ACID PRESERVATION OF ALFALFA HAY

FOR DAIRY COWS

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CHAPTER I

INTRODUCTION

High quality forage is an essential part of a good livestock feeding program. Alfalfa hay is an important forage to many dairymen in Oklahoma. Many years ago, Morrison (1958) stated, "Good Alfalfa hay is unexcelled as a dry roughage for dairy cattle and is the standard with which other kinds of hay are compared." Harvesting alfalfa hay with sufficient quality to maintain high levels of milk is very important to dairymen.

Weather conditions in Oklahoma do not always permit adequate curing of hay. A relatively new approach to hay harvesting involves adding a small amount of organic acid to the hay at the time of baling. This permits baling hay at higher moisture levels than would normally be recommended. It could also prevent nutrient loss by decreasing leaf shattering during handling.

Insufficient data are available on the acid preservation of alfalfa hay for dairy cows. Reliable data would have immediate application for Oklahoma dairymen; therefore, information in this area is needed.

The specific objectives of this project were to: 1) compare the nutrient loss and resultant nutrient content of alfalfa hay harvested with the addition of organic acids as a preservative with hay harvested in the conventional manner, and 2) evaluate the effect of adding organic acids to alfalfa hay at time of baling on its feeding value for lactating cows.

CHAPTER II

LITERATURE REVIEW

High quality forage is an essential part of proper dairy herd management and nutrition. In Oklahoma, alfalfa hay plays a major role in many dairy feeding programs. Initial moisture content, temperature reached during storage and microbial activity affect the quality of the hay at feeding time.

Hay Quality Factors

Initial Moisture Content

Gregory *et al.* (1963) found hay quality was inversely related to the initial moisture content of the hay. Miller *et al.* (1967) found that the apparent digestibility of protein and energy decreased as moisture content at the time of baling increased. Currence *et al.* (1975) reported that digestibility of protein and dry matter percentages dropped as moisture content at baling increased in large fescue hay packages. This work agreed with work done with grass hay by McKinley *et al.* (1976). In contrast, Weeks *et al.* (1975) found that *in vitro* digestibilities of alfalfa hay in loose stacks were not depressed by high initial moisture content indicating a potential for maintaining nutritive value of the loose - stacked hay with initial moisture content as high as 40 percent.

Hay Temperature During Storage

Miller et al. (1967) reported that there is a cause and effect relationship between the initial moisture content of hay and the temperature increase in hay bales following baling. Temperature increase is mainly caused by microbial action (Gregory et al., 1963). Temperature increase indicates microbial oxidation and consequent destruction of dry matter (Miller, 1947). Gregory et al. (1963) found that there were losses in sugars and liquids. High temperatures during hay curing were also noted to favor the Maillard or browning reaction (Gregory et al., 1963, Nissen, 1963).

Maillard Reaction

The Maillard or the non-enzymatic browning reaction involves the condensation of carbohydrate degradation products with protein or amino acids forming a dark colored insoluble polymer. The non-enzymic browning reaction is known to require water (Van Soest, 1965). Sugar residues appear to condense with amino groups at a 1:1 ratio. The extent of non-enzymic browning in heated forages is directly correlated with nitrogen bound in acid-detergent fiber (Van Soest, 1962). Gregory et al. (1963) found that a heated hay has a brown color and the intensity of the brown color is correlated with the degree of heating. Workers in Australia reported similar results and found higher lignin for heated hays. They also suggested that the increase was due to retention of protein in the crude lignin (Couchman, 1959). The dark colored nitrogenous polymer resulting from the browning reaction was noted to accumulate in the lignin fraction of acid-detergent fiber (Van Soest, 1965). Goering et al. (1972) observed that acid-detergent insoluble nitrogen and pepsin insoluble nitrogen as a percent of total nitrogen explained 86 and 83% of the variation in nitrogen digestion coefficients.

Forages differ in susceptibility to heat damage. Goering et al. (1973) compared 11 forages for susceptibility to heat damage as affected by moisture, temperature and pH. The greatest susceptibility to heat damage occured at moisture contents of 20 to 70% with all treatments. Acid-detergent insoluble nitrogen was used to assay the extent of heat damage. They found large differences in susceptibility which appeared unrelated to specie, nitrogen content, or initial insoluble nitrogen content. Nitrogen bound in acid-detergent fiber has a very low digestibility (Van Soest, 1962). Decreased digestibility of the protein and energy losses due to microbial action decrease the feeding value of the hay. Decreased utilization of protein and decreased dry matter digestibility were observed many years ago (Bechtel, 1945). Miller et al. (1967) reported that steers fed hay baled at lower moisture contents (26 and 36%) gained faster and more efficiently than those that received hay baled at 53 and 58% moisture. Knapp et al. (1974) found that high levels of fungal and bacterial activity caused high temperatures in hay baled at 32% moisture. These high temperatures were associated with high losses in digestibility and dry matter. Molded hay resulting from high initial storage moisture content is known to be of lower digestibility than well-cured hay (Bechtal et al. 1945, Mohanty et al. 1967).

Density of the hay package affects the temperature rise from spontaneous heating in high moisture bales. Raising the density of hay bales increases the temperature reached during storage (Nelson, 1966).

Higher density does not allow heat to escape from the hay package causing a more elevated temperature. This is especially true when bales are stacked for storage or hay is put up in large dense hay packages.

Organic Acid Preservation

Treatment of high moisture hay with organic acids is a relatively new concept in hay harvesting. The organic acids are added to the hay to prevent heating and nutrient loss because of their known anti-mierobial action.

Nutrient loss and heating in hay is directly related to initial moisture content. Researchers have found that as moisture increases levels of the organic acid needed for preservation increases. Sheaffer et al. (1975) added propionic acid to high moisture (31 and 40%) alfalfa-timothy hay at different application rates. They reported that increased application rates were needed for preservation as moisture levels increased. Hay baled at the 31% moisture level and treated with propionic acid at rates of 1.5 to 2% of hay weight at time of baling had significantly lower storage temperatures and higher in vitro dry matter digestibilities than untreated hay and hay sprayed at the 1% rate. For the hay baled at 40% moisture it took levels of 3 to 5% of wet hay weight to adequately preserve the hay. Goering et al. (1973) evaluated the effectiveness of propionic acid, acetic: propionic (57:40), sodium chloride, sodium propionate, and ammonium isobutyrate. They found that in laboratory trials propionic acid was the best preservative for alfalfa hay stored at 55% moisture in glass jars. However, it required levels of .8 to 1% to prevent mold growth. In a different trial the addition of 2.1% acetic:propionic (57:40) acids[1] or 1.1% ammonium isobutyrate on a w/w basis to a grass-clover moisture containing 35 to 50% moisture was reasonably effective in inhibiting mold growth. Propionic acid at 1.5% was not effective in inhibiting mold in this trial. Knapp et al. (1976) reported that hay treated with less than 1% propionic acid baled at a moisture level of 32.4% showed significant losses in dry matter and became moldy. However, a rate of 1% propionic acid on a wet hay basis inhibited molding and heating and reduces dry matter loss during storage.

There are several commercial organic acid preservatives on the market. They usually contain a mixture of organic acids with a high percent of propionic acid, in most cases.

One commercial acid product is guaranteed to contain 20% propionic acid.[2] Asplaund (1971) observed that the quality and digestibility of alfalfa hay baled at about 29 or 26% moisture with the addition of the commercial product at the .1% level was equal to that of hay baled at 11 or 16% moisture.

Waldern (1973) found that protein and dry matter digestibilities in orchardgrass-red clover hay were equal for hay treated with the commercial preservative (.02% propionic acid) at 30% moisture compared to an untreated control at 17% moisture. Hay baled at 40% and treated

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[1]Chemstor[R] a commercial organic acid preservative produced by Celanese Corporation, Corpus Christi, Texas.

[2]Hay Savor[R] a commercial acid product with 20% propionic acid produced by Kemin Industries of Des Moines, Iowa.

with a 2% (.04% propionic acid) of the commercial product showed lower digestibilities, however. Digestibilities of acid detergent fiber and neutral detergent fiber were higher for the treated hays than for the control. In contrast, Barrington et al. (1975) used an acid preservative with .1% propionic acid for three comparison trials in succeeding years. It was applied to alfalfa hay at the recommended rate of .1% (.0001 propionic acid). Each trial contained a wet control, a wet treated and a dry control. The wet hays ranged from 25 to 37% whereas the dry control was baled at a moisture content of 16 to 20%. They found acid-detergent nitrogen values for the wet hays significantly higher than the dry control. This indicates that both of the wet hays were heat damaged. They concluded that the commercial acid product applied at the recommended level did not effectively control hay stack temperatures and dry matter loss and did allow a reduction of protein digestibility when compared to the dry hay.

Another commerical product contains a blend of propionic and acetic acids.[3] Candlish et al. (1973) found that a blend of 30% propionic and 70% acetic to be the best organic preservative applied to high moisture (40%) orchard grass-alsike clover hay. This agrees with work done by Barrington et al. (1975), who achieved excellent dry matter loss control with a product which is a blend of 80% propionic and 20% acetic acid. They also observed that by diluting the preservative and applying the dilution at the 3% level that

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[3]Chemstor[R] a product with 57:40 acetic:propionic acids is produced by Celanese, Corpus Christi, Texas. ChemstorII[R] is a 20:80 acetic: propionic blend.

greater effectiveness was achieved. A better distribution of the preservative on the hay probably accounted for this difference.

Barrington et al. (1975) conducted other trials where they compared applications of propionic acid at the .5 and 1% levels and 1% plus .055% formaldehyde. Excellent control of dry matter losses was attained with both the 1% propionic and 1% propionic plus formaldehyde. There is a commercial product which is similar to the propionic plus formaldehyde used in this trial, but it contains 70% propionic and 30% formalin.[4]

Ammonium isobutyrate has been studied in a number of trials as a preservative for hay. Sheaffer et al. (1975) found that there were no significant differences in the preserving effects between ammonium isobutyrate and propionic acid. Rates of application of 1.5% or greater for hay baled at 31% moisture and 3% or greater for hay baled at 40% moisture were required for adequate preservation. Goering et al. (1973) found ammonium isobutyrate the most effective mold inhibitor when used in loose stacks of a grass clover mixture. Other treatments were propionic acid and a propionic:acetic acid blend. Mueller et al. (1976) found that hays treated with ammonium isobutyrate at 1 to 2% of forage wet weight at baling for the most part compared favorably with artificially dried hay in forage quality, animal acceptability, and animal weight gains. McNemar et al. (1977) found that storage temperatures were reduced when ammonium isobutyrate was applied at levels of 1.5% or greater.

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[4]Chemstor III[R] is a blend of 70% propionic and 30% formalin.

Many application methods for these acids have been tried. The most practical alternative seems to be accomplished by mounting a spray system on the hay baler. The hay is sprayed during baling as it enters the bale chamber (Mueller _et al._, 1976). The spray system which is the most desirable seems to be an electric motor driven pump operating from the tractor's electrical supply (Barrington _et al._, 1975).

The objectives of this study were to evaluate: 1) nutrient loss and resultant content of alfalfa hay with the addition of a commercial preservative with hay baled in the conventional manner, 2) the effect of this treatment on the feeding value of the alfalfa for lactating dairy cows.

CHAPTER III

EXPERIMENTAL PROCEDURE

Hay Baling and Treatment

Midbloom alfalfa hay from a common field was baled at an average moisture content of about 20% without additives and with about 28% moisture with .1% commercial acid product added on a wet hay basis. The product used was an acid-based hay preservative containing 20% propionic acid.[1] Hay was brought to the O.S.U. dairy and stacked in the same barn.

Hay Sampling

Eleven designated bales of control hay and seven of the treated were sampled at monthly intervals for 7 months to determine composition changes of the hay. One month after haverst a burlap sack was placed over each bale to prevent shattering loss of leaves. Also, composite monthly samples were taken from the two stacks for analysis. About ten core samples from each stack were used to make up the composites. Analyses made on the samples were crude protein, acid-detergent fiber, neutral-detergent fiber, acid-detergent nitrogen, ash and dry matter. The hay samples

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[1] Hay Savor, a product of Kemin Industries, Inc. Des Moines, Iowa.

were taken using a Pennsylvania State sampler. The percent nitrogen was determined by the Kjeldahl method and multiplied by the constant 6.25. ADP, NDF, and ADN were determined according to Goering et al. (1970). Ash was determined by placing a 1 gram sample in a crucible and ashing in a furnace for 4 hours at 500 C. Dry matter was determined by allowing samples to dry in a heated oven at 100 C for 24 hours. Treatment differences were analyzed by "T" test by the analysis for samples of unequal sizes according to Snedecor (1967).

Cow Feeding Trial

Twenty lactating dairy cows consisting of 14 Holsteins and 6 Ayrshires, 7-10 weeks postcalving, were selected from the University dairy herd. All cows were adjusted to a ration containing a 50:50 dry matter ratio of alfalfa hay to a concentrate mixture and were "challenge" fed for a 2-3 week adjustment period to establish maximum production. Feed allowances were calculated at the end of the adjustment period to meet 1971 NRC requirements considering milk yield, percent milkfat, body weight and lactation number. The total dry matter intake for each cow was reduced by 5% at the end of each comparison period during the experiment to minimize weight changes of the cows during the trial.

The cows were assigned to two treatment sequences in a switchback design described by Brandt (1938). The trial consisted of three 6-week period, with the first week of each period allowed by changeover from one ration to another. The 20 cows were assigned to 10 pairs based on breed and calving date. The cows in each pair were then randomly assigned to either treatment

A or B (Table I) where ration 1 contained the control hay and ration 2 contained the treated hay. Pairs were started on trial at different times, from September to December, 1975 as dictated by calving date.

The response in each period for grain intake, hay intake, milk yield, milkfat percent, non-fat solids percent, solids-corrected milk yield, dry matter digestibility, crude protein digestibility, acid-detergent fiber digestibility, crude protein digestibility, acid-detergent fiber digestibility, and organic matter digestibility were subjected to an analysis of variance for a switchback design according to Brandt (1938). The analysis of variance used to analyze the data for this cow trial is shown in Table II. Treatment means were calculated by adjusting the overall mean of the trial for each variable by the effect of the treatments. In order for these adjustments to be made a D value for each cow was calculated by the formula: D = response in the first period - 2 x the response in the second period + the response in the third period. The difference of the total of the D values for each sequence group is used to calculate the adjustments to obtain the treatment means according to Lucas (1956). The formula used for this calculation was $\bar{Y} \pm \frac{G_1 - G_2}{8_n}$ where $\bar{Y}$ is the overall mean and G_1 and G_2 equal the sums of the D values for each sequence group and where n equals to the number of cows in each sequence group.

The control and the treated hay comprised the treatments. Each was fed in a 50:50 dry weight ratio with a concentrate mixture (Table III). The hay type was changed after each comparison period.

TABLE I

EXPERIMENTAL DESIGN

Experimental Period	Treatment Sequence A	Treatment Sequence B
1	1[a]	2[b]
2	2	1
3	1	2

[a]Ration containing control hay.

[b]Ration containing treated hay.

TABLE II

ANALYSIS OF VARIANCE

Variance Source	Degrees of Freedom
Linear Term	1
Quadradic term	1
Pair	9
Sequence	1
Pair x Sequence	9
Linear term x Sequence	1
Linear term x Pair	9
Linear term x Pair x Sequence	9
Quadradic term x Pair	9
Quadradic term x Sequence[1]	1
Quadradic term x Pair x Sequence[2]	9
Total	59

[1]Quadradic term x Sequence interaction is equal to the effect due to treatment.

[2]Quadradic term x Pair x Sequence interaction was the error term used to test significance of treatment effects.

TABLE III

CONCENTRATE MIXTURE

Ingredient	Kg/Metric Ton	Percent As Fed
Wheat Middlings	500	50.0
Sorghum Grain, Fine Ground	275	27.5
Soybean Meal (44%)	125	12.5
Molasses (liquid)	75	7.5
Dicalcium Phosphate	20	2.0
Salt	5	0.5
	1000	100.0

The total ration had a calculated net energy of lactation value of 1.62 Mcal/kg dry matter.

Management of Cows

The cows were milked at 5:30 a.m. and 5:00 p.m. daily. One-half of the concentrate allotment was fed one hour prior to each milking in a stanchion barn. The hay was fed in individual tie stalls in a loafing barn adjacent to the outside lots. Following milking, the animals were moved to an outside lot where they remained for periods other than feeding and milking. At 1:00 p.m. the cows were placed in the loafing barn adjacent to the lots. For a period of two hours, the cows were allowed to consume their daily allotment of hay. The hay fed depended on the animal's treatment group for each period. Any cow that did not consume the entire allotment of hay at the scheduled time was returned to the stall the following morning at 8:00 a.m. for an opportunity to consume it. Weighbacks of hay and concentrate were made daily following the morning feeding.

Collection of Feeding Trial Data

Body weights of the cows were taken on three successive days, at the beginning of the trial and on the last three days of each period. Weights on the three days were averaged to correct for fluctuations in body weight due to gastrointestinal fill.

Milk weights were recorded twice daily throughout the trial, with samples collected at four consecutive milkings each week for percent milk fat and total solids analysis. Milk fat percentages were determined on a composite from the four consecutive milkings using a Milk-O-Tester. Analysis of total solids was made by placing 3 ml of milk in a aluminum dish and drying for four hours at 100 C in a forced air oven.

Representative samples of the concentrate mixture and the two hays were obtained each week. After dry matter determinations at 100 C, these were stored for later composition analysis. Analysis included crude protein, acid detergent fiber, organic matter and ash.

Digestibility of Ration Components

During the fourth and fifth week of each period 15 g of chromic oxide was added to the concentrate mixture at each feeding to serve as an external marker for determining the digestibility of ration components. Fecal "grab" samples were taken at 8:30 a.m. and 4:30 p.m. during the fifth week of each period and composited for each cow. Samples were subjected to the same analysis as for the feed samples. Samples from the morning milkings and evening milkings were composited separately. To correct for diurnal variation in chromic oxide excretion, fecal samples were taken every four hours for two days from two randomly selected cows in each period. Chromic oxide percentages were corrected for the mean of the 48 hour collection period. Chromium determinations were made by the method described by Williams et. al. (1972) using the atomic absorption spectrophotometer. The following formula was used to determine digestibility coefficients.

$$\% \text{ Digestibility} = 100 - \left(100 \times \frac{\% \text{ Cr. Feed}}{\% \text{ Cr. Feces}} \times \frac{\% \text{ Nutrient Feces}}{\% \text{ Nutrient Feed.}}\right).$$

CHAPTER IV

RESULTS AND DISCUSSION

Composition of the Hay

Crude protein of random composite samples varied greatly over the storage period (figure 1). However, crude protein means for June through August of the randomly selected individual bales were not significantly different (figure 2). There was a general rise in the means over the period. This agrees with work done by Miller et al. (1967). They conducted trials to determine the effect moisture content at time of baling had on the nutritive value of hay. They found that crude protein was not lost during storage but loss of carbohydrate resulted in an apparent increase in crude protein levels. Similar results were reported by Knapp et al. (1976).

Hay treated with the acid preservative had a higher acid-detergent fiber percentage than the control hay. Acid-detergent fiber of the composite samples from the treated stack increased to a higher level than the control stack after the initial sample (figure 3) and stayed at a higher level for the storage period. Similar results were evident from the mean of the individual bales (Table IV). Acid-detergent fiber percentages at the first sampling were similar, but were significantly different ($P < .05$) after one month of storage (Table IV). This agreed with Miller et al. (1967) who found that fiber content of forages

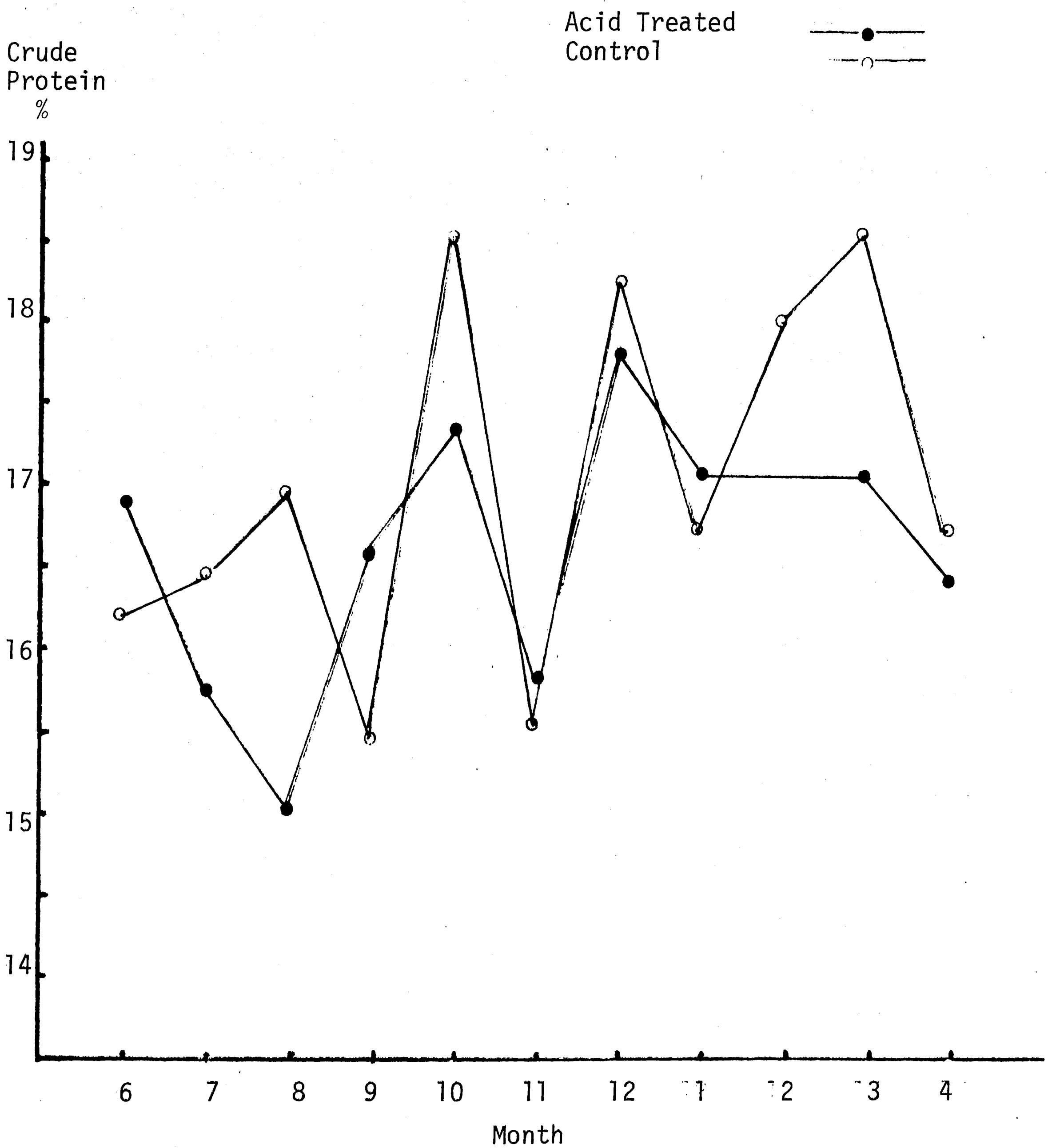

Figure 1. Crude Protein Percentages for Composite Samples During Storage

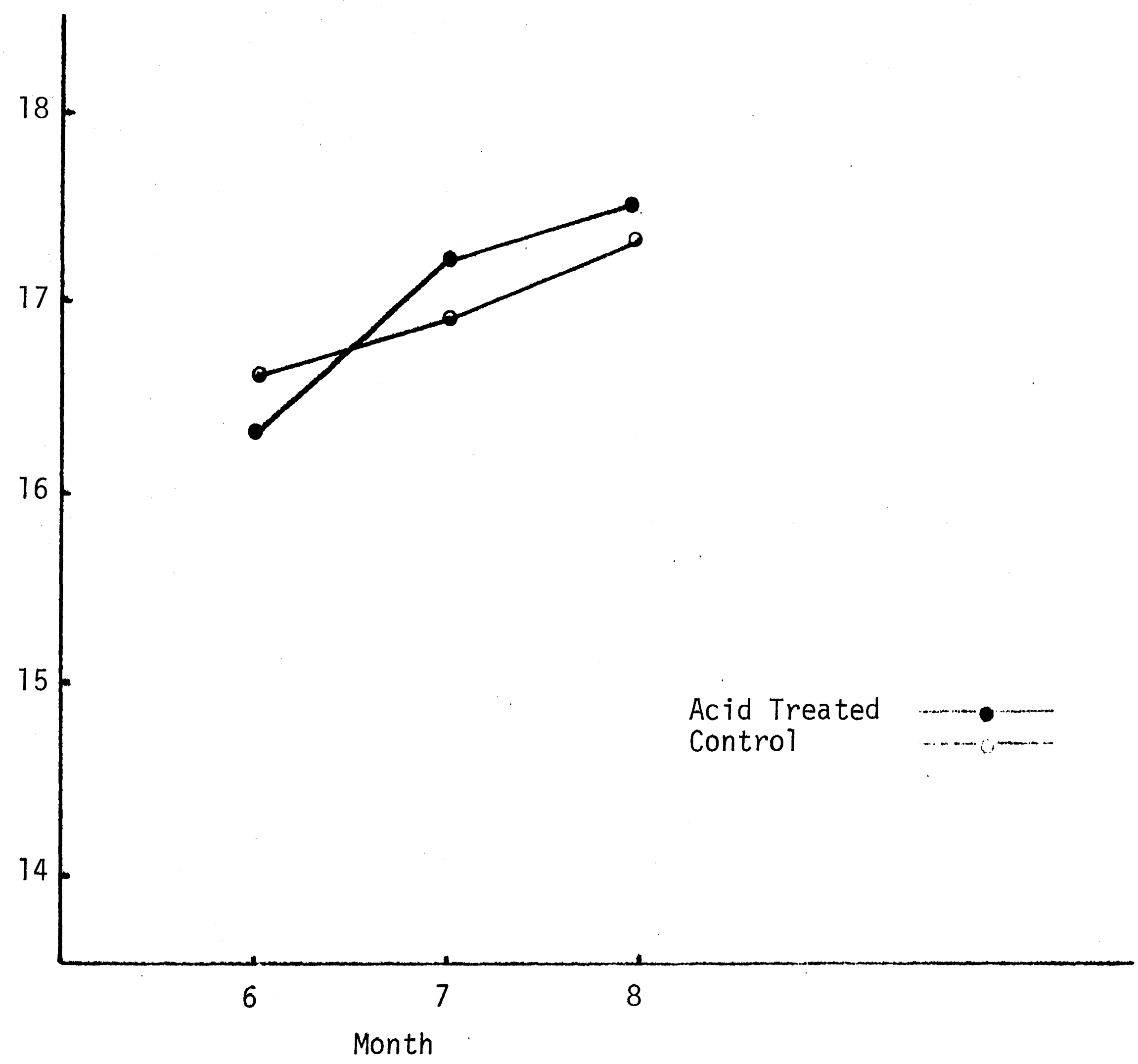

Figure 2. Crude Protein Percentages Means for Randomly Selected Individual Bales

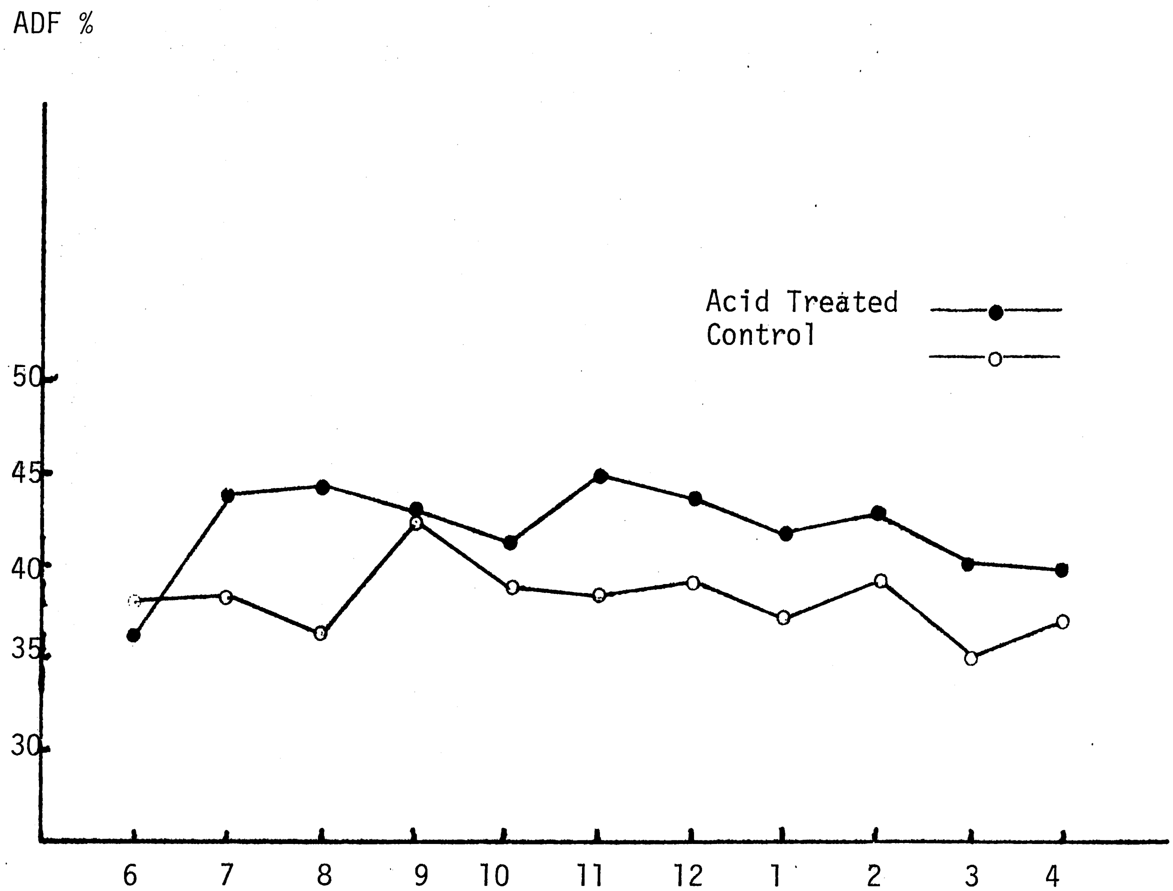

Figure 3. Acid-Detergent Fiber Percentages for Composite Samples During Storage

TABLE IV

COMPOSITION CHANGES IN THE INDIVIDUAL BALES

	June			July		
Item	Control	Treated	SE	Control	Treated	SE
ADF,%	39.82	40.56	.44	41.05[a]	45.00[b]	.63
ADF-N, % of Total N	12.64	13.14	.73	15.11[a]	17.57[b]	.41

[a,b]Means which do not have the same superscript are significantly different ($P<.05$), analyzed by "t" test according to analysis for samples of unequal sizes by Snedecor (1967).

increased as moisture content at baling increased, and these percentage changes indicated a loss in readily fermentable carbohydrates. Cell wall constituents (NDF) followed a similar pattern for the composite samples taken from each hay stack.

Van Soest (1965) reported the nitrogen content of acid-detergent fiber was a sensitive assay for nonenzymic browning due to overheating of feeds. Drying forages above 65 C was also reported to increase acid-detergent fiber nitrogen. Hay samples for this trial were inadvertantly dried at 100 C; therefore, values obtained may be biased upward. However, differences between the treatments should indicate whether heat damage occured. Acid-detergent nitrogen values as a percent of total nitrogen for the randomly selected individual bales is shown in Table IV. Values were similar for the initial sampling. There was a significant difference between the two treatments after one month of storage ($P < .05$). This indicated that the treated hay increased to a higher temperature during storage and underwent more damage than the control hay. This agreed with Barrington et al. (1975) who found that hay baled at high moisture content with the addition of .1% commercial acid product which contained 20% propionic acid and without acid treatment had higher acid-detergent nitrogen values than a dry control. They suggested that this indicated heat damage during storage.

Cow Trial

There were some of the treated hay bales which were molded or contained moldy areas. Molded hay was not fed to the cows. The cows were fed only hay which appeared unmolded. The control hay contained no mold.

The tests of significance for this trial are shown in Table V. Tests are shown for each of the response criteria.

There was little difference in feed intakes due to treatment (Table VI). Intakes on a dry matter basis were very close to the planned 50:50 roughage to concentrate ratio. This would be expected since the treated hay that had molded was not included in the ration. This was in agreement with Barrington et al. (1975) who found no difference in dry matter intake of hay treated with .1% commercial acid product containing .1% propionic acid and a dry control when fed to sheep and goats. Intakes of a wet untreated hay were significantly lower, however, Mueller et al. (1976) also reported very little difference in animal acceptability between treated and untreated alfalfa-timothy hay baled 25 to 35% moisture.

Milk cows fed the control alfalfa hay had significantly higher actual milk yield ($P<.02$) than cows fed the treated alfalfa hay (Table 6). This agrees with the composition data in Table IV where a significant difference in acid-detergent nitrogen indicated the treated hay had undergone heat damage, i.e., dry matter loss and lowered protein digestibility. This differed from results of Waldren (1973) who found no differences in milk yield in five lactating dairy cows offered orchard grass-red clover hay baled at different moisture levels with and without the addition of an organic acid product containing 20% propionic acid. Hay was baled at 40% moisture with the addition of .2% acid product (.04% propionic acid), 30% moisture with the addition of .1% acid product (.02% propionic acid) and 17% with .1% (.02% propionic acid) and without the addition of the acid product.

TABLE V

TESTS OF SIGNIFICANCE
FOR COW TRIAL

Item	Treatment[1] Mean Square	Error[2]	P7F
Milk Yield	3.12	.426	.02
Milkfat	.005	.026	.69
Non-Fat Solids	.019	.012	.24
Solids-Corrected Milk	2.02	.499	.07
DM Digest	9.368	16.541	.47
CP Digest	3.882	19.911	.67
ADF Digest	162.38	64.944	.15
OM Digest	11.021	13.380	.39
Hay Intake	.033	.025	.28
Grain Intake	.002	.004	.48
Weight Change	.533	114.260	.92

[1]The effect due to treatment is equal to the interaction of the quadratic term and sequence group term (a fraction of the sum of squares of the D value totals).

[2]The error term is a pooled interaction between the quadratic term and individuals in the two groups.

TABLE VI

RESPONSES OF COWS FED ALFALFA HAY
HARVESTED BY DIFFERENT METHODS

	Type of Hay			Difference
	Control	Acid Treated	SE	AT - C[a]
Feed DM Intake				
Grain, kg/day	7.41	7.41	.01	0.0
Hay, kg/day	7.42	7.51	.02	0.09
Cow Responses				
Milk Yield, kg/day	16.76	16.28	.13	-.48*
Fat test, %	3.67	3.69	.03	.02
Non-fat solids, %	8.58	8.54	.02	-.04
Solids corrected milk, kg/day	15.59	15.20	.14	-.39[+]
Weight change, kg/6 wk.	3.8	4.0	2.07	.20

[a]Acid Treated - Control

*Significant at .05 level

[+]Significant at .1 level

There were no differences in fat test or non-fat solids percentages between cows fed the different hays (Table VI). Waldren (1973) reported similar results.

Solids-corrected milk was calculated to express milk yield on an equivalent energy basis. Cows fed the control hay produced a higher yield of solids-corrected milk than cows fed the treated hay. This difference was significant ($P < .07$). This is consistent with actual milk yield and the composition data. It indicates that the hay fed received some heat damage and that the difference between the two treatments may have been greater if molded hay had been fed.

There was little difference between the two treatment groups in the weight changes of the cows per six-week period.

Digestibility Data

There were no significant differences in the digestibilities of ration components (Table VII). Dry matter, protein, and organic matter digestibilities were slightly higher for the production data and may not have reflected the true feeding value of the hay since molded hay was not fed. This agreed with work done by Barrington et al. (1975) who reported that protein digestibility was reduced in one of three trials where high moisture alfalfa hay was treated with .1% commercial acid product containing 20% propionic acid. They found no significant differences in dry matter digestibility.

The acid-detergent fiber digestion coefficient for the treated hay was higher than for the control hay. This difference was not significant but did agree with data reported by Waldren (1973). He found that hay treated with .2% at 40% moisture or .1 at 30% and 17%

TABLE VII

DIGESTIBILITY COEFFICIENTS OF RATION COMPONENTS

	Type of Hay		
Component	Control	Acid Treated	SE
Dry Matter, %	56.35	55.56	.91
Protein, %	64.20	63.68	1.64
Organic Matter, %	60.05	59.19	.75
ADF, %	21.88	25.20	.83

moisture had a higher digestibility coefficient for acid-detergent fiber than a control hay baled at 17% moisture without treatment. In contrast, Miller et al. (1967) found that the digestibility of fibrous fractions of hay was not influenced by moisture content at time of baling.

Economic Value

Organic acid preservatives can decrease damage to hay during curing. However, application of .1% of the commercial acid product used in this trial did not adequately preserve alfalfa hay. There was probably an inadequate amount of preservative when applied at the recommended rate for adequate distribution and proper preservation. Mueller et al. (1976) found thorough preservative distribution was imperative for adequate hay preservation.

The economic merit of adding chemical preservatives depends on several factors. The cost of the chemical plus the initial cost of the applicator will increase the cost of the hay, depending on the preservative and the apparatus used. For example, Chemstor[R] costs $8.00/T when applied at the 1% level and an applicator costs from $400 up. Additional labor is required to calibrate the spray apparatus and to handle the heavier hay. The organic acids are corrosive which increase wear on haying equipment. Treated hay may be unpleasant to handle and precautions must be taken when handling the preservatives.

On the other hand, there may be reduced field losses if hay can be baled at a higher moisture content reducing the loss of leaves due to shattering. Losses because of inclement weather at harvest time may be reduced. Reduced storage losses have been observed when preservatives are applied in adequate amounts to prevent microbial growth.

A dairyman or hay buyer should consider the moisture difference in buying hay baled at conventional moisture levels and relatively high moisture organic acid treated hay. For example, a ton of hay baled at 18% moisture would contain 1640 lbs. of dry matter whereas a ton of hay baled at 30% moisture would contain 1400 lbs. dry matter. Therefore, the price paid for wet hay should be 85% of the dry hay price ($\frac{1400}{1640}$ = .85). If the price of hay were $70/T the wet hay would be worth $59.50/T ($70 x .85 = 59.50). Caution should also be taken to buy hay to which an effective preservative was applied and an even distribution of the preservative achieved. If the history of the hay is not known, a producer may want to insist on a forage test before he buys the hay.

Additional research should be conducted to evaluate the merit of other chemicals for preservation of alfalfa. Trials with a wet control to determine changes in untreated wet hay would be an advantage when evaluating preservative effectiveness. Also, new spray applicators that will apply preservatives in a more even manner need to be developed.

CHAPTER V

SUMMARY

Alfalfa hay was baled from a common field either at about 20% moisture content or about 28% moisture with the addition of an acid-based commercial product (Hay Savor). Hay samples were taken to evaluate composition changes in the hay.

Twenty cows, 7-10 weeks postcalving, were fed a 50:50 dry matter ratio of forage to concentrate in a switchback design, to compare production responses of lactating cows fed alfalfa hay baled at 20% moisture or at 28% moisture with an organic acid preservative added. Response criteria were milk yield and composition, body weight changes, and digestibility of the ration components.

There was a small rise in crude protein percent in the hay presumably due to loss of fermentable carbohydrates. After one month of storage acid-detergent fiber and acid-detergent nitrogen was significantly higher for the acid treated hay than for the control.

Milk yield was significantly higher by .48 Kg/day for the cows fed the control hay. Milk fat and total solid percentages were not significantly different. Cows fed the control hay produced a higher yield of solids-corrected milk, but the difference was not statistically significant.

The commercial acid product used in this trial applied at the recommended level did not adequately preserve alfalfa hay baled at higher than normal moisture level.

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