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To the Graduate Council:

I am submitting herewith a thesis written by Bobby James Bearden entitled "The Effects of Adding Poor Quality Ground Hay to the Concentrate Mixture for Dairy Cows." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

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THE EFFECTS OF ADDING POOR QUALITY GROUND HAY TO THE CONCENTRATE MIXTURE FOR DAIRY COWS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

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Master of Science

by

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CHAPTER I

INTRODUCTION

The use of ground roughage in the dairy concentrate mixture is common practice in many parts of Tennessee. A visit to local feed mills in Middle Tennessee during the winter will show the magnitude of this practice. A few of the dairymen use only small quantities of good quality hay to mix with the grain, but many of them use larger amounts of poor quality hay. Molasses are usually added to make the mixture more palatable. This mixture is then fed, not as a roughage, but as a concentrate mixture to the dairy cows.

Owners of many of the higher producing herds in these areas of Tennessee do not use any ground hay but feed an all grain concentrate mixture. The use of poor quality ground hay seems to be more prevalent among, although not confined to, relatively small producers of manufacturing milk with lower producing cows. On many of these farms the roughage that is fed long is of a poor quality also. Thus, a cow is getting low-quality roughage and a concentrate mixture made up largely of the same low quality roughage.

Some of the reasons given by the farmers for using ground hay in the concentrate mixture are that feed costs are lowered and needed bulk is added to the concentrate mixture. Work by Moore, Huffman and Plum (12) has shown that the bulk of the concentrate mixture is not as important as believed formerly. It is probably true that feed costs are lowered but is milk production lowered? If so, how much? Is the

composition of milk affected? Also, are there other effects that should be expected?

In an effort to obtain answers to these questions, a study was conducted to determine the effects of adding poor quality ground hay to the concentrate mixture for dairy cows.

CHAPTER II

REVIEW OF THE LITERATURE

To determine the effects of using ground hay in the dairy mixture, a study of previous experiments concerning the use of ground hay for dairy cows was conducted. There were reports of many experiments in this field. Some of these trials had been conducted by feeding part or all of the roughage portion of the ration ground and still feeding an all grain concentrate mixture. Other trials had been conducted using ground hay as a partial grain substitute in the concentrate mixture and feeding the roughage unground. The latter is the situation more often found on dairy farms in Tennessee. A review of the literature relating to this practice is given.

Feeding a Portion of the Roughage Ground

Reed and Burnett (20) fed either ground or unground alfalfa hay to cows milked four times daily. Pairs of Holstein and Ayrshire cows were used. The hay was fed at the rate of one pound per hundred pounds of body weight. Silage was fed to cows of each group at the rate of three pounds per hundred pounds of body weight. Concentrates were fed individually according to milk production and breed. One pound of concentrates was fed to Holstein cows for each three and one-half pounds of milk produced while Ayrshires were fed one pound of concentrates for each three pounds of milk produced. They found no consistent differences in milk production or body weight regardless of whether the hay was ground or unground. They concluded that the use of ground hay as used in this trial was neither necessary nor profitable.

A similar experiment using ground and unground alfalfa or soybean hay when silage and grain were also fed was reported by Nevens (15). Unground hay was fed at one and one-half pounds per hundred pounds of body weight while ground hay was fed at one and one-fourth pounds per hundred pounds of body weight. The cows on the ground hay produced more milk per pound of hay consumed, but this was not believed by the author to be due to the different rations but due to the advanced stage of lactation of some of the cows on the unground hay ration. Cows on the ground alfalfa lost weight while the other groups gained weight. More soybean hay was refused when fed long rather than ground, but no difference was found when alfalfa was the hay used. In neither case did he find the grinding of the hay to be profitable.

Ingram and Meade (8) fed long or ground soybean hay to milking cows in a double reversal trial. One pound of the hay and three pounds of silage were fed per hundred pounds of body weight. Cows were given all the grain they would clean up at two feedings daily. The cows on the ground hay produced 1.31% more milk containing 4.84% more butterfat. Cows on the ground hay gained more body weight. The cows fed long hay refused more of the hay which was mainly the coarse stems. Even though there were slight increases in milk production and body weight gain, these increases were not enough to cover grinding costs.

Morrow and LaMaster (14) fed ad lib. alfalfa, soybean, or oat and vetch hay, either ground or unground. Corn silage was also fed at the rate of three pounds per hundred pounds of body weight and grains were fed according to milk production. When alfalfa was the hay used,

there were no appreciable differences in milk production or hay consumption. More milk was produced and less hay refused when the soybean hay was ground. Feeding ground oat and vetch hay gave similar results to the soybean hay but the differences in milk production and hay refusal were less. Results of digestion trials using these hays showed no significant differences of any component due to grinding except digestibility of the ash. The ash of the ground soybean hay was more digestible than in the unground hay, but the reverse was true for the oat and vetch hay with no difference in alfalfa hay whether ground or unground. They concluded that grinding the soybean hay fed might increase production enough to cover grinding cost but grinding alfalfa or oat and vetch hay would not pay.

Cows fed either ground alfalfa, sweet clover hay, or a combination of alfalfa hay and corn fodder were found by Olson (17) to produce slightly more milk than when fed the same roughages long. Silage and grain were also fed. Slight gains in body weight were found when either the hay or hay and fodder was ground. Feeding the corn fodder ground greatly reduced the refusal of it. Digestibility trials showed no significant change in digestibility due to grinding. Here again the increase in milk yield and body weight gains due to grinding was not sufficient to cover the cost of grinding.

Hayden, Monroe and Perkins (6) fed complete mixed rations of two parts grain, two parts hay and one part stover to two groups of milking cows. One group of cows was fed part of the hay and stover hammermill ground and the remainder chopped with a silage chopper. All of the hay

and stover for the other group was chopped only. Molasses were added to each ration to increase palatability. The group of cows fed part of the hay and stover ground produced more milk, gained more weight and consumed more feed but none of these differences were sufficient to be statistically significant.

Espe and Cannon (5) compared chopped alfalfa to long alfalfa when fed to milking cows and found no significant difference in milk or butterfat yield. Corn silage and concentrates were also fed. In another trial they replaced one-half of the corn silage in a ration with a mixture consisting of 40% ground alfalfa hay and 60% ground corn fodder. Long alfalfa hay was also fed at the rate of seven and one-half pounds per cow per day and concentrates were fed according to milk production. Here again they found no significant differences in milk or fat yield.

Feeding All of the Roughage Ground

Powell (19) reported that grinding or grinding and pelleting all of the roughage fed to milking cows greatly lowered the butterfat per cent of the milk produced for complete lactations without affecting the quantity of milk produced.

It was shown by Porter et al. (18) that chopping all of the hay in an alfalfa hay and grain ration did not cause any change in milk or butterfat yield. However, grinding or grinding and pelleting the hay fed caused some increase in milk yield with a reduced butterfat yield.

Balch et al. (1) found a reduced butterfat test of milk produced when hay was limited to four or eight pounds per cow per day. Grinding the eight pounds daily allowance reduced the test even further.

Rodrique and Allen (21) obtained a lowered butterfat test by grinding all of the roughage fed either coarse, medium or fine. The finer the grinding the greater was the decrease in fat test.

Ronning (22) fed ground pelleted rations containing alfalfa hay as the only feed to dairy cows with varying levels of concentrates included. Concentrate levels were 0, 15, 30 and 45 per cent of the total weight of the ration. All of the rations, which were fed ad lib., showed some decrease in per cent butterfat. The milk yield was increased as the level of concentrates increased to 30 per cent. Butterfat per cent was decreased at all levels of concentrates but decreased most at higher levels of concentrates. Total feed and total digestible nutrient (TDN) intake was highest at the 30% level of concentrates.

Using Ground Hay as a Partial Substitute for Grain in the Concentrate Mixture

Mairs (11) compared alfalfa meal to wheat bran in the concentrate mixture for milking cows. Alfalfa meal replaced all of the wheat bran on an equal weight basis and equal amounts of each mixture were fed. Enough of either concentrate mixture was then fed individually to equal two-fifths of the weight of milk produced by each cow. Corn silage was fed to each group at the rate of three pounds per hundred pounds of body weight and mixed hay at the rate of 1.2 pounds per hundred pounds of body weight. There was a decrease in milk production due to the use of alfalfa meal in every case. The mixture containing the alfalfa meal was noticeably less palatable.

In a similar experiment Snyder and Burnett (25) replaced wheat bran with chopped alfalfa hay. There was a slight decrease in milk and fat production due to the use of chopped hay but a slight increase in body weight. They concluded that chopped alfalfa was at least equal to wheat bran when an average of milk production and body weight gains was considered.

Kuhlman and Cave (9) used ground alfalfa hay to replace 30% of the grain in a concentrate mixture. The two mixtures were fed on an equal TDN basis. Sufficient prairie hay was fed to meet maintenance requirements and enough concentrates to meet TDN requirements for milk production. There was no significant difference in milk production between the groups of cows fed the two mixtures. More pounds of the mixture containing the ground hay were fed in order to keep the TDN furnished by the two concentrate mixtures equal. In this experiment 100 pounds of ground hay were equal in milk production value to 24 pounds of shelled corn, 13.8 pounds of oats, 13.8 pounds of wheat bran and 17.2 pounds of cottonseed meal.

Thirty per cent of the grain in a dairy concentrate mixture was replaced with dehydrated alfalfa hay either ground, ground and pelleted, or chopped in experiments reported by Blosser et al. (3). Each of these mixtures was then fed at the rate of one pound of the mixture for each three pounds of four per cent fat corrected milk (4% FCM) produced. Chopped medium quality alfalfa hay and corn silage were fed as roughages. The cows fed the mixture containing pelleted hay yielded the most milk while the cows receiving the ground hay mixture yielded the least, but

the differences were not statistically significant. Fewer cows went off feed when fed the mixture containing pelleted hay.

Hope et al. (7) compared concentrate mixtures containing 0, 15, 30 and 45 per cent ground dehydrated legume-grass hay when fed to milking cows on an equal weight basis. Long hay was fed free choice and silage was fed at three pounds per hundred pounds of body weight. The cows fed the all grain mixture produced significantly more milk and gained more body weight than any of the other groups. Efficiency of production and weight gain combined was greatest per pound of TDN on the all grain concentrate mixture.

Seath et al. (23) conducted an experiment for two consecutive years using ground alfalfa or soybean hay to replace part of the concentrate mixture fed to milking cows. Long hay was fed at 1% of body weight and silage at 3% of body weight each year. The concentrates were then added to equal Morrison's minimum standard for maintenance and production. During the first year, ground alfalfa or ground soybean hay replaced 27% of a basal grain mixture. All three of the mixtures were then fed on an equal TDN basis. During the second year, ground alfalfa hay replaced either 23 or 37% of the basal ration and then all three mixtures were fed on an equal TDN basis. There were no differences in milk production of cows fed the different mixture for either year. The cows receiving the ground hay gained more body weight but the difference was very small. They concluded that ground alfalfa hay could substitute for up to 37% of the concentrate mixture if more pounds were fed in order to supply the same TDN as the basal mixture. The cows in these trials

consumed all of the concentrate mixtures with no refusals. The digestibility of the dry matter of the entire ration was slightly lowered when ground hay was added to the concentrate mixture.

Berousek (2) reported a series of trials where 20% to 57% of the grain in a concentrate mixture was replaced with ground alfalfa hay. These mixtures were then compared to the basal grain mixture and were fed on an equal TDN basis. In the first trial 20% of the grain was replaced with the ground hay and long hay was fed free choice. There were no differences in milk production. One trial with 30% ground hay in the concentrate mixture and long hay fed at 2 pounds per hundred pounds of body weight gave no differences in milk production. However, in another trial, with 30% ground hay in the concentrate mixture and long hay fed free choice, the cows receiving the ground hay produced less milk. In further trials at levels of 50 and 57% ground hay, the milk production was lowered and the palatability of the mixture was lowered. There were no significant differences in body weight changes between any of the mixtures.

The use of ground hay in a dairy concentrate mixture adds bulk to the mixture. The addition of this bulk has been one of the reasons given by Tennessee dairymen for using such a mixture. As hay is not only more bulky but also higher in fiber than grain, the fiber content of a concentrate mixture containing ground hay would also be increased. The fact that bulkiness of the concentrate mixture is not as important as once thought, was shown by Moore, Huffman and Plum (12). By use of a rumen fistula and also slaughter data they demonstrated that heavy

feeds were not passed immediately out of the rumen as had been thought but were thoroughly mixed with the roughage contents of the rumen. Nordfeldt et al. (16) reported that when the crude fiber content of the total ration exceeded 16%, there was a decrease in milk production even though intake of TDN remained the same. Leighton and Rupel (10) found that increasing the crude fiber in rations decreased milk production during hot weather even though it did not during the cooler seasons.

Summary of Review

Milk yield and per cent butterfat. Grinding a portion of the roughage was found to increase milk production slightly (8, 14, 15) when soybean hay was the part of the roughage which was ground. Slight increases in milk yield due to grinding alfalfa hay in other similar type rations were reported in some experiments (15, 17) while other experiments (5, 14, 20) revealed no increase. Grinding the corn fodder or stover was found to increase milk production slightly (6, 17). None of the increases in milk production due to feeding ground hay were significant. All workers concluded that grinding roughage did not pay. The percent butterfat was not significantly affected by feeding a portion of the roughage ground.

Grinding all of the hay, when hay was the only roughage fed, was found to have no appreciable effect on milk production but did significantly lower the percent butterfat of the milk produced (1, 18, 19, 21, 22).

When ground hay replaced a part of the grain in the concentrate mixture and this mixture was fed at the same rate as the control mixture, there was a decrease in milk and fat production (7, 11, 25). When

similar concentrate mixtures containing ground hay were fed on the basis of equal pounds of TDN as furnished by the control mixture, there was no consistent decrease in production (2, 9, 23) except when the ground hay made up about 50% or more of the concentrate mixture (2).

Bulkiness of the concentrate mixture was not found to be of importance (12). The use of high fiber rations was found to decrease milk production when different levels of fiber were the only variable (10, 16).

Body weight changes. There was no consistent pattern of body weight changes of cows fed ground hay in any portion of their ration as compared to those having no ground hay. Results of several trials showed greater increases in weight gains on ground hay (6, 8, 17, 23, 25) while others (7, 15) showed greater body weight gains on rations containing no ground hay. Some of the experiments revealed no differences in body weight changes due to grinding either a portion or all of the hay (2, 11, 20).

Palatability and digestibility. Grinding coarse stemmed hay such as soybean hay when fed as a roughage tended to increase consumption, (8, 14, 15) but grinding of finer textured hay such as alfalfa did not (14, 15). The addition of ground hay to the concentrate mixture did not increase its palatability in any trial and lowered it in some trials (2, 11). In the digestion trials reported there were no increases in nutrient digestibility due to grinding the hay (14, 17, 23).

Several experiments comparing all grain concentrate mixtures with concentrate mixtures containing ground hay were found which had been

conducted in other states, but under different conditions from those usually found on Tennessee dairy farms. In most of this previous work a high-quality hay was ground and usually the two concentrate mixtures were fed on the basis of equal amounts of TDN. As pointed out previously, the hay used by Tennessee dairymen is of a rather poor quality and it is believed that this mixture is then fed, not on a TDN basis, but on the same bulk or weight basis as a good grain concentrate mixture would be fed.

After the literature was reviewed, it was felt that the effects of using ground hay in the dairy mixture, as practiced by many dairymen in Tennessee, were still not fully known. A series of experiments was then conducted in an attempt to simulate conditions as they exist in Tennessee.

CHAPTER III

EXPERIMENTAL METHODS

Three feeding trials were conducted at the Middle Tennessee Experiment Station, Spring Hill, Tennessee, to determine the effects of replacing part of the grain in an all grain dairy concentrate mixture with poor quality ground hay. All of these trials were of the same continuous type using paired groups of milking cows. Each trial consisted of three periods: (1) a preliminary period during which both groups received the same amount of an all grain concentrate mixture; (2) an experimental period during which the control group continued on the all grain concentrate mixture while the experimental group received the same pounds of a concentrate mixture in which a portion of the grain had been replaced with poor quality ground hay; and (3) a post-experimental period during which both groups were again fed the same all grain concentrate mixture. Other feeding and management practices were the same for each group.

The cows used were Purebred Holsteins from the station dairy herd. Most of the cows selected for pairings were at or just past the peak of lactation at the beginning of each experiment and only one cow in one trial was beyond the sixth month of gestation at the end. The cows were paired as equally as possible on the basis of milk and butterfat production, stage of lactation and gestation, body weight and age. Paired mates were then allotted to each of the groups so that the groups were balanced as equally as possible in all respects considered. The

cows of each pair were close enough in milk production at the start of each trial so that the same amount of concentrates was fed to both cows.

Routine milking and management of the cows on the trials were handled by the regular milkers and herdsman at the station during each trial. All of the cows were machine milked in a milking parlor twice daily at 11 and 13 hour intervals. Other management details peculiar to each trial will be presented later.

Milk produced by each cow was weighed at each milking. Weekly butterfat tests were conducted during Trial I. During Trials II and III bi-weekly butterfat and solids-not-fat (SNF) tests were conducted. Individual concentrate consumption was measured in all trials. Roughage consumption was measured on the group basis during Trials II and III only. Body weights were taken on three consecutive days at the beginning and end of each trial.

The two treatments were evaluated by analyzing for differences in responses between the two groups of cows. This method, as outlined by Burt (4), is based upon individual cow responses for each item measured. The responses of each cow involved her performance during the preliminary, experimental and post-treatment periods. A numerical value for the response of each cow was obtained by using the following formula:

$$\text{Response} = Y - \tfrac{1}{2}(X_1 + X_2)$$

in which

Y = average during experimental period,

X_1 = average during preliminary period, and

X_2 = average during post-experimental period.

The method is further illustrated in Appendix A using the milk production data of Trial I. Yields of milk, butterfat, 4% FCM, and SNF were analyzed statistically according to responses. Responses in % butterfat and SNF were also analyzed in this manner. The t test as described by Snedecor (24) was used to test for differences between the two groups of cows in butterfat and SNF percentages and in concentrate consumption.

Chemical analyses of the two concentrate mixtures of Trials II and III were determined from composited samples. Also samples of the hay used for grinding in Trials II and III were analyzed. Chemical analyses were made of composited samples of the long hay and silage fed during Trial III.

Trial I

The first trial was conducted during the summer of 1960 using seven pairs of cows. Cows were paired and the preliminary period of one week began April 28. A twelve-week experimental period followed. The post-experimental period was for two weeks and ended August 10. The control mixture was an all grain concentrate mixture while the experimental mixture was prepared by replacing 25% of the TDN in the all grain control mixture with an equal amount of TDN in the form of poor quality ground hay. The composition of the two concentrate mixtures compared in Trial I is shown in Table I.

TABLE I

COMPOSITION OF THE TWO CONCENTRATE MIXTURES USED IN TRIAL I

Ingredients	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)
	lbs	
Ground grain sorghum	600	600
Ground oats	500	500
Ground wheat	400	400
Cottonseed meal	300	300
Ground hay	0	940
Salt	18	27
Dicalcium phosphate	9	13

The grain was crushed through a roller mill and the hay through a hammermill. All ingredients for each mixture were thoroughly mixed. No molasses were added to either mixture during this first trial. Enough of each mixture was prepared at each mixing to last for two to three weeks.

The hay that was ground was mature first-cutting alfalfa-orchardgrass mixed hay with orchardgrass predominating. This hay was lower in quality than that normally fed the milking herd at the station. It was brown in color, coarse in texture, and relatively unpalatable. The estimated TDN content was 48 per cent. The TDN content of the all grain control mixture was estimated to be 74% using average analyses of the ingredients as given by Morrison (13). To obtain the experimental mixture, enough ground hay was mixed with a batch of the all grain control mixture so that 25% of the TDN of the resulting mixture would be in the form of poor quality ground hay. The experimental concentrate mixture contained an estimated 65% TDN. One pound of the experimental concentrate mixture contained only 88% as much TDN as one pound of the all grain control concentrate mixture.

Concentrate allowances were fed initially at the rate of one pound of concentrates for each two and one-half pounds of milk above 24 pounds daily for mature cows and one pound of concentrates for each 2 pounds of milk above 20 pounds daily for the animals in their first lactation. A maximum of 20 pounds daily for any one animal was fed. Both cows of a pair were fed the same total pounds of their respective mixture. Allowances were decreased according to the decline in production

of the highest producing cow of each pair. Concentrate mixtures were fed twice daily in individual stanchions prior to the milking operation. No concentrates were fed during the milking operation. Refusals of concentrates were weighed once daily after the A.M. feeding.

These cows were pastured for the entire period and alfalfa hay was kept in racks in the pasture, but very little was eaten. The cows in both groups were pastured together with the remainder of the herd and no attempt was made to determine consumption of pasture or hay. The pasture was Ladino clover-orchardgrass permanent pasture and pearl millet supplemental pasture. The quantity and quality of the pasture varied some according to the weather conditions, but an adequate quantity of a good quality was usually available.

Trial II

Trial II was conducted during the winter of 1960-61 using eight pairs of cows. The preliminary and post-experimental periods were of three weeks each with the experimental period lasting twelve weeks. The preliminary period began January 13, 1961 and the post-experimental period was completed April 17, 1961. The concentrate mixtures used were slightly different from those used in Trial I. For the experimental mixture 50% of the dry matter in the grain of the control mixture was replaced with poor quality ground hay. Then 10 per cent molasses was added to each concentrate mixture. The concentrate mixtures used in Trial II are presented in Table II.

TABLE II

COMPOSITION OF THE TWO CONCENTRATE MIXTURES USED IN TRIAL II

Ingredients	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)
	lbs	
Ground corn	900	200
Ground barley	300	100
Ground oats	300	100
Soybean oil meal	500	600
Ground hay	0	1000
Molasses	200	200
Salt	20	20
Dicalcium phosphate	10	10

The grain and hay were ground through a hammermill and mixed by a local feed mill. Enough was prepared at each mixing to last for three to four weeks. The hay that was ground and used in the experimental mixture was a fine-textured but unpalatable mixed-grass hay. The color was light brown. The all grain control mixture was estimated to contain 75.5% TDN and 17.2% crude protein. The experimental mixture containing the ground hay was estimated to contain 60.6% TDN and 16.9% crude protein.

Initial concentrate allowances for each pair of cows were set at a rate of one pound of concentrates for each four pounds of 4% FCM based on the average production of each pair. Allowances were then decreased 2% per week regardless of the level of production. The concentrate mixtures were hand weighed into a separate bucket for each cow and fed twice daily in the milking parlor as the cows were milked. Refusals were weighed after each cow was milked.

Each group of cows was housed separately and fed corn silage and alfalfa-orchardgrass hay ad lib. Consumption of silage and hay was measured on a group basis. The hay fed was good-quality, early-cut alfalfa-orchardgrass hay. It was a green-colored, fine-textured hay that was quite palatable. The corn silage fed had a good grain content and was eaten readily by the cows. The average dry matter content of the silage was 26% on an air-dry basis.

Trial III

Trial III was conducted during the winter of 1961-62 using 10 pairs of cows and was very similar to Trial II. The preliminary and post-experimental periods were each of two weeks duration with the

experimental period again being twelve weeks. The preliminary period started December 20, 1961 and the post-experimental period ended April 4, 1962. The major difference in Trial III was that the cows were allowed only 30 pounds of corn silage and 10 pounds of alfalfa-orchardgrass hay per cow per day instead of all they would eat, and the concentrate allowances were increased. The TDN intake from the silage and hay was estimated and then a sufficient amount of concentrates was fed, based on the TDN of the control mixture, to meet the requirements for milk production and maintenance according to Morrison (13). Both cows in each pair were fed initially at this calculated level and then concentrate allowances were decreased 3% every 2 weeks.

The composition of the two concentrate mixtures used was the same as for Trial II and as shown in Table II. During the third trial only enough concentrates were prepared at each mixing to last one to two weeks. The cows were fed their concentrates in individual stanchions prior to milking, as in Trial I, in order to allow adequate time for consumption. In other respects, this trial was the same as Trial II having the same type and quality of hay and silage with the limited allowances being fed to the cows on the group basis. The silage fed during this third trial contained approximately 27% dry matter on an air-dry basis.

CHAPTER IV

RESULTS

Results are reported separately for each trial and then the findings for items common to all three trials are combined and presented. The cows in the group which received the all grain concentrate mixture are referred to as controls. The cows in the group fed the experimental concentrate mixture containing ground hay are referred to as experimentals. Average production, consumption and body weight changes are given for the actual experimental period. Some of the production data are shown graphically for the complete experiment including preliminary and post-experimental period averages with averages for each week during the experimental period. Also average responses of some of the production data are presented.

Trial I

Average daily milk and fat production, concentrate consumption and body weight changes during the experimental period are shown in Table III. Milk production of the control cows averaged 2.1 pounds per day higher than for the experimental cows. As shown in Figure 1, the experimental cows averaged slightly higher in milk production during the pre-experimental period but the control cows produced at a higher level during the first week of the experimental period and maintained this advantage for the entire 12-week experimental period. During the post-experimental period, when the experimental cows were again returned to the all grain control mixture, they increased in milk

production and actually surpassed the controls. The average responses of the two groups of cows in milk production are shown in Table IV. The response of the control cows was +5.7 pounds of milk per cow per week while the experimental cows had a negative response of -16.0 pounds of milk per cow per week. This made the total difference in average response between the two groups of cows 21.7 pounds per cow per week. Statistical analysis of these individual responses showed a significant difference in milk production between the two groups of cows.

Table III shows that the group of cows fed the all grain control concentrate mixture averaged 0.02% higher in fat test for the experimental period than the group of cows fed the experimental mixture containing ground hay. This difference between the two groups was small and not significant. It may be seen in Figure 1 that the fat test of each group of cows varied from week to week with neither group testing consistently higher than the other during the experimental period. The control cows did have a higher percent fat during both the preliminary and post-experimental periods. This was responsible for the control cows having a 0.10 lower per cent fat response (Table IV) than the experimental cows, but this difference between the two groups was not significant.

The cows in the control group averaged 0.07 pound more fat per day than the cows in the experimental group as shown in Table III. Due to the fact that the control cows produced more milk, the difference in response of fat yield was 0.20 pound higher per cow per week

in favor of the controls (Table IV). However, this difference between the two groups in fat response was not sufficient to be significant.

The difference between the two groups of cows in production of 4% FCM was 2.0 pounds per cow per day in favor of the control cows (Table III). The pattern of production of 4% FCM as illustrated in Figure 1 was generally the same as for milk production, but week by week differences varied more because of the fluctuations in per cent fat. The difference in response was 15.3 pounds 4% FCM per cow per week in favor of the control cows but this difference between the two groups was not statistically significant.

Cows fed the experimental concentrate mixture containing ground hay often refused a portion of their feed. Some feed refusals by cows fed the all grain control concentrate mixture were also observed, but these were neither as frequent nor as large. As the cows of each group were fed the same pounds of concentrates, this difference between the two groups in refusal is reflected in the average daily concentrate consumption shown in Table III. Even though the control cows consumed more concentrates, the difference in consumption between the two groups in concentrate consumption was not sufficient to be statistically significant.

Some cows in both groups gained body weight while others lost body weight. On an average, the experimental cows gained 0.09 pound body weight per cow per day during the experimental period while the control cows lost 0.15 pound body weight per cow per day. This is shown in Table III. Even though on an average the experimental group

TABLE III

DAILY AVERAGES FOR PRODUCTION AND COMPOSITION OF MILK, CONCENTRATE CONSUMPTION AND BODY WEIGHT CHANGES FOR 7 PAIRS OF COWS FED EITHER OF TWO CONCENTRATE MIXTURES FOR 12 WEEKS DURING TRIAL I

Item	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)
Milk (lb)	56.4	54.3
Fat (%)	3.45	3.43
Fat (lb)	1.94	1.87
4% FCM (lb)	51.7	49.7
Concentrate consumption (lb)	16.6	15.9
Body weight change (lb)	- .15	+ .09

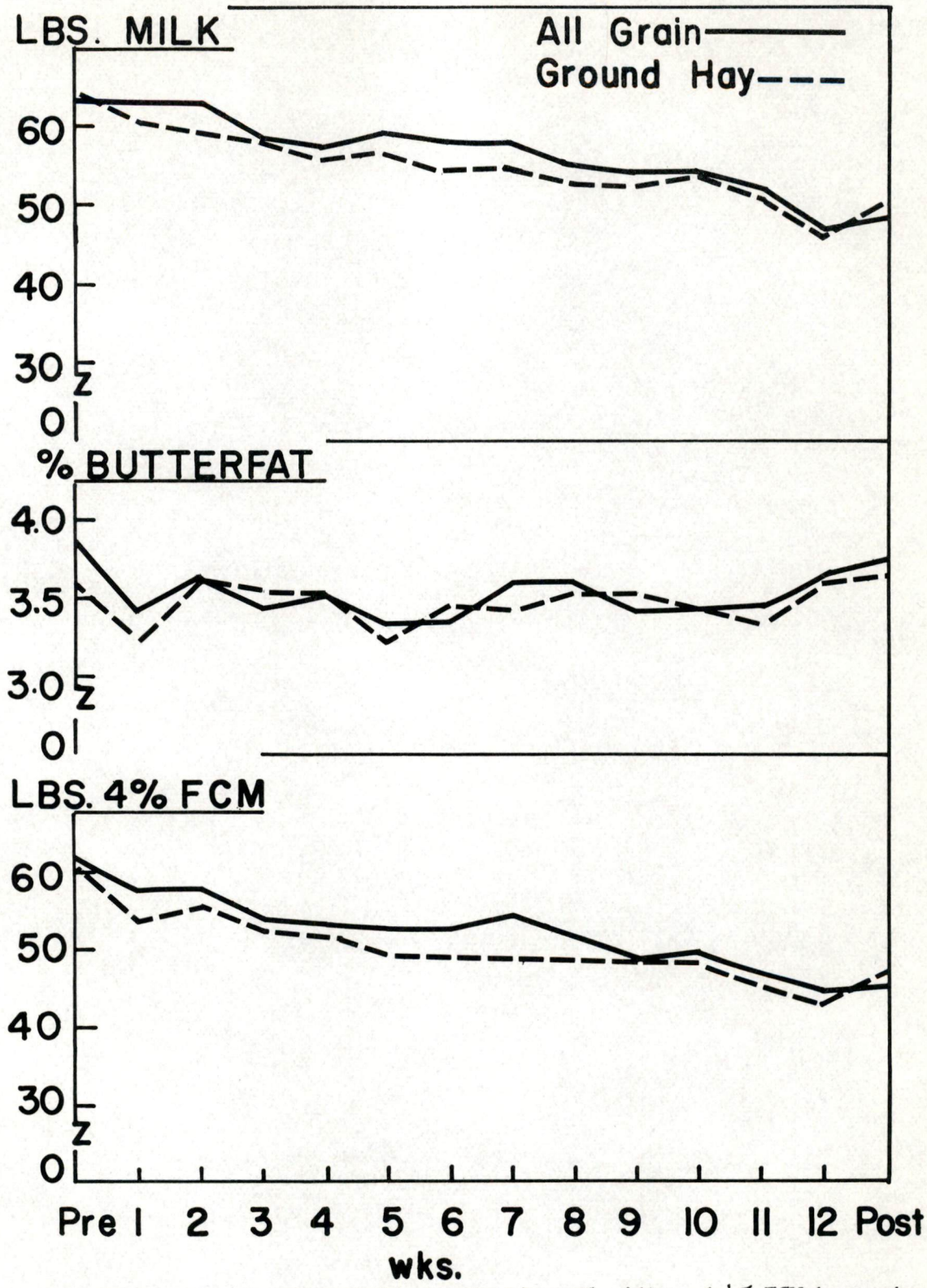


Figure 1. Average daily production of milk and 4% FCM by weeks and average weekly % butterfat for 7 pairs of cows fed either of two concentrate mixtures during Trial I.

TABLE IV

AVERAGE WEEKLY RESPONSES IN PRODUCTION AND COMPOSITION OF MILK FOR 7 PAIRS OF COWS FED EITHER OF TWO CONCENTRATE MIXTURES FOR 12 WEEKS DURING TRIAL I

Item	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)	Difference
Milk (lb)	+ 5.7	-16.0	+21.7*
Fat (%)	- .25	- .15	- .10
Fat (lb)	- .86	- 1.06	+ .20
4% FCM (lb)	-10.4	-25.7	+15.3

*Significant at 5% level of probability.

of cows gained weight and the control group lost weight, large variations in weight changes of cows within each group caused the difference between the two groups not to be significant.

Trial II

Average daily production and composition of milk, feed consumption and changes in body weight during the experimental period of Trial II are shown in Table V. The control cows again averaged higher in milk than the experimental cows. The difference between the two groups was only 1.2 pounds of milk per cow per day during Trial II, as compared to a difference of 2.1 pounds per cow per day during Trial I. The same trend in milk production was observed for each group during Trial II as had been noted in Trial I. This trend may be seen in Figure 2. The difference between the two groups of cows in milk production was not large during any of the experiment, but the control cows were consistently the higher producers during the experimental period. During the preliminary and post-experimental period the two groups were producing about equal. The response difference between the two groups of cows was again in favor of the control cows, but as shown in Table VI, it was only about one-half as large as during Trial I. Statistical treatment of the individual cow responses revealed that this difference between the groups in milk production was not significant.

The cows fed the experimental ground hay concentrate mixture had a 0.14% higher average fat test than the cows fed the all grain control concentrate mixture (Table V). Figure 2 shows that most of the

difference in fat test occurred during the first six weeks of the experimental period. The response may be seen in Table VI. Both groups of cows had a negative response in fat test with the difference being 0.17% more for cows fed the all grain concentrate mixture. Neither the difference between the two groups in fat per cent nor the difference in response in fat per cent were statistically significant.

Because of their higher fat test and only slightly lower milk production, the experimental cows produced more pounds of fat than the control cows. The difference between the two groups, as shown in Table V, was only 0.01 pound of fat per cow per day in favor of the experimental group. The control cows had a greater negative response in fat of -.25 pound per cow per week (Table VI), but this was not a statistically significant difference between the groups.

There was a difference between the two groups in 4% FCM production of only 0.3 pound per cow per day in favor of the control group. As shown in Figure 2, the cows fed the ground hay mixture had a higher level of 4% FCM during the first portion of the experimental period than the cows fed the all grain concentrate mixture. This was due to the higher fat test of the experimental cows during this portion of the trial. During the latter portion of the experimental period the production level of 4% FCM of the two groups was reversed. During the post-experimental period both groups produced at the same level. As presented in Table VI, the difference in response between the two groups of only 0.4 pound of 4% FCM per cow per week in favor of the controls are not significant.

The SNF per cent of the two groups, as may be seen in Table V, was 8.68 for the controls and 8.82 for the experimentals. Statistical analysis of the average tests revealed no significant difference between the groups in SNF. The per cent SNF of the experimentals was higher throughout most of the experimental period than for the controls. This is shown by weekly averages in Figure 2. The SNF per cent of each group closely paralleled the butterfat per cent of the same group during the first portion of the experimental period, but not during the latter portion. Table VI shows that there was only .02% difference between the two groups in SNF response in favor of the cows on the experimental ground hay mixture and this difference was not significant.

The control cows produced more pounds of SNF than the experimental cows. The difference between the two groups was small, only 0.06 pound per cow per day. The difference between the two groups of cows in SNF response was 0.9 pound per cow per week in favor of the controls as shown in Table VI. Analysis of the individual SNF responses revealed that this was not a significant difference between the two groups.

Again, as in the first trial, the cows fed the mixture containing ground hay refused more of their concentrate mixture than the control cows. This difference between the two groups in refusal is reflected in consumption of concentrates which is shown in Table V to be 10.2 pounds daily for the controls and 9.3 pounds for the experimentals. The difference between the two groups in consumption was not sufficient to be significant.

TABLE V

DAILY AVERAGES FOR PRODUCTION AND COMPOSITION OF MILK, FEED CONSUMPTION AND BODY WEIGHT CHANGES FOR 8 PAIRS OF COWS FED EITHER OF TWO CONCENTRATE MIXTURES FOR 12 WEEKS DURING TRIAL II

Item	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)
Milk (lb)	41.0	39.8
Fat (%)	3.58	3.72
Fat (lb)	1.47	1.48
4% FCM (lb)	38.4	38.1
SNF (%)	8.68	8.82
SNF (lb)	3.56	3.50
Concentrate consumption (lb)	10.2	9.3
Silage consumption (lb)	73.0	70.0
Hay consumption (lb)	10.8	11.1
Body weight change (lb)	+ .61	+ .37

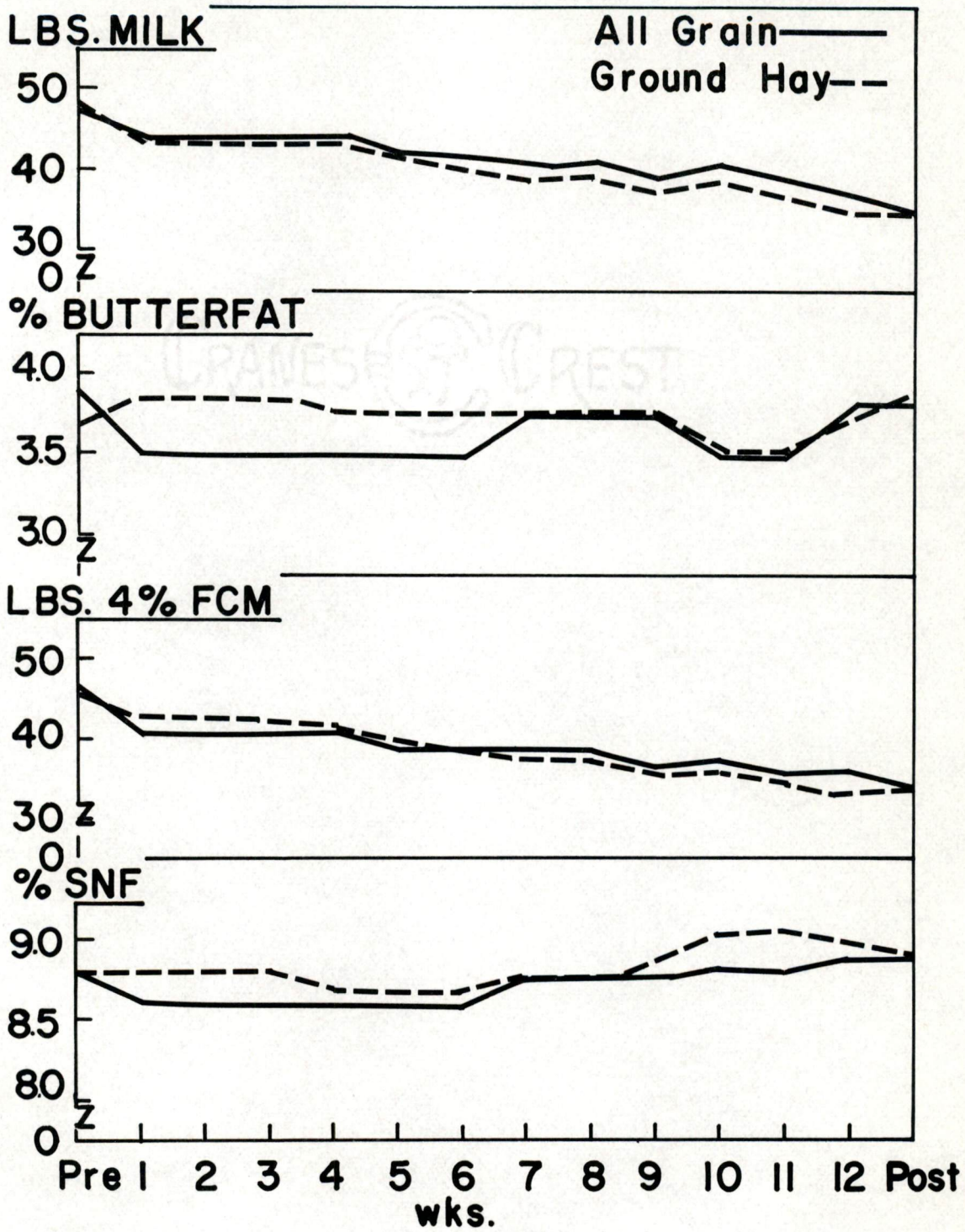


Figure 2. Average daily production of milk and 4% FCM by weeks and average weekly % butterfat and SNF for 8 pairs of cows fed either of two concentrate mixtures during Trial II.

TABLE VI

AVERAGE WEEKLY RESPONSES IN PRODUCTION AND COMPOSITION OF MILK FOR 8 PAIRS OF COWS FED EITHER OF TWO CONCENTRATE MIXTURES FOR 12 WEEKS DURING TRIAL II

Item	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)	Difference
Milk (lb)	+1.6	- 9.0	+10.6
Fat (%)	- .23	- .06	- .17
Fat (lb)	- .70	- .45	- .25
4% FCM (lb)	-9.6	-10.0	+ .4
SNF (%)	- .14	- .12	- .02
SNF (lb)	- .2	- 1.1	+ .9

The group of cows fed the ground hay concentrate mixture consumed slightly more long hay per cow per day than the cows fed the all grain concentrate. The difference, as may be seen in Table V, averaged only .3 pound per cow per day. Consumption of silage of the two groups is also shown in Table V. The control cows consumed 73 pounds of silage per cow per day compared to 70 pounds per cow per day for the experimental cows.

Each group of cows gained weight during Trial II. The cows on the control mixture gained .24 pound per cow per day more than the cows on the experimental mixture. Statistical analysis of the body weight changes revealed no significant difference between the two groups of cows.

Trial III

Daily averages of production and composition of milk, feed consumption and body weight changes are shown in Table VII. The cows fed the control mixture averaged 3.5 pounds more milk per cow per day than the cows fed the experimental mixture. As illustrated in Figure 3, there was a consistent difference between the two groups in milk production throughout the experimental period in favor of the control cows but during both the preliminary and post-experimental periods the experimental cows produced as well as the controls. The control cows had a response of 35 pounds of milk per cow per week more than the experimental cows, and as shown in Table VIII, this difference between the groups was highly significant.

The average difference in butterfat per cent was 0.11 in favor of the controls but this was not a significant difference between the two groups. Figure 3 shows that the per cent fat of the control cows was slightly higher throughout most of the complete experiment. The control cows showed less decrease in average response as shown in Table VIII. This difference between the two groups in response of only .04% fat was not significant.

The average yield of butterfat given in Table VII shows that the control group of cows produced .17 pound more fat per cow per day than the experimental group of cows. The response of fat yield was 1.10 pounds per cow per week (Table VIII) higher for the control group than for the experimental group. When the individual responses were treated statistically, the difference between the two groups was highly significant.

The difference in production of 4% FCM between the groups was very similar to the difference in production of milk. The group of cows fed the all grain concentrate mixture produced 4.1 pounds more 4% FCM per cow per day during the experimental period than the group fed the experimental mixture containing ground hay. Due to the slightly higher fat test of the control cows, this difference between the two groups in production of 4% FCM was even larger than the difference in actual milk production.

Daily production of 4% FCM by weekly periods is shown in Figure 3. The cows in the control group produced slightly more 4% FCM during the preliminary period than the cows of the experimental group. After the

experimental period started, the cows on the experimental mixture dropped in production and the difference between the two groups became much greater. During the post-experimental period both groups were equal in production of 4% FCM. The average response of the control cows was 26.8 pounds of 4% FCM per cow per week higher than the response of the experimental cows. Analysis of the responses in 4% FCM production revealed a highly significant difference between the two groups in favor of the control cows.

There was little difference between the two groups in average % SNF as may be seen in Table VII. The weekly average is shown in Figure 3. Both groups fluctuated some in % SNF but were very close throughout the entire trial. The difference in the % SNF response shown in Table VIII as only .01% in favor of the control cows was not significant. Likewise, the t test revealed no significant difference between the groups in average SNF tests.

The average yield of SNF was 3.85 pounds per cow per day for the controls and 3.53 for the experimental cows. Table VIII presents the average weekly responses of SNF production for each group. The difference between the two groups in response of 2.71 pounds per cow per week in favor of the control group of cows was found to be highly significant.

Both groups of cows were fed the same allowance of concentrates. With the exception of one cow in the control group that went off feed a few days, there were no refusals. The average daily consumption of the control mixture was 17.5 pounds and 17.6 pounds of the experimental mixture (Table VII). Again the difference between the two groups in concentrate consumption was not statistically significant.

TABLE VII

DAILY AVERAGES FOR PRODUCTION AND COMPOSITION OF MILK, FEED CONSUMPTION AND BODY WEIGHT CHANGES FOR 10 PAIRS OF COWS FED EITHER OF TWO CONCENTRATE MIXTURES FOR 12 WEEKS DURING TRIAL III

Item	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)
Milk (lb)	44.5	41.0
Fat (%)	3.51	3.40
Fat (lb)	1.56	1.39
4% FCM (lb)	41.4	37.3
SNF (%)	8.65	8.62
SNF (lb)	3.85	3.53
Concentrate consumption (lb)	17.5	17.6
Silage consumption (lb)	30	30
Hay consumption (lb)	10	10
Body weight change (lb)	+ .84	+1.02

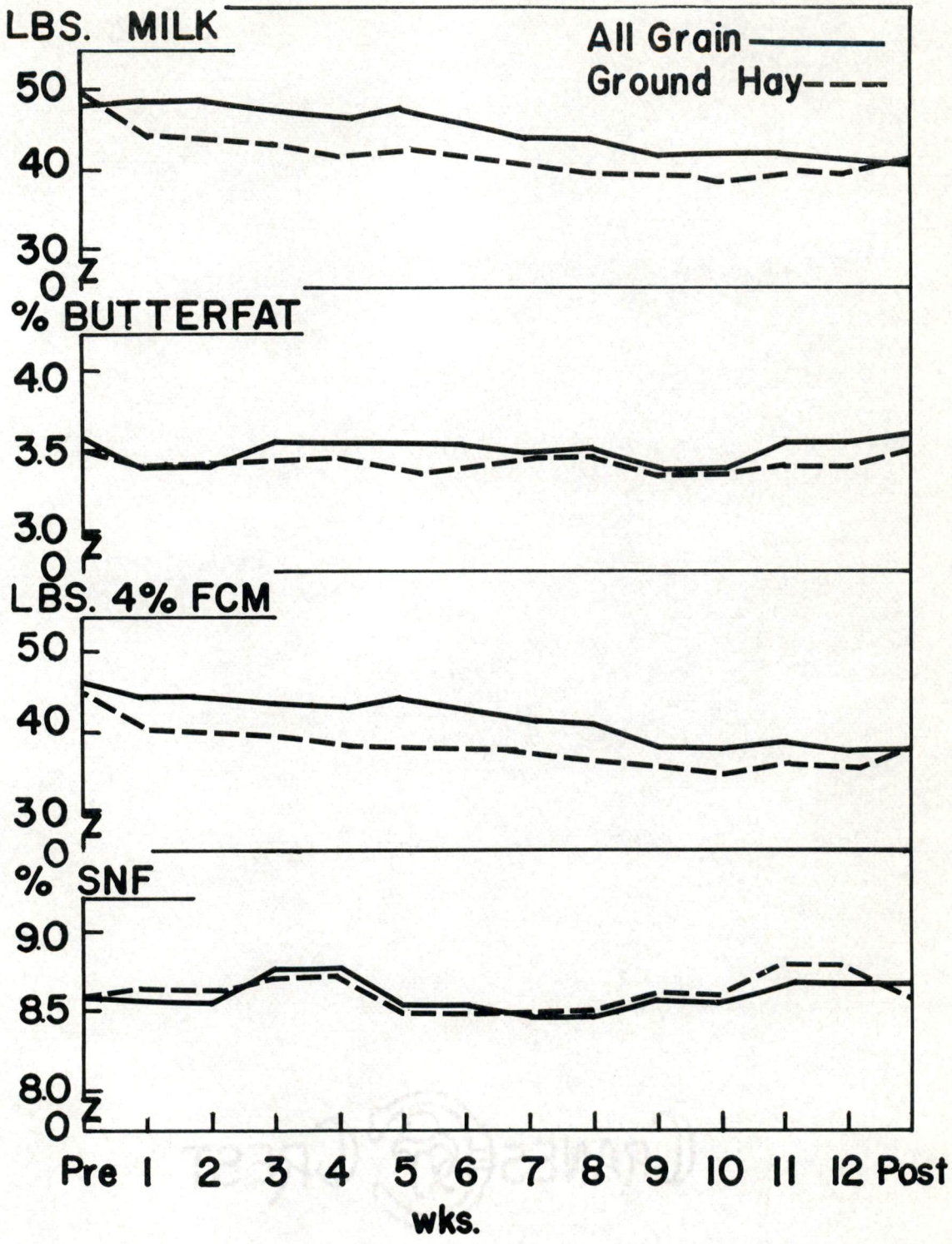


Figure 3. Average daily production of milk and 4% FCM by weeks and average weekly % butterfat and SNF for 10 pairs of cows fed either of two concentrate mixtures during Trial III.

TABLE VIII

AVERAGE WEEKLY RESPONSES IN PRODUCTION AND COMPOSITION OF MILK FOR 10 PAIRS OF COWS FED EITHER OF TWO CONCENTRATE MIXTURES FOR 12 WEEKS DURING TRIAL III

Item	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)	Difference
Milk (lb)	+3.5	-31.5	+35.0**
Fat (%)	- .10	- .14	+ .04
Fat (lb)	- .19	- 1.29	+ 1.10**
4% FCM (lb)	-1.9	-28.7	+26.8**
SNF (%)	- .03	- .04	+ .01
SNF (lb)	+ .17	- 2.54	+ 2.71**

**Significant at 1% level of probability.

Each group was fed and consumed 30 pounds corn silage and 10 pounds alfalfa-orchardgrass hay per cow per day.

There were rather large increases in body weights of the cows in both groups. As may be seen in Table VII, the experimental cows gained more weight than the controls but this difference in weight gains was not sufficient to be statistically significant.

All Trials Combined

After the data were summarized for each individual trial it was felt that much of the data could be combined to determine an average of all three trials. The combined average daily yield and composition of milk, concentrate consumption and body weight changes are shown in Table IX. The control cows averaged 2.4 pounds of milk per cow per day higher than the experimental cows. This difference is illustrated graphically by weeks in Figure 4. The difference in average response of milk production between the two groups of cows is shown in Table X. Analysis of the individual responses in milk production of all 25 pairs of cows revealed a highly significant difference between the two groups of cows in favor of the control group.

The average per cent fat is shown in Table IX to be within .01% for the two groups with the control group being the higher. This difference was not significant. A look at Figure 4 reveals how these fat percentages fluctuated from week to week for each group with neither group being consistently higher than the other. Each group showed a negative per cent fat response (Table X). The difference between the

two groups of cows was .06% in favor of the experimental group, but this difference was not statistically significant.

The control cows produced slightly more butterfat than the cows of the experimental group. This difference between the two groups was only .08 pound of fat per cow per day. Analysis of individual responses in butterfat production failed to show a significant difference between the groups in yield of butterfat even though the control group had a higher response of .42 pound per cow per week (Table X).

The average production of 4% FCM of the 25 control cows was 43.3 pounds per cow per day compared to 41.0 pounds per cow per day for the experimental cows. The pattern of production of 4% FCM for each group shown by weeks in Figure 4 closely follows that of the actual milk production of the two groups. The average response of the control group of cows was 15.1 pounds of 4% FCM per cow per week higher than the experimental group. Analysis of the individual responses revealed this difference between the groups in 4% FCM production to be highly significant.

Data for SNF were only collected from the 18 pairs of cows used during Trials II and III. It may be seen in Table IX that the cows on the all grain control concentrate mixture produced 0.20 pound more SNF daily per cow from milk having 0.04% less SNF content. This was due to the higher average milk production of the controls. Weekly average % SNF of each group presented in Figure 4 shows that the experimental cows tested higher throughout most of the latter two trials. The difference between the two groups in % SNF was not significant.

TABLE IX

COMBINED DAILY AVERAGES FOR PRODUCTION AND COMPOSITION OF MILK, CONCENTRATE CONSUMPTION AND BODY WEIGHT CHANGES FOR 25 PAIRS OF COWS FED EITHER OF TWO CONCENTRATE MIXTURES FOR 12 WEEKS DURING TRIALS I, II AND III

Item	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)
Milk (lb)	46.7	44.3
Fat (%)	3.51	3.50
Fat (lb)	1.64	1.56
4% FCM (lb)	43.3	41.0
SNF (%)[a]	8.66	8.70
SNF (lb)[a]	3.72	3.52
Concentrate consumption (lb)	14.9	14.5
Body weight change (lb)	+ .49	+ .56

[a]Average of only the 18 pairs of cows used during Trial II and Trial III.

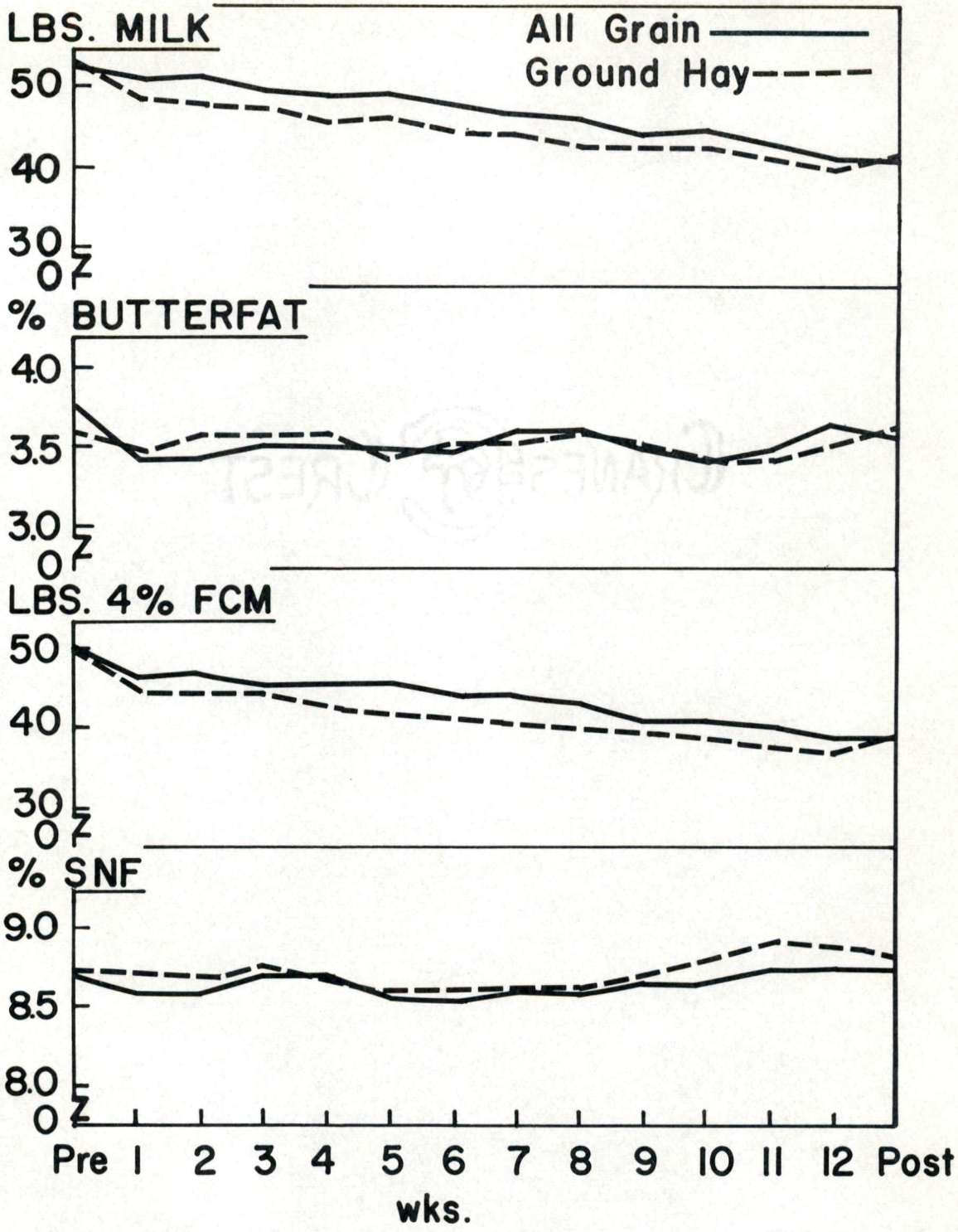


Figure 4. Average daily production of milk and 4% FCM by weeks and average weekly % butterfat and SNF for 25 pairs of cows fed either of two concentrate mixtures during the combined trials.

TABLE X

COMBINED AVERAGE WEEKLY RESPONSES IN PRODUCTION AND COMPOSITION OF MILK FOR 25 PAIRS OF COWS FED EITHER OF TWO CONCENTRATE MIXTURES FOR 12 WEEKS DURING TRIALS I, II AND III

Item	Control Mixture (All Grain)	Experimental Mixture (Ground Hay)	Difference
Milk (lb)	+3.5	-20.0	+23.5**
Fat (%)	- .18	- .12	- .06
Fat (lb)	- .54	- .96	+ .42
4% FCM (lb)	-6.8	-21.9	+15.1**
SNF (%)[a]	- .08	- .07	- .01
SNF (lb)[a]	+ .01	- 1.89	+ 1.90**

**Significant at 1% level of probability.

[a]Average of only the 18 pairs of cows used during Trial II and Trial III.

Likewise, the average response difference between the groups of only .01% in favor of the experimental cows was not significant. However, the response difference between the two groups of 1.90 pounds of SNF per cow per week in favor of the controls was found to be highly significant.

Comparing the concentrate consumption data shown in Table IX will show that on an average of the three trials the control cows consumed .4 pounds per cow per day more than the experimental cows. There was no significant difference in concentrate consumption between the two groups within either trial and as expected, analysis of the three trials combined showed no difference.

The data in Table IX show that the cows fed the ground hay mixture gained 0.07 pound more per cow per day than the cows fed the all grain concentrate mixture. Statistical treatment of the individual body weight changes failed to show this difference between the two groups to be significant.

Chemical analyses of composited samples of the two concentrate mixtures fed and the hay used for grinding during Trials II and III are shown in Appendix B. Also shown there are chemical analyses of composited samples of the roughages fed during Trial III.

CHAPTER V

DISCUSSION

There were no major sicknesses encountered during Trial I and Trial II. During Trial III one cow in the control group and two cows in the experimental group had abnormal short-time decreases in milk production due to acute mastitis attacks. As these cows returned to normal before the end of the experiment, production results were interpolated for this period of low production. One cow in the control group of Trial III refused concentrate for a few days due to stomach compaction but no interpolation of the milk yield was made in this instance because, even though a decrease did occur, this could have been due to the refusal of a portion of the concentrates.

The preliminary period of Trial I was for one week only and the post-experimental period was for two weeks. It would have been desirable to have the two periods of the same length. Due to the small number of cows at the desired stage of lactation and gestation, one pair of cows was included in the trial that had not reached the peak production of their lactation. In order to have the experimental period last for 12 weeks and still not have cows beyond the sixth month of gestation at the end of the post-experimental period, only one week was used for the preliminary period. The one week was eliminated from the preliminary period rather than the post-experimental period because it was felt that more than one week was needed for the cows to return to normal after having been fed a different concentrate mixture. All cows used in

both groups were handled under the same conditions before the preliminary period began.

One of the cows in the experimental group in Trial I was later found to have conceived to an earlier service than was thought and was actually in the seventh month of gestation when the trial ended. As her average milk production decline and response were not different from other cows of her group, it was decided to include her data in the trial. However, she did gain more body weight than any other cow in her group, which is partially, but not completely, responsible for the difference between the two groups of Trial I in body weight gains.

Greater numbers of cows in the desired stage of lactation and gestation were available for Trials II and III than had been for Trial I. Preliminary and post-experimental periods were each of three weeks during Trial II and of two weeks each during Trial III. Two pairs of first lactation cows were used in Trial III which had not quite reached the peak production of their lactation at the beginning of the preliminary period. These two pairs were balanced in stage of lactation, however; and they responded similarly to other cows of their respective groups.

Milk production was lower in each trial for cows fed a concentrate mixture containing ground hay than for cows fed an equal amount of an all grain concentrate mixture. This agrees with work of other investigators (7, 11, 25). The same general trend in differences between the two groups of cows in milk production was noted in all three trials. The difference was less during Trial II, even though the

experimental mixture of Trial II contained only 80% as much estimated TDN (60.6% compared to 75.5%) as the control mixture, while in Trial I the experimental mixture contained 88% as much estimated TDN (65% compared to 74%) as the control mixture. High-quality corn silage and alfalfa-orchardgrass hay had been fed ad lib. to each group of cows during Trial II. Looking at the consumption data revealed that cows in each group consumed excess nutrients above their requirements for body maintenance and milk production. Therefore, any difference in TDN intake from concentrate mixtures may have been partially masked by adequate intake of high-quality alfalfa-orchardgrass hay and corn silage.

Trial III was then designed to limit total feed intake to equal the nutrient requirements for body maintenance and production, based on estimated TDN content of the roughage and control concentrate mixture. High-quality roughages were fed in Trial III as in Trial II but in limited amounts in an attempt to simulate conditions where roughage intake is limited due to poor quality. Greater differences in milk production and in responses of milk production were found during this third trial than had been found in either of the first two trials. Thus, the difference in TDN content of the two mixtures was shown.

There were no significant differences between the two groups of cows in either per cent fat or solids-not-fat. Although Powell (19) and others (1, 18, 21, 22) reported significant decreases in fat test when ground hay was fed, this was only true when all of the roughage fed was ground hay. This was not the case in these trials as cows had free access to roughage (Trials I and II) or were fed at least 10 pounds of long hay and 30 pounds of silage per cow per day (Trial III).

During Trial I the control cows had a significantly higher response in milk production than the experimental group, but no significant difference between the two groups was found in response in 4% FCM production. This was because the control cows had a higher negative response in per cent butterfat even though they had a slightly higher average per cent butterfat than the experimental group during the 12-week experimental period.

During Trial II there was no significant difference between the two groups of cows in any item analyzed. The control cows produced more milk but had a lower butterfat test and yield than the experimental cows. The reason for this lowered fat test of the control cows is not clear. It was noted that during the preliminary period some of the cows in the control group had higher than normal fat tests which could partially account for their larger negative response in fat test than the experimental group.

The average milk production level of the cows used during Trial I was higher than for Trial II or III. The cows used during Trial I were producing at a much higher level of milk at the start of the experiment than the cows of Trial II and III, and even though they declined more rapidly in production they still averaged higher for the experiment. This higher production during the summer could partially be attributed to the earlier stage of lactation of some of the cows used and partially to the very good quality and quantity of pasture available during the early portion of the experiment. The greater decline could partially be attributed to the effect of drier weather on pasture during the latter portion of the trial.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Three feeding trials were conducted comparing two concentrate mixtures for dairy cows. One of the mixtures used as the control during each trial was an all grain concentrate mixture which was compared with a concentrate mixture containing a certain amount of poor quality ground hay. In Trial I, seven pairs of cows were used and 25% of the TDN in the control mixture was replaced with poor quality ground hay. In Trial II with 8 pairs of cows and Trial III with 10 pairs of cows, 50% of the dry matter of the control mixture was replaced with poor quality ground hay. Both mixtures were fed on an equal weight basis.

Milk production of the cows fed the ground hay concentrate mixture was lower in every trial than for paired mates fed the same amount of the all grain control concentrate mixture. The milk production of cows fed the experimental ground hay concentrate mixture was lowered less during Trial II when high-quality corn silage and alfalfa-orchardgrass hay were fed ad lib. to both groups. When roughage intake was limited during Trial III, the difference in milk production between the two groups of cows was much greater. The difference in production between the two groups during Trial I, when cows were allowed free access to pasture and hay, was less than when the roughage intake was limited during Trial III.

Responses of individual cows were measured by comparing the performance of each cow during the 12-week experimental period with

her performance during the preliminary and post-experimental periods. The control cows had significantly higher responses in milk production than the experimental cows during Trials I and III but the difference between the two groups was not significant during Trial II.

The average milk production for all trials combined was 46.7 pounds per cow per day for the control cows compared to 44.3 pounds per cow per day for the experimental cows. The milk production responses were significantly higher for the 25 cows fed the control mixture than for the 25 cows fed the experimental mixture. Likewise, the difference in responses in 4% FCM production between the two groups was significant.

There were no significant differences between the two groups of cows in per cent of butterfat or SNF. The average fat test for the control cows was 3.51% and 3.50% for the experimental cows. The average % SNF was 8.66 for the control cows and 8.70 for the experimental cows.

Consumption of the concentrate mixture containing the ground hay was less than for the all grain concentrate mixture, especially when the cows were allowed free access to good quality roughage. However, this difference between the two groups in concentrate consumption was not significant. There was no appreciable difference between the two groups in consumption of roughages fed ad lib. during Trial II or when fed in limited amounts during Trial III.

There was no significant difference between the two groups of cows in body weight changes. Even though milk production was less, the average body weight gains for cows on the ground hay concentrate mixture were greater than for the cows on the all grain concentrate mixture.

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APPENDICES

APPENDIX A

CALCULATION OF AVERAGE WEEKLY MILK PRODUCTION RESPONSES OF 7 PAIRS OF COWS FED EITHER OF TWO CONCENTRATE MIXTURES FOR 12 WEEKS DURING TRIAL I

Control						Experimental					
Cow No.	Pre. Period (X_1)	Exptl. Period (Y)	Post Period (X_2)	Av. of Pre.+Post $\frac{1}{2}(X_1+X_2)$	Weekly Response $Y-\frac{1}{2}(X_1+X_2)$	Cow No.	Pre. Period (X_1)	Exptl. Period (Y)	Post Period (X_2)	Av. of Pre.+Post $\frac{1}{2}(X_1+X_2)$	Weekly Response $Y-\frac{1}{2}(X_1+X_2)$
100	356	319	282	319	0	15	386	320	288	337	-17
48	508	400	322	415	-15	112	452	358	331	392	-34
91	394	335	269	332	+ 3	107	360	282	216	288	- 6
109	575	554	445	510	+44	110	585	551	510	548	+ 3
135	456	413	356	406	+ 7	152	563	458	395	479	-21
162	465	420	360	412	+ 8	171	451	378	353	402	-24
173	360	323	300	330	- 7	165	343	315	314	328	-13

APPENDIX B

AVERAGE CHEMICAL ANALYSES OF COMPOSITED FEED SAMPLES

Feed stuff	Crude Protein	Ash	Dry Matter	Ether Extract	Crude Fiber	Nitrogen-free Extract
	%					
Trial II						
Control mixture	18.1	8.20	89.0	2.77	4.8	55.13
Ground hay mix	16.9	9.01	90.1	1.71	18.7	43.78
Hay (ground)	6.2	5.95	90.6	1.37	37.5	39.58
Trial III						
Control mixture	18.0	5.63	90.8	2.47	5.4	59.30
Ground hay mix	16.8	7.21	90.9	1.50	18.8	46.59
Hay (ground)	6.6	7.18	92.5	1.49	33.9	43.33
Hay (long)	15.6	8.20	90.9	2.01	30.3	34.79
Silage (air dry basis)	8.2	4.44	92.1	2.17	25.2	52.09