preserver was not more effective than the lower application rate in the range of moisture studied. However, the temperatures of the high moisture bales were much higher than those of the low moisture bales for all concentrations of the preserver used. The results indicate that the preserver would be effective in checking temperature rise and spoilage in the bales only up to a certain initial moisture content of the hay, probably up to 28%, and that a higher application rate may be required at the high moisture level. If high moisture content hay is to be preserved, the addition of other compounds, as well as the preserver, may be required to prevent the rapid development of beneficial bacteria or to help slow the initial growth of harmful microorganisms. This is especially important in the first few weeks of storage when the moisture content of the bales drops steadily to a level where the preserver would be more effective. Of course, the bales must be stored in a well ventilated covered area. The moisture profiles for all treatments are shown in Figure 3. It can be observed that the high moisture bales dried steadily in storage while the moisture content of the low moisture bales remained constant.

Quality

Solely on the basis of temperature data, greatest spoilage would be expected in the high moisture treated and untreated hay. This was evident in the quality estimates of the hay sampled after one month in storage. The summarized results of the quality analyses are presented in Table 1. All low moisture bales were significantly higher (p<0.05) in digestible dry matter than the high moisture bales and significantly lower in fiber components. There was no significant difference in crude protein content for all treatments. Also, there was no significant difference in the quality parameters among the three low moisture treatments and among the three high moisture treatments. This again indicates that the preserver would be effective only up to a certain initial moisture content hay.

Table 1 Chemical estimates of alfalfa hay quality after one month in storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>IVDOM1,4</th>
<th>CP4</th>
<th>ADP4</th>
<th>NDF4</th>
<th>HM4</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.M2- untreated</td>
<td>62.6 ab 13.25a 34.3b 55.9b 21.6b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.M - 1 ounce</td>
<td>62.0 ab 13.20a 34.5b 53.4b 19.3b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.M - 3 ounce</td>
<td>63.8 a3 14.41a 34.1b 51.8b 17.7b</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M2- untreated</td>
<td>59.3d 12.69a 39.4a 64.1a 24.7a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M - 1 ounce</td>
<td>59.9cd 13.28a 39.1a 66.8a 27.7a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M - 3 ounce</td>
<td>60.2bcd 14.40a 39.0a 64.8a 25.8a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Values are in weight percent of hay dry matter.
2L.M = low moisture samples.
3Values followed by the same letter are not significantly different (p<0.05).
4IVDOM = In Vitro Digestible Dry Matter; CP = Crude Protein;
ADP = Acid Detergent Fiber; NDF = Neutral Detergent Fiber;
HM = Hemicellulose

Table 2 Chemical estimates of alfalfa hay quality after three months in storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>IVDOM1,4</th>
<th>CP4</th>
<th>ADP4</th>
<th>NDF4</th>
<th>HM4</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.M2- untreated</td>
<td>60.3a 12.50a 37.8a 59.9a 22.0a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L.M - 1 ounce</td>
<td>60.1a 12.86a 36.1a 57.3a 19.6a</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>L.M - 3 ounce</td>
<td>61.5e2 12.65a 36.7a 56.7a 20.0a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M2- untreated</td>
<td>58.9a 14.1a 39.2a 63.1a 23.9a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M - 1 ounce</td>
<td>58.8a 14.2a 39.8a 62.7a 22.9a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H.M - 3 ounce</td>
<td>60.7a 14.82a 37.8a 60.8a 23.0a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1Values are in weight percent of hay dry matter.
2L.M = low moisture samples.
3Values followed by the same letter are not significantly different (p<0.05).
4IVDOM = In Vitro Digestible Dry Matter; CP = Crude Protein;
ADP = Acid Detergent Fiber; NDF = Neutral Detergent Fiber;
HM = Hemicellulose

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Quality data for hay sampled at the end of three months of storage are shown in Table 3. There was no significant difference among all treatments. While it appeared that the high moisture bales were already spoiled in the first month of storage, the low moisture bales deteriorated slowly in the last two months. The reduction in quality was expected and was probably the result of both the beneficial and non-beneficial bacteria using up some of the more digestible fraction of the hay, thus causing a loss in dry matter content. Since the bacteria from the preserver were supposed to produce lactic acid as part of the mechanism for inhibiting the growth of harmful bacteria and reduce heat build-up in the bales, the pH values for hay samples taken from the bales at the end of one month in storage were also recorded. The results are presented in Table 3. It can be observed that while there was a general decrease in pH for the low moisture bales, this did not occur in the high moisture treatments.

### Table 3
Average pH value of alfalfa hay samples after one month in storage.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average pH value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low moisture - untreated</td>
<td>6.55</td>
</tr>
<tr>
<td>Low moisture - 2 ounces</td>
<td>6.28</td>
</tr>
<tr>
<td>Low moisture - 3 ounces</td>
<td>6.20</td>
</tr>
<tr>
<td>High moisture - untreated</td>
<td>7.10</td>
</tr>
<tr>
<td>High moisture - 2 ounces</td>
<td>7.16</td>
</tr>
<tr>
<td>High moisture - 3 ounces</td>
<td>7.12</td>
</tr>
</tbody>
</table>

CONCLUSIONS

Alfalfa hay at different moisture contents was sprayed and baled with a bacteria-based hay preserver. Bale temperatures were monitored during storage. Chemical estimates of hay quality were determined after one month and three months in storage. The results revealed that although heat build-up in all treatments was reduced, the preserver was not very effective in preventing deterioration of the hay in the higher moisture range (30 to 35%) after one month in storage. These results were also supported by the pH values of the hay. While the low moisture treated hay showed an increase in acidity due to lactic acid generated by the bacteria in the preserver, such a trend was not observed in the high moisture bales. It appears that the upper moisture range at which the preserver would still be effective is around 25 to 28% (w.b.). A higher application rate may be required. There was no significant difference between treatments after three months in storage.

LITERATURE CITED


REFERENCES


of large and small hay packages. ASAE Paper no. 83-1534. ASAE, St. Joseph, MI 49085.

