THE USE OF ALFALFA SILAGE IN
DAIRY CATTLE RATIONS

by

BALLARD KELLER BENNETT

B. S., Oklahoma Agricultural
and Mechanical College, 1938

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Dairy Husbandry

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1949

TABLE OF CONTENTS

INTRODUCTION

Silage has an important place in dairy cattle feeding. The high tonnage yield per acre of silage crops, low cost of harvesting, and quality of feed produced make it a valuable means of storing such crops as corn, sorghums and more recently hay crops. Much interest has been aroused in the use of alfalfa as a silage crop. In Kansas, a protein deficient area, apparently there is an increased interest in hay crop silage. Using hay crops for silage is not a new idea, but the need for producing more protein during World War II is probably one of the reasons for renewed interest in hay crop silage.

With the possibilities of saving a hay crop under unfavorable weather conditions by ensiling it, many farmers and research workers have experimented with various ensiling methods of preserving hay crops. Favorable and unfavorable results have been obtained. Much has been learned about methods best suited for producing hay crop silage and it now appears that a satisfactory product can be produced when alfalfa is used.

Research investigators report different results in feeding trials when alfalfa silage has been fed (6, 7, 8, 12, 20, 25, 33, 34, 35, 40, 43). It was the purpose of this study to determine if satisfactory milk production could be maintained on a ration of alfalfa silage, prairie hay, and farm grain; and to determine the amount of protein concentrates that could be saved by the inclusion of alfalfa silage in an otherwise low protein ration. Research workers generally are in agreement in the belief that including hay crop silage in the dairy cow's ration should save protein, since alfalfa silage is a high protein succulent (6, 13, 14, 23). Theoretically, it is possible to meet the nutrient requirement of dairy cows on the suggested ration; however, no experimental work has been found to support this theory.

Williams (48) of Indiana has reported one farmer who fed a farm grain mixture, alfalfa silage and alfalfa hay and secured high milk production.

REVIEW OF LITERATURE

Literature dealing with hay crop silage is rather extensive. This review shall be limited largely to literature dealing with alfalfa silage or other pertinent to this investigation. Most authors of technical papers are in agreement that much more skill in control methods is necessary to produce a good quality alfalfa silage than to produce high quality corn or sorghum silage. Huffman (26) refers to a Vermont farmer, who in 1887 made the first legume silage. In 1896, Headden compared alfalfa, red clover, and pea vine silage on a chemical basis. He stated that seldom would it be advantageous for a farmer to make a hay crop into silage, but that such silage would compare favorably with a good quality hay.

The work of Reed and Fitch (36) of the Kansas station in 1917 was among the early investigations of alfalfa silage. They recommended feeding of such silages within four months after being ensiled. They also recommended that when possible to make a high quality hay the crop should not be put in the silo. Their work indicated that the addition of some form of carbohydrate material such as corn meal, molasses, sweet sorghum, stover or green rye to alfalfa when put in the silo, resulted in better preservation and for a longer period of time than when alfalfa was ensiled alone. Bohstedt, Peterson, and Bahler (15) at the Wisconsin station reported that ground corn was used with fair success in preserving legume silage. According to these investigators, a larger proportion of the starch of the corn grain apparently was converted to preservative acid than had previously been thought possible. One outstanding result of using such a preservative was the improved palatability of the alfalfa silage as compared with alfalfa silage made with several other methods. They also suggested that when either shelled or ear corn was used that they shall be ground rather finely. A survey conducted in 1935 by the Pennsylvania station (7) revealed that 100 farmers within the state stored grasses, legumes or some kind of crop other than corn in the silo. A similar survey five years later showed that this practice had been carried out by two to three thousand farmers (7).

Advantages of Hay Crop Silages

The making of hay crop silages has many advantages. It is commonly known that in Kansas, where heavy rains often occur in the spring during the first hay harvesting, much hay is seriously damaged or ruined. Delwiche et al. (19) reported that in Wisconsin plans were followed whereby hay was made out of the cleanest crop of alfalfa, and the weedy crop that contained timothy and quack grass was made into silage. This silage was put up without a preservative and proved to be satisfactory feed, whereas it would have made poor quality hay. Many authorities (8, 13, 23, 35, 38) agree that ensiling hay crops is particularly advantageous for harvesting first cutting hay crops that might otherwise be lost and that good legume silage provides home grown protein for economical feeding. Other advantages which they listed in comparison with hay making are the use of crops costing less to produce, preservation of more nutrients in weedy crops, more extensive use of the silo, more even distribution of labor, easier control of insects and soil erosion, destruction of viability of weed seeds, and the removal of fire hazard. Bohstedt et al. (13) stated that hay crop silage has more protein than corn silage in that an early cut hay crop of any kind is relatively high in protein and that it usually contains more or less legume forage. In the northeastern part of the United States perennial legumes and mixtures of legumes and timothy can be produced more cheaply than corn under normal conditions. Dairymen in that area have always had to purchase protein supplement to increase the protein content of their home grown grain whereas the use of hay crop silage will eliminate much of the need for purchased high protein feeds (8).

Limitation of Hay Crop Silages

In spite of the advantages of using hay crop silage in the dairy cow's ration, such silage has its limitations. Archibald and Parsons (4) state that although the making of grass silage has become the accepted alternative method of storing forage, it should be considered as a supplement to rather than as a substitute for ordinary hay making. Nevens et al. (35) also state that the making of hay crop silage is much more complicated than ordinary silage.

Legume silage is not as palatable as corn silage; however, cows will learn to eat it (7, 14). Bender (8) concluded that hay crop silage may be used to replace all of the corn silage in the dairy cow's ration or all of the corn silage and part of the hay, however the hay should not be reduced below a minimum of six pounds daily.

Duffee et al. (20) state that the high initial cost of necessary equipment needed to harvest economically hay crop silage and the high cost as well as scarcity of farm labor has proved to be a limiting factor to smaller farms. They listed the minimum equipment needed to harvest hay crop silage to be: a forage harvester, one tractor, a blower equipped with a motor and 3 wagon type conveyances, either trucks, wagons or trailers equipped with a box type bed. They also predicted that the day is coming when many farmers will put up hay crop silage on a custom basis due to the initial cost of the minimum equipment needed to harvest hay crop silage. In a study of harvesting costs they reported that a forage harvester saves labor and costs in putting up hay crop silage. The equipment used handled 5.7 tons of hay crop silage per hour at a cost of $0.317 when used only 60 hours per week. Duffee et al. (20) also cited labor requirements in Ohio for this modern method to be 1.053 man hours per ton as compared with 2.3 man hours per ton when less modern methods were used.

Conservation of Nutrients

The conservation of nutrients in hay crop silages has been studied by Newlander et al. (33), who employed 10 pound cheese cloth bags which were filled with variously treated silages and buried in their respective silos in an effort to determine nutrient conservation in silages prepared by the following methods:

Alfalfa cut one-fourth bloom

A Silage ensiled promptly after cutting, not sun wilted

(1) Molasses added, none

(2) Molasses added, three percent

B Silage, sun wilted two hours

(1) Molasses added, none

(2) Molasses added, three percent

Chemical analyses were made of the feed material before and after ensiling and the nutrients were calculated. In this investigation, the alfalfa silage in which all nutrients were best preserved was made from alfalfa to which three percent of molasses had been added. The sun wilted silage to which 3 percent of molasses had been added outranked its competitors, having 7 pounds of digestible crude protein and 44 pounds of total digestible nutrients recovered per 100 pounds of dry matter. The unwilted, no molasses lot of silage ranked last of these silages with a recovery of 5.4 pounds digestible crude protein and 35.6 pounds of total digestible nutrients per 100 pounds dry matter of the fresh green material which was ensiled. The sun wilted, 3 percent molasses silage contained 41.5 percent dry matter when ensiled and showed a loss of 19.03 percent dry matter during the ensiling process. Dry matter of the unwilted lots when ensiled were less than 30 percent and produced a foul-smelling silage. Camburn, et al. (17), in a series of trials on conservation of nutrients in alfalfa silage treated by various methods, showed that alfalfa to which 10 percent molasses were added resulted in the greatest recovery of nutrients. The digestible nutrients recovered in edible portions per 100 pounds dry matter ensiled by various methods are shown below:

Alfalfa	Dry matter When ensiled	Actual recovery D. C. P.	T. D. N.
Silage-molasses added, none	29.74	8.3	44.3
Molasses added, 2%	38.06	7.1	40.9
Molasses added, 4%	33.54	7.3	42.2
Molasses added, 10%	34.77	7.7	48.8
Phosphoric acid added, 1%	27.83	7.9	47.6
A.I.V. solution, 11%	41.50	6.4	37.3

The alfalfa silage to which 10 percent molasses had been added was followed by the alfalfa silage without molasses with a recovery of 44.3 pounds of total digestible nutrients, indicating green forage can be ensiled successfully without a preservative being added. Hayden et al. (21) treated 14 lots of meadow crops, mostly alfalfa, with 40 to 100 pounds of molasses per ton. These lots were compared with each other and with lots prepared by the wilting method. When all factors were considered, the molasses treated silage appeared to be slightly better than the wilted lots, as judged on the basis of taste, odor, and appearance. There was no decided increase in palatability or milk production as shown by tests with dairy cows. The average acidity of molasses treated silages was somewhat higher than the wilted lots. In no case where the crop was largely legume, was the acidity greater than pH 4.0. In the opinion of these investigators, increases in volume of molasses greater than 40 pounds per ton seemed to have no particular benefit upon the quality of silage in these trials. They also concluded that dry matter was probably the most important single factor governing the quality of meadow crop silage in their study.

Fermentation Studies

In an attempt to determine differences in fermentation, McAuliffe, Stone and Bechdel (29) prepared alfalfa silage under exactly comparable conditions with various concentrations and mixture of molasses and phosphoric acid. These silages were studied with respect to bacterial organisms present and chemical changes produced. Serial samples were taken from these silages by drilling holes through the silo walls at different levels and removing the silage with a soil auger. Irrespective of the large number of lactobacilli present, the amount of lactic acid was small. Serial analysis of the silage samples showed the first stage of fermentation to be normal with an increase of lactic acid to a relative high level and a corresponding drop in pH and fermentable sugar. When the reducing sugars decreased to approximately one percent by dry weight, a second stage of fermentation brought about a lowering in the lactic acid and an increase in the pH. The fate of the lactic acid was suggested by the continued increase in volatile acid; however, there was no apparent change in the bacterial flora during the second period of fermentation.

Swanson (46) in early chemical studies involving alfalfa silage, stated that most of the acids present in alfalfa silage were produced during the first two weeks of the ensiling process, and that wilted alfalfa silage was more suitable for making silage than was unwilted.

Stone, et al. (43) prepared a number of alfalfa silages which were ensiled in nine small silos in an effort to determine the effect of wilting, addition of dry hay, corn stover, ground corn and salt as preservatives. During the first week following ensiling, all silages were subjected to the development of lactic acid bacteria, regardless of treatment used. All silages developed an initial concentration of at least 1.5 percent lactic acid. In the control silage with no treatment, this condition soon gave way to the formation of acetic acid and was accompanied by a rise in pH and a decrease in quality. In the silage in which moisture had been lowered by the addition of dry hay and corn stover, the rate of spoilage was retarded but nevertheless a high quality silage was not produced. The addition of 15 pounds of salt per ton did not maintain the lactic acid. The silage to which 200 pounds of ground corn and cob meal per ton were added produced a silage equal in quality to that produced by the addition of 80 pounds of molasses to the ton. Alfalfa which had been wilted two to three hours produced a good quality silage. All silages of good quality continued to develop lactic acid until at least 2 percent or more was present. Apparently an adequate supply of fermentable carbohydrate is a prime requisite for making good quality alfalfa silage. Archibald and Parsons (4) state that the use of lactic acid cultures and common salt failed to produce desirable results in preserving hay crop silages. Other authorities also are in agreement (4, 43).

Becker et al. (6) prepared silages from Napier grass and pigeon pea forage in which citrus molasses was used as a preservative.

Influence of Moisture and Acidity on Palatability and Fermentation Losses

Moisture control apparently is an important factor in the making of high quality hay crop silage. Woodward and Shepherd (49) are of the opinion that about 68 percent moisture in legumes is the dividing line in respect to producing satisfactory silage. A reduction in moisture content of high moisture crops should be made either by wilting or adding a dry material such as hay before ensiling, or the acidity increased by the addition of acid or some acid forming material. The addition of acid improves the odor of high moisture legume silage and palatability of all hay crop silages. Reducing moisture content of crops has no material effect on the acidity of silage. The crop to be ensiled should be wilted only enough to prevent leakage which will insure a good odor and better preservation of carotene.

Wilted Silage

Under certain well controlled conditions, grass silage can be made without preservatives (11, 33, 35, 38, 41, 43). The formation of lactic acid is one of the most important factors in the production of good silage from crops of various kinds. Since the formation of lactic acid is from sugars or carbohydrates in the plant by lactobacilli organisms, it is necessary to add carbohydrate in the form of molasses or some other carbohydrate material to legume crops, because these crops lack sufficient natural carbohydrate necessary for lactic acid formation (41). Satisfactory legume silage may be made by wilting the crop long enough to bring the dry matter content to 30-40 percent. One reason wilting the forage improves the silage is that it increases the amount of sugar in each pound of forage due to the removal of part of the water (44). Control conditions such as wilting the crop to approximately 65 percent moisture, limiting the filling of the silo to two, not more than 3 days, thoroughly tramping the upper third of the silo and putting 4 to 6 feet of heavy unwilted silage on top of the wilted silage are to be considered the most important phases in making wilted silage (11, 38). The percentage losses of nutrients from top spoilage will vary with the size of silo and precaution taken in sealing the silo (31). They report that a loss of 3 to 6 percent of the total dry matter of ensiled material has been estimated. The percentage losses of nutrients through seepage varied also with the size of the silo and moisture content of the material ensiled. Archibald and Gunness (3) studied seepage losses from a 100 ton silo and concluded that these losses in silage are not so serious as the losses from other causes and that proper management can reduce such losses to an insignificant amount. They found that the dry matter losses from this cause are less than one percent when the original forage contained 70 percent or less moisture and that fermentation losses in dry matter normally varied between 5 and 10 percent. Monroe et al. (31) found that carotene is generally well preserved in the ensiling process. The type of treatment was also shown to have an effect on carotene preservation. In general, treatment with mineral acids shows high retention of carotene and no treatment or wilting shows lowest retention of carotene (31).

Correlation Between Acidity and Quality of Silage

The importance of acidity in silage in relation to high quality has been studied by several workers (12, 30, 42). There appears to be a definite correlation between acidity of silage and its quality, regardless of the crop from which it is made (42). Best silage is obtained when the acidity is at a pH of 4.0 or lower (12, 30, 42).

Importance of Quality in Crop to be Ensiled

Quality of silage is largely determined by the quality of the crop to be ensiled. Bohstedt et al. (13) have reported that palatability and nutritive value of grass silage depend largely on the quality and palatability of the crop ensiled: and that some hays are more palatable than others, and so are silage crops. Legumes, or grass and legume mixture usually make a more nutritious silage than grasses alone (40). Weedy crops of legumes or grasses will make a more satisfactory silage crop than hay (19, 35).

Feeding Value of Alfalfa Silage

In an effort to compare the feeding value of wilted alfalfa silage, Shepherd et al. (39) conducted four feeding trials in which such silage was compared with alfalfa hay as the sole roughage. Some grain concentrates were fed with the wilted alfalfa silage and with the alfalfa hay to dairy cows. The silage was of good quality. The hay used was purchased and graded U. S. number 2 leafy. The cows on the silage maintained their live weight better and were more consistent in maintaining the body weight than those on alfalfa hay. In each of the four experiments the decline in average milk production was less rapid when the cows were getting wilted alfalfa silage than when they were getting alfalfa hay. In the last two experiments, milk production was 7.2 percent and 3.1 percent higher respectively when the cows received wilted alfalfa silage than when alfalfa hay was fed. It was concluded that such silage was as palatable as the best quality hay used since the cows ate as much or more alfalfa dry matter in the form of silage as in the form of hay. Rupel et al. (37) found that cows fed wilted alfalfa silage lost body weight rapidly and when the two groups of cows which were on the feeding trial were reversed the cows getting wilted alfalfa silage dropped off more rapidly in milk production and lost an average of 33 pounds of body weight each while the cows on alfalfa silage preserved with corn and cob meal gained 11 pounds each.

Molasses and Phosphoric Acid Alfalfa Silage for Dairy Cows

A comparison of molasses and phosphoric acid-alfalfa silage was made by King et al. (28). These silages were fed to two groups of three dairy cows each on a continuous feeding trial.

Limestone sufficient to neutralize one hydrogen of the phosphoric acid was fed for a period of 28 days to the group receiving acid silage alone. Digestion trials and balance studies of nitrogen, calcium and phosphorus were run throughout the trial at various times. A significant difference was found in the nitrogen balance of all cows depending on the method of analysis. The daily nitrogen balance changed as much as 20 grams when analysis was made on a wet basis as compared with analysis made on dry basis. All of the calcium and phosphorus values were negative with the acid silage even when limestone was fed. A comparison of digestion results for the silages when fed alone or when fed with hay and grain showed only small differences between the two methods (7, 28).

A. I. V. Alfalfa Silage Compared With Molasses Alfalfa Silage

It is interesting to note that Hegsted et al. (24) prepared alfalfa silages by both the A. I. V. process and molasses method. These silages were compared during three years. Such comparisons were made on chemical analysis of the product and quantity and quality of milk produced. Chemical studies showed no material difference although the protein and carotene were better preserved with the A. I. V. process. When dry matter content of the alfalfa ranged between 20-25 percent satisfactory preservation resulted. There was no impressive difference in either silages when compared for milk producing ability. However, under general farm conditions, the molasses method was considered to be the most satisfactory method of making silage.

Waugh et al. (47) carried on two feeding trials in which alfalfa brome grass silage was compared with corn silage and concluded that, when alfalfa and brome grass were treated with 80 pounds of molasses per ton, it was equal to or nearly equal to corn silage in maintaining milk production. They also indicated that the alfalfa-brome grass silage was superior to corn silage in preserving carotene.

EXPERIMENTAL PROCEDURE

Eighteen cows were divided into two groups of nine each on the basis of age, stage of lactation and milk yield. A double reversal system was used for the purpose of determining if satisfactory milk production could be maintained and how much protein could be saved. Two different combinations of feeds were used:

Ration A - Prairie hay, sorgo silage and 24 percent protein dairy concentrate.

Ration B - Prairie hay, alfalfa silage and a farm grain mixture.

The grain mixtures were as follows:

Ration A - 24 percent protein concentrate

100 pounds ground corn
100 pounds wheat bran
100 pounds soybean meal
3 pounds salt
3 pounds bonemeal

Ration B - Farm grain mixture

400 pounds ground corn
200 pounds ground oats
6 pounds salt
6 pounds bonemeal

The chemical composition of all feeds is given in Table 3 of the Appendix.

This experiment was divided into three periods of time. Each consisted of a 10 day conditioning period followed by a 21 day test period. The cows in group I began their first period on ration B, were changed to ration A during the third period. Group II began the first period on ration A, was switched to ration B for the second period and returned to ration A for the third period. This is shown graphically as follows:

Period	Group I	Group II
1	Ration B	Ration A
2	Ration A	Ration B
3	Ration B	Ration A

Prairie hay for each of the two rations was taken from the same source of supply. Two different lots of hay were used during the experimental period. The prairie hay was purchased locally and was judged by a competent grader to be of U. S. no. 2 and 3 quality. The hay was fed as long hay.

The sorgo silage was made from atlas sorgo grown on the Kansas State College farm, mowed, windrowed, and hauled to a stationary cutter as soon as possible after cutting. It was blown into an upright, monolithic concrete silo on top of approximately 12 feet of alfalfa silage held over from 1947. About 64 tons of alfalfa were ensiled. The silo was not completely filled by this alfalfa silage; therefore the silo filling was completed with sorgo silage which was later fed off until the alfalfa silage was reached.

Plans of Feeding

The cows were fed silage on the basis of three pounds per 100 pounds of body weight; hay was fed on the basis of eight-tenths pounds per 100 pounds body weight and enough grain was fed to complete the total digestible nutrient requirement of each cow. It was deemed necessary to increase the total digestible nutrient intake to 110 percent of suggested requirements for the second period due to loss in body weight, otherwise the feeding standard recommended by the National Research Council (45) was closely followed. All feeds offered were accurately weighed and recorded daily for each cow at each feeding. All refused feed was carefully weighed and recorded once daily. All grain offered was sampled daily, composited for chemical analysis in the first period only.

Silage samples were taken by accepted methods weekly. These weekly samples were composited and sampled for chemical analysis for each of the three periods.

Hay samples were secured according to accepted methods. Such samples were ground in a hammer mill, thoroughly mixed and sampled for chemical methods.

All feed samples were analyzed by the Department of Chemistry, Kansas State College.

Records

Each cow was weighed on three consecutive days at the beginning of the experiment and on three consecutive days at the end of each 31 day period. The average of the three weights was used in calculating maintenance requirements for the ensuing period and as part of the basis for evaluating the nutrient worth of the ration.

The milk production of the previous week was used in estimating the feed to be fed for the succeeding period. Daily milk weights were kept on each cow and the milk sampled at each milking for butterfat tests. The milk samples were composited and tested once each week. Production was evaluated on the basis of yield of four percent fat-corrected milk.

Observations on the physical appearance and behavior of the cows were recorded at frequent intervals. Any clinical history during the trial was recorded. Breeding records as well as records of estrus were kept.

Management

The 18 cows used in this experiment were housed in the southeast section of the Kansas State College Dairy Barn. Wood shavings were used for bedding. All cows were fed and milked twice daily.

The cows were turned out into a small lot about two hours daily for exercise and sun exposure on all except stormy days.

Each cow was groomed daily. Any cow which needed treatment for illness was administered to by and on the discretion of the college veterinarian assigned to the dairy herd.

EXPERIMENTAL RESULTS AND DISCUSSION

For convenience, the results of this experiment shall be presented under five headings, as follows:

Feed Consumption
Milk Production
Efficiency of Production
Changes in Body Weight
Health and Appearance of Cows

Feed Consumption

While the feed offered was constant and determined according to body weight and milk production, there was a difference in the amount consumed, particularly of silage and grain. Feed offered and consumed is shown in Tables 8 and 9 of the Appendix. Palatability was definitely a factor in the results obtained in this trial. The quality of the alfalfa silage was judged to be only fair on the basis of appearance, odor, and acceptance by the cows. There was considerable variation in the quality of the alfalfa silage which made it difficult to get the cows to consume enough alfalfa silage to meet their nutrient requirements. Cow 152A disliked the alfalfa silage more than did any of the other cows. The low palatability of the alfalfa silage resulted in considerable waste. Often long, coarse weeds were found in the refused feed. The quality of the alfalfa silage was undoubtedly affected by the quality of the material ensiled and the methods practiced in the ensiling process. The alfalfa silage was cut rather long and apparently did not pack well in the silo as evidenced by moldy spots occasionally found in the silo which made it necessary for the feeder to use extreme care to avoid offering such undesirable silage.

The amount of feed offered during the first period was based on the nutrient requirements for maintenance and milk production using the standards of the National Research Council (45) and average feed analyses as published by Morrison (32). Since the feeds offered were sampled for chemical analyses during the period, it was impossible to determine accurately the nutrients offered until actual chemical analyses were made. The nutrients offered, the average daily intake of digestible crude protein and total digestible nutrients in percent of requirements are shown in Figs. 2 and 3. Actually the nutrients offered the group fed alfalfa silage were less than the nutrient requirements which was due to the fact that it was impossible to sample the feed in advance of feeding.

The digestible protein and total digestible nutrients were found by chemical analysis to be less than anticipated, thus the amount of protein and total digestible nutrients offered was less than calculated. Furthermore the nutrient intake was less than calculated because the cows getting alfalfa silage refused to consume all of the silage offered. Lack of sufficient nutrient intake also occurred in the second period of the trial because of feed refusal despite the fact that the total digestible nutrients offered were increased to 110 percent of requirements. In the third period, the cows fed ration B, which consisted of prairie hay, alfalfa silage and a farm grain mixture, were offered more nutrients than they required. This was due to the silage having a higher dry matter content which resulted in excess digestible protein and total digestible nutrients. As in the first two periods, chemical analysis of the silage was not available until after the period was completed.

Intake of digestible crude protein during the first period by group I which was fed ration B containing the alfalfa silage was only 88 percent of requirement for body maintenance and milk production. Group II fed ration A, containing sorgo silage, had an average intake of digestible crude protein of 150 percent of requirements.

In the second period, group I was switched from ration B containing alfalfa silage to ration A which contained sorgo silage and group II was changed from ration A to ration B. During this second period, the average daily intake of digestible crude protein for group I increased to 146 percent of requirements, while for group II the average daily intake of digestible crude protein was decreased to 98 percent of requirement.

In the third and final period of the trial, group I was switched back to the original ration B and group II was changed back to ration A. In group I the average daily intake of digestible crude protein was 119 percent of requirement and in group II it averaged 151 percent.

On a dry matter basis, protein content of the alfalfa silage varied but little during the three periods.

The total digestible nutrient intake shows a somewhat different picture as may be seen by observing Fig. 3, Appendix. Group I had an average daily intake of total digestible nutrients of 93 percent of requirement when fed ration B during the final period, while group II averaged 99 percent. In the second period group I on ration A had an average daily intake of total digestible nutrients of 97 percent of requirements while group II averaged 89 percent.

In the third period, group I on ration B averaged 110.0 percent of requirements and group II averaged 99.9 percent. The higher average daily intake in percent of requirement for group I was apparently due to the higher total nutrient content which was a direct result of the higher dry matter content of the alfalfa silage.

Milk Production

The two groups of cows were so divided that production of four percent fat-corrected milk was almost identical at the beginning of the experiment. Lower milk production occurred in the group when fed alfalfa silage than when fed sorgo silage. In general, greatest reduction of milk production occurred in group I when fed alfalfa silage during the first 10 day conditioning period. This is illustrated in Fig. 1 and in Table 17 of the Appendix. This reduction extended over into the experimental period in some instances before the low point of production was reached, and before the cows developed a tendency toward leveling off in production. At the beginning of this experiment, the cows in group I had an average of 36.3 pounds of 4 percent fat-corrected milk. During the first 10 days of the preliminary period of the experiment, this average decreased to 30.5 pounds of 4 percent fat-corrected milk and further decreased to 29.5 pounds for the first week of the first period, and an average of 27.8 pounds the second week before increasing to 29.0 pounds during the last week of this first period of the experiment. The cows in group II had an average of 36.4 pounds of 4 percent fat-corrected milk at the beginning of the preliminary. This average decreased to 35.4 pounds for the 10 day preliminary, 33.5 pounds the first week of the first period, 31.8 pounds in the second week and practically remained at this level (31.5 pounds) for the third week. The marked reduction in production occurred with the group receiving the ration containing alfalfa silage. The cows that were fed the sorgo silage ration decreased more moderately.

Group I actually increased in production of 4 percent fat-corrected milk during the second period of the experiment while on ration A. This group had an average of 29.1 pounds for the preliminary period of 10 days in the second period. This was increased to an average of 30.0 pounds in the first week of the second period, 30.5 pounds in the second week and of 31.0 pounds in the third week of this second period. The cows in group II declined in milk production while on ration B from 31.5 pounds of 4 percent fat-corrected milk in the third week of the first period to 27.3 pounds in the third week of the second period.

In the third period group I had an average of 29.0 pounds in the preliminary period. This decreased each week and in the last week the average had decreased to 24.6 pounds. Group II had an average of 26.3 pounds of 4 percent fat-corrected milk which decreased slightly during the period and ended with an average of 25.1 pounds in the last week of the period. This, as in other periods, was a more moderate decrease in milk production in the group receiving sorgo silage than in the group receiving the alfalfa silage. The complete graphic curve of milk production for the experiment is shown in Fig. 1. In every instance where the cows were switched from sorgo silage to alfalfa silage there was a marked decrease in milk production. As the end of the feeding trial neared, there was a noticeable narrowing of the difference that existed in milk production between the two groups. This apparently can be accounted for by the fact that there was a higher average daily intake of protein in group I which was fed ration B.

Total production of 4 percent fat-corrected milk of the cows receiving the ration containing alfalfa silage was 92 percent of the milk produced by the cows receiving the ration which contained sorgo silage. These data are shown in Table 20 of the Appendix.

Average daily milk production in comparison with average daily intake of digestible crude protein in percent of requirements and with daily intake of total digestible nutrients in percent of requirements has been shown in Figs. 2 and 3. Data on milk production have been analyzed, using Brandt's (16) method for testing the significance of results in reversible or switchback trials. The differences were calculated for each animal according to the following formula:

$$\text{Difference} = X_1 - 2X_2 + X_3$$

X_1 = Performance for Period 1

X_2 = Performance for Period 2

X_3 = Performance for Period 3

It will be noted in Table 23, where the results are given from the use of the above formula, that in every instance a negative difference occurred for cows in group I while in every instance a positive difference occurred for cows in group II. These differences in favor of the sorgo silage, high protein grain ration were found to be highly significant ($P = < .01$). The detailed analysis is shown in Table 23 of the Appendix.

It is believed that the results shown in the third period, where protein was increased, indicate that inadequate protein was the cause of the low production of the group fed alfalfa silage in Period 1 and Period 2.

Efficiency of Milk Production

Efficiency of production has been measured by using the pounds of protein and the total digestible nutrients needed to produce 100 pounds of 4 percent fat-corrected milk. It is interesting to note that, although the alfalfa silage, farm grain ration was inadequate for maximum milk production, the cows made more efficient use of the protein while on this ration; however, the more efficient use of protein did not result in economical milk production. It is apparent that a limited amount of protein supplement furnished in a ration containing alfalfa silage, would result in satisfactory production. In the ration used in this experiment, group I required 7.48 pounds of digestible crude protein for each 100 pounds of 4 percent fat-corrected milk while on ration B in the first period. In the second period, this group required 11.04 pounds while on ration A and 10.49 pounds on ration B in the third period. Group II required 11.00 pounds of digestible crude protein for 100 pounds of 4 percent fat-corrected milk in the first period on ration A, 7.93 pounds on ration B, and 11.38 pounds on ration A. Although differences were small, the cows made more efficient use of total digestible nutrients when fed the sorgo silage ration. Cows in Group I required 69.1 pounds total digestible nutrients to produce 100 pounds of 4 percent fat-corrected milk in Period 1 on ration B, 67.7 pounds while on ration A and 86.1 pounds when returned to ration B. Similarly the total digestible nutrients required per 100 pounds of 4 percent fat-corrected milk for group II while on ration A were 65.6 pounds, 72.6 pounds when changed to ration B and 70.9 pounds when switched back to ration A. This information is presented in Tables 18 and 19 of the Appendix.

Effect of the Rations on Body Weight

The cows in group I had an average body weight in the preliminary weighings of 977 pounds. At the end of the first period it had decreased to 931 pounds or a decrease in body weight of 46 pounds while on the first period when ration B was fed or a loss of 4.7 percent. Group II had an average initial weight of 1024 pounds. At the end of the first period, it had decreased to 980 pounds or a decrease of 4.3 percent.

During the second period, group I, while on ration A showed an average gain of 5 pounds in body weight while group II on ration showed a loss of 10 pounds of body weight. These differences were no more than normal variations on daily weighings.

In the third period, group I was returned to ration B and at the end of that period, the average body weight was 975 pounds or a gain of 39 pounds over the average weight at the end of the second period. Group II, upon being returned to ration A, showed an average gain of 17 pounds in body weight during the third period over the average weight at the end of the second period. It is apparent that the changes that occurred in body weight are of no significance in evaluating the nutrient worth of the rations.

Health and Appearance of the Cows

In general, the health of the cows remained good throughout the experiment. There were few cases of illness where it was deemed advisable to use the services of the college veterinarian.

Cow 366A stepped on the end of her right front teat and developed a slight case of mastitis in the first period. Treatment was administered, using penicillin bougies placed in the teat canal. Recovery was fairly rapid and with little loss in milk production.

Cow 257A developed a rather acute attack of mastitis in the last week of the second period. She was treated with penicillin bougies locally and with sulfanilamide orally. Recovery was rather rapid with little loss in milk production. An adjustment in milk weight was made by plotting the cow's normal lactation curve and using the figures which applied to the curve. This illness occurred during the last week of the second period and by the first week of the third period she apparently had fully recovered her normal milk production.

Cow 262A developed a mild case of infection in the first week of the second period. Treatment was administered by the college veterinarian and she recovered with little loss in milk production.

Cow 498A had a rather severe case of infection during the third 10-day conditioning period. Treatment was administered for three succeeding days. This cow apparently recovered partially; however, a milder recurrence developed during the second week of the third period. The experiment was over before complete recovery was made. There was a larger loss in milk production on this cow and an adjustment was made similarly to that made on cow 257A. It is believed that the adjustment did not affect the average milk production of the groups to which these four cows belonged. Other than for the cases cited above, the cows remained in good health and developed an excellent hair coat.

SUMMARY AND CONCLUSIONS

Two groups of 9 cows each were placed on an experiment which consisted of three 21 day periods, each preceded by a 10 day conditioning period. A double reversal system of feeding was used with two different rations. Ration A consisted of prairie hay, sorgo silage and a high protein concentrate, and ration B consisted of prairie hay, alfalfa silage and a farm grain mixture. The experiment was designed to include extremes in protein intake, ration A to furnish more than adequate protein and ration B to furnish approximately only enough protein to meet the minimum needs of the cow.

The quality of the alfalfa silage was judged to be of only fair quality based on appearance, odor and acceptance by the cows. Because the nutrient content of the alfalfa silage was lower than was anticipated and because the cows refused to consume all of the feed offered, their daily intake of nutrients was inadequate to maintain satisfactory milk production. The production of 4 percent fat-corrected milk of the cows fed the ration containing alfalfa silage was only 92.0 percent of that of the cows fed the ration containing the sorgo silage. This difference in production is highly significant.

If the protein intake in the cows fed the ration that contained alfalfa silage had been higher in the first and second period, apparently there would have been less difference in the production of 4 percent fat-corrected milk. This is borne out by the third period when a higher dry matter content of the alfalfa silage developed. This resulted in the cows in group I to have a higher intake of nutrients than the cows that were fed alfalfa silage in period one and two. Such intake was reflected in a narrower margin in the milk production between the group that was fed the ration which contained alfalfa silage and the group fed the ration that contained sorgo silage.

It is apparent from these results that the lack of palatability and the lack of protein in the alfalfa silage ration were the limiting factors in maintaining satisfactory milk production. It further appears that if a high quality alfalfa silage was used, that such silage would save protein and that satisfactory milk production could be maintained. It is apparent that with a ration containing fair quality alfalfa silage that satisfactory production could be maintained provided the grain ration was supplemented with a limited amount of protein concentrate. Further work is necessary before final conclusion can be determined.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to Dr. F. C. Fountaine of the Department of Dairy Husbandry, for his valuable assistance in planning, organizing and criticizing this investigation; to Professor F. W. Atkeson for his helpful suggestions and criticism of this paper, and to Dr. F. E. Eldridge for his suggestions and help in analyzing the results. Further appreciation is extended Dr. F. C. Fountaine for his patience and helpful suggestions throughout the entire investigation.

LITERATURE CITED

(1) Allen, N. N. and J. B. Fitch.
Hay crop silage. Minn. Agr. Expt. Sta. Bul. 360. 1942.

(2) Archibald, J. G., G. Bohstedt, J. C. Knott, C. F. Monroe, T. E. Woodward and C. B. Bender. Committee report on silage methods evaluations. Jour. Dairy Sci. 26:213-215 p. 1942.

(3) Archibald, J. G., and C. D. Gunness.
Seepage losses from a silo. Jour. Dairy Sci. 38:321-324. 1945.

(4) Archibald, J. G. and C. H. Parsons.
Grass silage. Mass. Agr. Expt. Sta. Bul. 425. 1945.

(5) Annonymous.
Which silage preservative in war time. Wisc. Agr. Expt. Sta. Ann. Rept. 455: 1-5. 1942.

(6) Becker, R. B., P. T. Dix Arnold, G. K. Davis, and S. P. Marshall. Ensilability of Florida forage crop. Florida Ann. Rept. 54. 1943.

(7) Bechdel, S. I., R. W. Stone, P. S. Williams and F. R. Murdock. Legume silage in dairy feeding. Pa. Agr. Expt. Sta. Bul. 411. 1941.

(8) Bender, C. B.
Feeding grass silage. N. J. Agr. Expt. Sta. Bul. 695. 1942.

(9) Bender, C. B., J. W. Bartlett, H. H. Tucker and J. Mixner. Molasses grass silage. Reprint Guernsey Breeder's Jour. 52:299-300. 1937.

(10) Bender, C. B. and D. K. Bosshardt.
Grass silage - a critical review of the literature. Jour. Dairy Sci. 22:637-646. 1939.

(11) Bender, Carl B., and Howard B. Sprague.
Silage without molasses. N. J. Agri. Expt. Sta. Circ. 439. 1942.

(12) Bohstedt, G.
Nutritional values of hay and silage as affected by harvesting, processing, and storage. Reprint from Agricultural Eng. 25: 337-340, 388, 390, 392. 1944.

(13) Bohstedt, G., W. H. Peterson, F. W. Duffee and N. N. Allen. Grass silage. Wisc. Ext. Ser. stencil circ. 277. 1948.

(14) Bohstedt, G., W. H. Peterson and F. W. Duffee. Grass silage. Wisc. Ext. Circ. 299. 1940.

(15) Bohstedt, G., W. H. Peterson and G. P. Bahler. Corn meal as a grass silage preservative. Guernsey Breeder's Jour. 60:357. 1941.

(16) Brandt, A. E. Tests of significance in reversal or switchback trials. Iowa State Research Bul. 234. 1938.

(17) Camburn, O. M., H. B. Ellenberger, C. H. Jones and G. C. Crooks. The conservation of alfalfa and timothy nutrients as silage and as hay III. Ver. Agri. Expt. Sta. Bul. 509. 1944.

(18) Churchill, B. R., and R. E. Harwood Methods of making and feeding alfalfa molasses silage. Jour. Dairy Sci. 21: 105-106. 1938.

(19) Delwiche, E. J., D. H. Holt and Carl Rydberg. Grass silage fits well in the north. Wisc. Ann. Rept. 27. Bul. 463. 1944.

(20) Duffee, Floyd, H. D. Bruhn, and C. H. Kreuger. Custom grass silage making is feasible. Wisc. Ann. Rept. Bul. 456. 3-12 p. 1942.

(21) Hayden, C. C., A. E. Perkins, C. F. Monroe, W. E. Krauss, C. E. Knoop and R. G. Washburn. Molasses treatment for meadow crop silage. Ohio Agr. Expt. Sta. Bul. 234. 1945.

(22) Hayden, C. C., A. E. Perkins, C. F. Monroe, W. E. Krauss, R. G. Washburn and C. E. Knoop. Hay crop silage - a summary of ten years work. Ohio Agri. Expt. Sta. Bul. 656. 1945.

(23) Herman, H. A. and A. C. Ragsdale. Grass silage in wartime. Mo. Agri. Expt. Sta. Circ. 234. 1942.

(24) Hegsted, D. M., F. W. Quackenbush, W. H. Peterson, G. Bohstedt, I. W. Rupel, and W. A. King. A comparison of grass silages prepared by the A. I. V. and molasses method. Jour. Dairy Sci. 22: 489-499. 1939.

(25) Hodgson, R. E., J. B. Shepherd, L. G. Schoenleber, H. M. Tysdal, R. E. Wagner, and W. H. Hosterman. Comparative efficiency of siloing, barn curing and field curing forage crops. U. S. D. A. B. D. I. M.-Inf.-43: 1946.

(26) Huffman, C. F.
Roughage quality and quantity in the dairy ration - a review. Jour. Dairy Sci. 11: 889-980. 1939.

(27) King, Willis A.
Comparison of molasses-grass silage and ground barley-grass silage. N. J. Agr. Expt. Sta. Bul. 722. 1945.

(28) King, W. A., G. C. Patrias, and W. C. Russell.
The value of molasses and phosphoric acid-alfalfa silage in the ration of dairy cows. Jour. Animal Sci. 1. 1942.

(29) McAuliffe, H. D., R. W. Stone, and S. I. Bechdel.
Fermentation studies on alfalfa silage prepared by the phosphoric acid and molasses methods. Jour. Dairy Sci. 23: 561. 1940.

(30) Monroe, C. F., C. C. Hayden, A. E. Perkins, W. E. Krauss, C. E. Knoop and R. G. Washburn. Phosphoric acid treatment for meadow crop silage. Ohio Agri. Expt. Sta. Bul. 234. 1945.

(31) Monroe, C. F., J. H. Hilton, R. E. Hodgson, W. A. King, and W. E. Krauss. The loss in nutrients in hay and meadow crop silage during storage. Jour. Dairy Sci. 29: 239-252. 1946.

(32) Morrison, Frank B.
Feeds and feeding. New York: Morrison Publishing Company, 1948.

(33) Newlander, J. A., H. B. Ellenberger, O. M. Camburn and C. H. Jones. The conservation of alfalfa, timothy and soybean nutrients as silages and hays. Ver. Agri. Expt. Sta. Bul. 456. 1940.

(34) Newlander, J. A., H. B. Ellenberger and C. H. Jones.
The conservation of nutrients in grass silage IV. Ver. Agri. Expt. Sta. Bul. 485. 1942.

(35) Nevens, W. B., K. E. Harshbarger and K. A. Kendall.
Grass and legume silages for dairy cattle. Ill. College of Agri. Circ. 605. 1946.

(36) Reed, O. E., and J. B. Fitch.
Alfalfa silage. Kans. Agri. Expt. Sta. Bul. 217. 1917.

(37) Rupel, I. W., C. E. Zehner, W. H. Peterson and J. J. Stefanick. Silage. Wisc. Ann. Rept. Bul. 463. 26-27. 1944.

(38) Shepherd, J. F. How to put up wilted grass silage. BDIM-Inf.-33. U.S.D.A. 1946.

(39) Shepherd, J. B., R. E. Hodgson and W. J. Twostman. Comparative value of wilted alfalfa silage and alfalfa hay for milk production. B.D.I.M.-Inf.-34. 1946.

(40) Shepherd, J. B., R. E. Hodgson, N. R. Ellis and J. R. McCalmont. Ensiling hay and pasture crop. Yearbook of Agriculture, United States Department of Agriculture. Washington: Government Printing Office. 1948.

(41) Shepherd, J. B. and T. E. Woodward. Experience in ensiling partially cured alfalfa, methods used, losses sustained at feeding value. Jour. Dairy Sci. 21: 104-105. 1938.

(42) Shuey, G. A. Legume silage. Tenn. Agri. Expt. Sta. Ann. Rept. Bul. 52. 23-26. 1937.

(43) Stone, R. W., F. R. Murdock, and S. I. Bechdel. The fermentation in legume silage, with wilting and with corn and cob meal as a preservative. Jour. Dairy Sci. 26: 734-735. 1943.

(44) Stone, R. W., S. I. Bechdel, H. D. McAuliffe, F. R. Murdock, and R. C. Malyahn. The fermentation of alfalfa silage. Pa. Agri. Expt. Sta. Bul. 444. 1943.

(45) National Research Council. Recommended nutrient allowances for domestic animals. A report by the committee on animal nutrition. J. K. Loosli, chairman. 1945.

(46) Swanson, C. O. and E. L. Tague. Chemical studies in making alfalfa silage. Jour. Agri. Research. 10: 1917.

(47) Waugh, R. K., S. M. Hague, J. W. Wilbur and J. H. Hilton. A comparison of alfalfa-brome grass silage and corn silage for dairy cows. Jour. Dairy Sci. 26: 921-927. 1943.

(48) Williams, G. A. Legume silage saves protein. Hoard's Dairyman. 94: 343. April 25, 1949.

(49) Woodward, T. E. and J. B. Shepherd.
A statistical study of the influence of moisture and acidity on the palatability and fermentation losses of ensiled hay crops. Jour. Dairy Sci. 25: 517-523. 1942.

APPENDIX

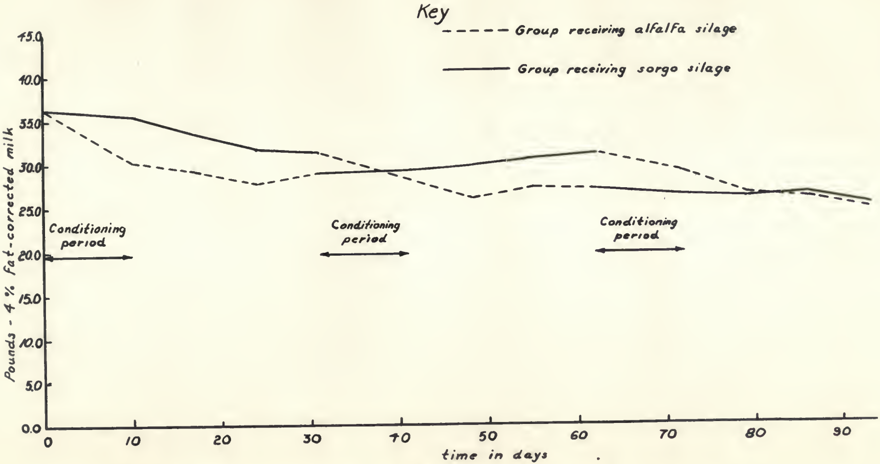

Fig. 1 Average daily production 4.0 % fat-corrected milk.

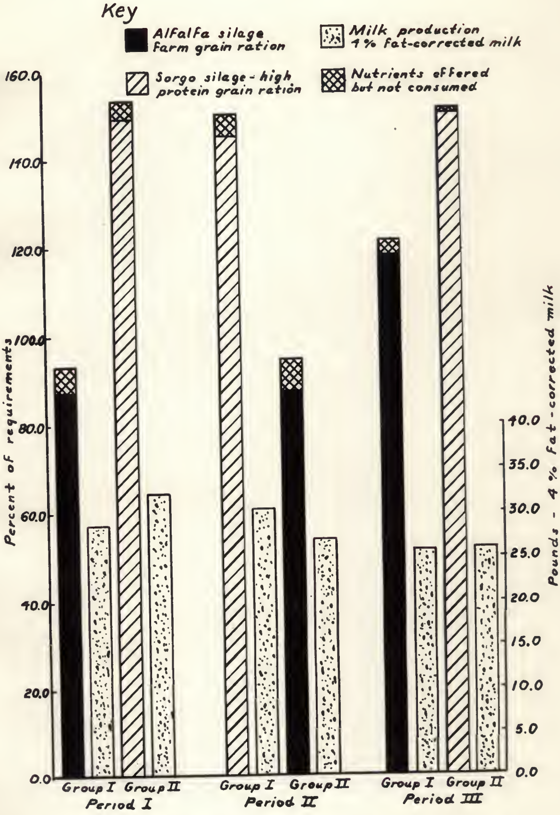

Fig. 2 Average daily intake of digestible crude protein in percent of requirement and average daily milk production.

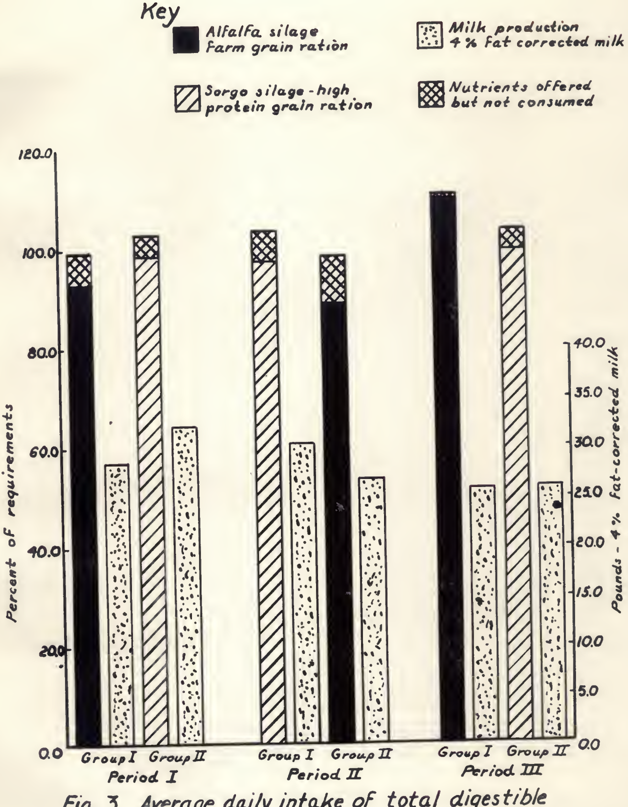

Fig. 3 Average daily intake of total digestible nutrients in percent of requirements and average milk production.

Table 1. General information on cows used in experiment.

Ear tag no.	Date of birth	Last calving date prior to experiment	Breed
		Group I	
366A	5-24-42	10-20-48	Jersey
373A	6- 9-44	11-21-48	Jersey
271A	7-16-46	11-23-48	Ayrshire
262A	12-22-45	11-21-48	Ayrshire
152A	2-14-46	11- 1-48	Holstein
305B	6-24-46	11-16-48	Jersey
264A	4-13-46	11-13-48	Ayrshire
261A	7- 9-45	4-19-48	Ayrshire
256A	12-19-44	5-23-47	Ayrshire
		Group II	
392A	5-28-45	11- 6-48	Jersey
139A	11-28-44	10-24-48	Holstein
257A	1-19-45	10-22-48	Ayrshire
137A	9- 1-44	7- 5-48	Holstein
259A	3-18-45	9-15-48	Ayrshire
498A	6- 5-46	10-23-48	Guernsey
301B	5- 7-46	11-17-48	Jersey
255A	12-15-44	3-10-48	Ayrshire
251A	3- 9-44	4-19-48	Ayrshire

Table 2. Details of double reversal experimental design.

Cow's ear tag no.	Period I	Period II	Period III
	Group I - Rations		
366A	B	A	B
373A	B	A	B
271A	B	A	B
262A	B	A	B
152A	B	A	B
305B	B	A	B
264A	B	A	B
261A	B	A	B
256A	B	A	B
	Group II - Rations		
392A	A	B	A
139A	A	B	A
257A	A	B	A
137A	A	B	A
259A	A	B	A
498A	A	B	A
301B	A	B	A
255A	A	B	A
251A	A	B	A

Table 3. Body weights of cows based on average weights of three consecutive days.

Ear tag nos. of cows	Initial weight	End of Period 1	End of Period 2	End of Period 3
		Group I		
366A	874	801	813	843
373A	966	900	873	910
271A	886	897	900	954
262A	1029	990	973	1037
152A	1217	1141	1176	1217
305B	707	675	683	714
264A	1088	1042	1051	1083
261A	955	929	962	1003
256A	1069	1001	998	1019
Average	977	931	936	975
Percent of previous weight		95.3	100.5	104.2
		Group II		
392A	805	775	767	778
139A	1122	1077	1060	1084
257A	900	810	776	826
137A	1323	1256	1253	1253
259A	1007	956	948	965
498A	1000	980	985	956
301B	770	765	752	799
255A	1157	1121	1118	1154
251A	1132	1084	1068	1070
Average	1024	980	970	987
Percent of previous weight		95.7	99.0	101.7

Table 4. Protein and total digestible nutrient content of feeds used.

	Digestible crude protein	Total digestible nutrients
Wilted alfalfa silage (Morrison)	4.1	21.3
Fed period 1 (1st analysis)	3.26	20.5
Fed period 2 (2nd analysis)	3.29	19.4
Fed period 3 (3rd analysis)	4.86	27.9
Atlas sorgo silage (Morrison)	1.03	15.4
Fed period 1 (1st analysis)	1.29	17.3
Fed period 2 (2nd analysis)	1.09	17.9
Fed period 3 (3rd analysis)	1.26	16.68
Prairie hay (Morrison)	2.6	49.2
Sample no. 1	2.29	48.7
Sample no. 2	1.71	51.4
Farm grain mixture (calculated from Morrison)	7.86	76.9
Actual analysis	7.74	77.47*
High protein concentrate (calculated from Morrison)	19.0	76.1
Actual analysis	18.67	74.7*

* Calculated, using average digestion coefficients.

Table 5. Daily nutrient requirements - Period 1.

Cow's eartag no.	Production requirements		Maintenance requirements		Total requirements	
	Digestible crude protein	Total digestible nutrients	Digestible protein	Total digestible nutrients	Digestible protein	Total digestible nutrients
	lbs.		lbs.		lbs.	
			Group I			
366A	2.12	15.16	.503	7.16	2.62	22.26
373A	2.26	16.06	.58	7.77	2.84	23.83
271A	1.31	9.34	.92	10.43	2.23	19.77
262A	1.97	13.98	.61	8.02	2.58	22.00
152A	1.93	13.70	.70	9.62	2.63	23.32
305B	1.60	11.36	.88	9.30	2.48	20.66
264A	1.49	10.62	.97	11.44	2.46	22.06
261A	1.07	7.65	.99	10.77	2.06	18.42
256A	.95	6.78	.63	8.50	1.58	15.28
			Group II			
392A	2.28	16.22	.502	7.07	2.78	23.29
139A	2.03	14.46	.66	8.92	2.69	23.38
257A	2.02	14.40	.55	7.33	2.57	21.73
137A	1.73	12.29	.71	10.42	2.44	22.71
259A	1.63	11.61	.97	11.00	2.60	22.61
498A	1.39	9.86	.95	11.0	2.34	20.86
301B	1.37	9.73	.89	9.77	2.26	19.50
255A	1.25	8.90	.68	9.17	1.93	18.07
251A	1.04	7.39	.66	9.00	1.70	16.39

Table 6. Daily nutrient requirements - Period 2.

Cow's eartag no.	Production requirements: Digestible crude protein	Production requirements: Total digestible nutrients	Maintenance requirements: Digestible crude protein	Maintenance requirements: Total digestible nutrients	Total requirements ≠ 10%: Digestible crude protein	Total requirements ≠ 10%: Total digestible nutrients
	lbs.		lbs.		lbs.	
Group I						
366A	1.49	10.56	.503	7.16	2.18	19.49
373A	1.65	11.71	.58	7.77	2.45	21.42
271A	1.10	7.84	.92	10.43	2.22	20.09
262A	1.60	11.39	.58	8.02	2.43	21.35
152A	1.54	10.98	.70	9.62	2.46	22.66
305B	1.39	9.89	.88	9.30	2.49	21.10
264A	1.30	9.25	.97	11.44	2.49	22.75
261A	.98	6.94	.99	10.77	2.16	19.48
256A	.72	5.12	.63	8.50	1.48	14.98
Group II						
392A	1.59	11.30	.502	7.07	2.29	20.20
139A	1.69	12.03	.66	8.92	2.58	23.04
257A	1.89	13.41	.55	7.33	2.68	22.81
137A	1.40	9.98	.71	10.42	2.32	22.44
259A	1.57	11.14	.97	11.00	2.79	24.35
498A	1.32	9.38	.95	11.00	2.49	22.42
301B	1.26	8.96	.89	9.77	2.36	20.60
255A	1.17	7.94	.68	9.17	2.03	18.82
251A	.93	6.56	.66	9.00	1.75	17.11

Table 7. Daily nutrient requirements - Period 3.

Cow's eartag no.	Production requirements: Digestible crude protein lbs.	Production requirements: Total digestible nutrients lbs.	Maintenance requirements: Digestible crude protein lbs.	Maintenance requirements: Total digestible nutrients lbs.	Total requirements: Digestible crude protein lbs.	Total requirements: Total digestible nutrients lbs.
			Group I			
366A	1.61	11.42	.503	7.16	2.11	18.58
373A	1.65	11.71	.58	7.07	2.23	19.43
271A	1.13	8.06	.92	10.43	2.05	18.49
262A	1.65	11.71	.61	8.02	2.26	19.73
152A	1.74	12.38	.70	9.62	2.44	22.00
305B	1.54	10.98	.88	9.30	2.42	20.28
264A	1.48	10.50	.97	11.44	2.45	21.94
261A	1.07	7.62	.99	10.77	2.06	18.39
256A	.68	4.86	.63	8.50	1.31	13.36
			Group II			
392A	1.24	8.83	.502	7.07	1.74	18.58
139A	1.50	10.69	.66	8.92	2.16	19.61
257A	1.64	11.68	.55	7.33	2.19	19.01
137A	1.19	8.45	.71	10.42	1.90	18.87
259A	1.34	9.54	.97	11.00	2.31	20.54
498A	1.14	8.10	.95	11.00	2.09	19.10
301B	1.18	8.42	.89	9.77	2.07	18.19
255A	1.00	7.14	.68	9.17	1.68	16.31
251A	.75	5.31	.66	9.00	1.41	14.31

Table 8. Amount of feed offered during experiment.

Cow's ear tag no.	Period 1			Period 2			Period 3		
	Hay	Silage	Grain	Hay	Silage	Grain	Hay	Silage	Grain
	lbs.			lbs.			lbs.		
				Group I					
356A	134.4	545.0	364.0	134.4	525.8	331.4	134.4	642.6	273.0
373A	163.8	609.4	381.7	163.8	609.0	353.2	163.8	709.8	264.6
271A	151.2	709.6	294.0	151.2	558.6	335.6	151.2	558.6	298.2
262A	172.2	651.0	310.8	172.2	640.0	338.2	172.2	651.0	281.4
152A	197.8	746.9	328.0	205.8	768.6	325.6	205.8	768.6	289.8
305B	117.6	445.2	365.4	117.6	445.2	406.2	117.6	445.2	394.8
264A	184.8	678.0	298.2	184.8	684.6	359.2	184.8	659.8	323.7
261A	159.6	600.6	235.2	159.6	600.6	305.4	159.6	600.6	264.6
256A	180.6	668.0	117.6	180.6	672.0	147.6	180.6	672.0	79.8
Total	1462.0	5653.7	2694.9	1470.0	5504.4	2902.4	1470.0	5708.2	2469.9
Average	162.4	628.2	299.4	163.3	611.6	322.5	163.3	634.2	274.4
				Group II					
392A	134.4	508.2	453.6	134.4	508.2	314.0	134.4	508.2	264.6
139A	189.0	705.4	382.2	189.0	705.6	303.8	189.0	705.6	289.8
257A	151.2	567.0	386.4	151.2	567.0	346.0	151.2	567.0	336.0
137A	222.6	835.8	315.0	222.6	835.8	229.0	222.6	835.8	210.0
259A	172.2	634.2	386.1	172.2	634.2	326.8	172.2	634.2	348.6
498A	168.0	630.0	340.2	168.0	620.0	321.4	155.0	582.0	286.1
301B	130.2	487.2	357.0	130.2	487.2	345.0	130.2	487.2	344.4
255A	193.2	730.8	226.8	193.2	730.8	180.2	193.2	730.8	120.4
251A	189.0	714.0	184.8	189.0	714.0	138.4	189.0	714.0	126.0
Total	1549.8	5812.6	3032.1	1549.8	5802.8	2504.6	1536.8	5764.8	2325.9
Average	172.2	645.8	336.9	172.2	644.7	278.3	170.7	640.5	258.4

Table 9. Amount of feed consumed during experiment.

Cow's ear tag no.	Period 1			Period 2			Period 3		
	Hay	Silage	Grain	Hay	Silage	Grain	Hay	Silage	Grain
	lbs.			lbs.			lbs.		
				Group I					
366A	110.2	494.2	346.5	120.3	525.8	331.4	110.5	637.5	273.0
373A	138.4	606.9	381.7	148.8	609.0	353.2	144.0	709.3	264.3
271A	113.8	551.3	288.2	106.1	558.6	478.4	123.5	554.1	297.4
262A	134.9	601.7	310.8	124.0	640.0	338.2	148.2	644.4	281.4
152A	167.1	587.8	328.0	176.2	768.6	325.6	181.9	748.4	289.8
305B	84.2	371.7	365.2	92.4	445.2	403.7	85.2	403.1	390.8
264A	161.1	551.7	298.0	140.8	684.3	359.2	133.8	575.5	323.7
261A	110.2	571.9	234.8	109.0	597.0	304.9	109.1	562.4	262.6
256A	144.5	609.8	117.0	142.7	671.7	147.6	139.1	563.3	79.8
Total	1164.4	4947.0	2670.2	1160.3	5500.2	3042.2	1175.3	5438.0	2462.8
Average	129.4	549.7	296.7	128.9	611.1	338.2	130.6	599.7	273.6
				Group II					
392A	122.4	508.2	453.6	105.1	501.2	299.3	126.9	508.2	264.6
139A	183.9	705.6	382.2	173.7	705.6	303.8	184.4	705.6	289.8
257A	110.5	567.0	380.2	101.1	485.1	325.9	125.3	567.0	334.2
137A	194.8	835.2	315.0	181.3	804.0	229.0	201.2	835.8	210.0
259A	159.8	634.2	381.7	147.6	628.9	306.2	159.8	634.2	348.6
498A	159.3	630.0	339.9	150.3	585.9	320.9	122.4	554.9	279.9
301B	87.0	486.2	357.0	81.9	447.8	343.8	112.1	487.2	344.4
255A	171.2	730.5	226.8	149.7	687.0	180.2	173.2	730.8	180.6
251A	150.1	714.0	184.8	144.8	638.9	138.4	156.6	714.0	126.0
Total	1339.0	5810.9	3021.2	1235.5	5484.4	2447.5	1361.9	5737.7	2378.1
Average	148.8	645.6	335.7	137.3	609.4	271.9	151.3	637.5	264.2

Table 10. Nutrient intake during experiment.

Cow's eartag number	Digestible crude protein			Total digestible nutrients		
	Alfalfa silage Period 1	Sorgo silage Period 2	Alfalfa silage Period 3	Alfalfa silage Period 1	Sorgo silage Period 2	Alfalfa silage Period 3
	lbs.			lbs.		
Group I						
366A	45.44	69.74	54.63	439.33	403.50	443.41
373A	52.48	75.21	58.23	487.62	449.34	473.06
271A	42.86	70.66	52.76	391.79	405.21	445.38
262A	46.72	72.20	56.49	429.91	428.95	470.22
152A	48.42	72.26	62.98	456.06	471.31	522.19
305B	42.86	81.93	51.78	403.66	428.73	456.95
264A	44.72	77.04	56.07	422.49	463.18	476.76
261A	39.34	65.36	50.14	352.88	390.65	413.70
256A	32.23	37.35	36.72	286.03	303.82	278.10
Total	395.07	621.75	479.80	3669.77	3944.69	3979.77
Average	43.89	69.08	53.31	407.75	416.07	442.19
Group II						
	Sorgo silage	Alfalfa silage	Sorgo silage	Alfalfa silage	Sorgo silage	Alfalfa silage
392A	94.24	41.50	58.76	486.38	383.20	344.19
139A	84.70	49.77	67.28	497.11	461.60	423.96
257A	80.94	42.96	72.50	435.91	398.59	405.23
137A	74.12	47.35	62.22	474.75	426.62	394.26
259A	83.21	46.98	76.79	472.66	435.17	443.86
498A	75.33	46.72	62.13	440.46	439.62	361.24
301B	75.01	42.77	73.12	393.31	395.19	393.11
255A	52.76	39.18	46.92	379.15	349.85	341.14
251A	47.17	34.26	36.14	334.64	305.62	289.49
Total	667.48	391.49	555.86	3914.37	3595.46	3396.48
Average	74.16	43.49	61.76	434.93	399.49	377.38

Table 11. Average daily nutrient requirements and intake - Period 1.

Eartag numbers	Digestible crude protein: Daily requirements	Digestible crude protein: Daily intake	Total digestible nutrients: Daily requirements	Total digestible nutrients: Daily intake
	lbs.		lbs.	
		Group I		
366A	2.62	2.16	22.26	20.92
373A	2.84	2.50	23.83	23.22
271A	2.23	2.04	19.77	18.66
262A	2.58	2.22	22.00	20.47
152A	2.63	2.30	23.32	21.72
305B	2.48	2.04	20.66	19.22
264A	2.46	2.13	22.06	20.12
261A	2.06	1.87	18.42	16.80
256A	1.58	1.53	15.28	13.62
Total	21.48	18.79	187.59	174.75
Average	2.38	2.09	20.84	19.41
Percent of requirements		87.6		93.1
		Group II		
392A	2.78	4.49	23.29	23.16
139A	2.69	4.03	23.38	23.67
257A	2.57	3.85	21.73	20.76
137A	2.44	3.53	22.71	22.61
259A	2.60	3.96	22.61	22.51
498A	2.34	3.59	20.86	20.97
301B	2.26	3.57	19.50	18.73
255A	1.93	2.51	18.07	18.05
251A	1.70	2.25	16.39	15.93
Total	21.31	31.78	188.54	186.39
Average	2.36	3.53	20.94	20.71
Percent of requirements		149.6		98.9

Table 12. Average daily nutrient requirements and intake, Period 2.

Ear tag numbers	Digestible crude protein: Daily requirements	Digestible crude protein: Daily intake	Total digestible nutrients: Daily requirements	Total digestible nutrients: Daily intake
	lbs.		lbs.	
Group I				
366A	2.18	3.32	19.49	19.21
373A	2.45	3.58	21.42	21.40
271A	2.22	3.36	20.09	19.29
262A	2.43	3.44	21.35	20.43
152A	2.46	3.44	22.66	22.44
305B	2.49	3.90	21.10	20.41
264A	2.49	3.67	22.75	22.06
261A	2.16	3.11	19.48	18.60
256A	1.48	1.78	14.98	14.47
Total	20.36	29.60	183.31	178.31
Average	2.26	3.29	20.36	19.81
Percent of requirements		145.6		97.3
Group II				
392A	2.29	1.98	20.20	18.25
139A	2.58	2.37	23.04	21.98
257A	2.68	2.04	22.81	18.98
137A	2.32	2.25	22.44	20.31
259A	2.79	2.24	24.35	20.72
498A	2.49	2.22	22.42	20.93
301B	2.36	2.04	20.60	18.83
255A	2.03	1.86	18.82	16.66
251A	1.75	1.63	17.11	14.55
Total	21.29	18.63	191.79	171.21
Average	2.39	2.07	21.31	19.02
Percent of requirements		87.7		89.3

Table 13. Average daily nutrient requirements and intake, Period 3.

Ear tag numbers	Digestible crude protein: Daily requirements (lbs.)	Digestible crude protein: Daily intake (lbs.)	Total digestible nutrients: Daily requirements (lbs.)	Total digestible nutrients: Daily intake (lbs.)
		Group I		
366A	2.11	2.60	18.58	21.11
373A	2.23	2.77	19.48	22.53
271A	2.05	2.51	18.49	21.21
262A	2.26	2.69	19.73	22.39
152A	2.44	3.00	22.00	24.87
305B	2.42	2.46	20.28	21.76
264A	2.45	2.67	21.94	22.70
261A	2.06	2.39	18.39	19.70
256A	1.31	1.75	13.36	13.24
Total	19.33	22.84	172.25	189.51
Average	2.14	2.54	19.13	21.06
Percent of requirements		118.7		110.0
		Group II		
392A	1.74	2.80	15.90	16.39
139A	2.16	3.20	19.61	20.18
257A	2.19	3.45	19.01	19.30
137A	1.90	2.96	18.87	18.77
259A	2.31	3.66	20.54	21.14
498A	2.09	2.96	19.10	17.20
301B	2.07	3.48	18.19	18.71
255A	1.68	2.23	16.31	16.24
251A	1.41	1.72	14.31	13.78
Total	17.55	26.46	161.84	161.71
Average	1.95	2.94	17.98	17.97
Percent of requirements		150.7		99.9

Table 14. Production of milk, butterfat and four percent fat-corrected milk by weeks, Period 1.

Ear tag no.	1st week Total lbs. milk	% test	Lbs. fat.	Av. daily lbs. 4% f.c.m.	2nd week Total lbs. milk	% test	Lbs. fat	Av. daily lbs. 4% f.c.m.	3rd week Total lbs. milk	% test	Lbs. fat	Av. daily lbs. 4% f.c.m.	Total lbs. 4% fat corrected milk
							Group I						
366A	229.6	4.21	9.66	33.8	248.5	3.60	8.94	33.3	231.2	4.00	9.25	33.0	701.5
373A	271.4	4.20	11.39	39.9	258.0	3.65	9.41	34.9	238.4	4.50	10.73	36.6	780.1
271A	189.6	3.58	6.71	25.1	187.2	3.10	5.80	23.1	188.8	3.40	6.42	24.5	510.2
262A	262.4	3.73	9.78	35.9	260.8	3.40	8.86	33.8	267.4	3.55	9.49	35.6	738.2
152A	268.2	2.70	7.24	30.8	281.3	2.30	6.47	29.9	282.6	3.0	8.48	34.3	665.7
305B	188.5	5.06	9.54	31.2	198.8	4.90	9.74	32.2	189.8	4.95	9.39	30.9	660.9
264A	204.6	4.59	9.39	31.8	196.2	3.60	7.06	26.3	199.3	4.10	8.17	28.9	609.3
261A	153.8	3.69	5.68	20.9	156.1	3.45	5.38	20.4	156.6	3.80	5.95	21.7	441.7
256A	103.5	4.79	4.96	16.5	103.5	4.70	4.86	16.3	104.3	4.50	4.69	16.0	342.2
Total	1871.6		74.35	265.9	1890.4		66.52	250.2	1858.4		72.57	261.5	5449.8
Av.	207.7	3.98	8.26	29.5	210.0	3.52	7.39	27.8	206.5	3.90	8.06	29.0	605.5
							Group II						
392A	250.7	5.63	14.11	44.5	238.6	4.95	11.81	38.9	216.3	4.95	10.70	35.3	831.5
139A	309.1	3.47	10.72	40.6	303.5	3.20	9.71	38.1	284.5	3.50	9.96	37.3	814.7
257A	292.4	4.27	12.48	43.4	292.4	3.95	11.54	41.4	282.8	4.25	12.02	41.9	892.1
137A	272.2	3.25	8.84	34.5	266.4	2.90	7.73	31.8	252.7	3.10	7.83	31.2	682.5
259A	264.2	3.89	10.27	37.1	269.9	3.20	8.63	33.9	261.1	3.55	9.27	34.8	740.6
498A	180.1	4.20	7.56	26.5	178.2	4.85	8.64	28.7	185.3	4.70	8.71	29.3	591.1
301B	188.3	4.37	8.23	28.4	180.5	4.60	8.30	28.1	178.5	4.65	8.30	28.0	591.4
255A	154.5	4.94	7.63	25.2	161.9	4.65	7.52	25.3	158.5	4.65	7.37	24.8	527.8
251A	123.2	5.34	6.58	21.1	125.4	4.95	6.20	20.4	126.8	4.90	6.21	20.5	435.0
Total	2034.7		86.42	301.3	2016.8		80.08	286.6	1946.5		80.37	283.4	6106.7
Av.	226.1	4.25	9.60	33.5	224.1	3.97	8.89	31.8	216.3	4.13	8.93	31.5	679.1

Table 15. Production of milk, butterfat and four percent fat-corrected milk by weeks, Period 2.

Ear tag no.	1st week: Total lbs. milk	1st week: % test	1st week: Lbs. fat	1st week: Av. daily lbs. 4% f.c.m.	2nd week: Total lbs. milk	2nd week: % test	2nd week: Lbs. fat	2nd week: Av. daily lbs. 4% f.c.m.	3rd week: Total lbs. milk	3rd week: % test	3rd week: Lbs. fat	3rd week: Av. daily lbs. 4% f.c.m.	Total lbs. 4% fat corrected milk
Group I													
366A	244.0	3.85	9.39	34.1	240.7	3.95	9.51	34.1	248.5	4.05	10.06	35.7	727.7
373A	243.5	4.70	11.44	38.4	235.9	4.55	10.73	36.5	228.5	4.80	10.97	36.6	780.3
271A	195.5	3.35	6.55	25.2	189.3	3.45	6.53	24.8	190.9	3.50	6.68	25.2	526.7
262A	274.1	3.50	9.59	36.2	278.1	3.55	9.87	37.0	276.9	3.50	9.69	36.6	768.9
152A	298.3	3.05	9.10	36.5	310.3	3.10	9.62	38.3	316.4	3.05	9.65	38.7	795.5
305B	189.5	5.05	9.56	31.3	194.2	5.15	10.00	32.5	192.7	5.75	11.08	34.3	690.2
264A	210.5	3.95	8.31	29.8	213.8	4.45	9.51	32.6	220.1	4.30	9.46	32.8	667.0
261A	162.7	3.95	6.42	23.1	163.0	3.90	6.36	22.9	164.5	4.10	6.74	23.8	488.9
256A	101.3	4.35	4.40	15.2	107.1	4.35	4.66	16.1	101.9	4.30	4.38	15.2	325.7
Total	1919.4		74.76	269.8	1932.4		76.79	274.8	1940.4		78.71	278.9	5770.9
Av. per cow	213.3	3.89	8.30	30.0	214.7	3.97	8.53	30.5	215.6	4.05	8.74	31.0	641.2
Group II													
392A	163.2	5.00	8.16	26.3	158.8	5.65	8.97	28.3	157.8	5.50	8.68	27.6	579.1
139A	247.5	3.45	8.53	32.4	256.5	3.45	8.85	33.6	258.9	3.35	8.67	33.4	695.9
257A	242.5	4.25	10.30	35.9	243.2	4.20	10.42	36.5	240.7	4.65	11.19	37.7	771.2
137A	190.5	3.35	6.38	24.6	200.5	3.15	6.32	25.0	204.9	3.35	6.86	26.4	531.8
259A	220.0	3.45	7.59	28.8	218.0	3.60	7.85	29.3	213.5	3.85	8.22	29.8	615.5
498A	157.1	4.75	7.46	25.0	164.1	4.95	8.12	26.8	159.1	4.76	7.56	25.3	539.2
301B	155.8	4.80	7.47	24.9	158.9	5.00	7.94	26.1	158.2	5.10	8.07	26.3	541.4
255A	130.3	4.85	6.32	21.0	142.3	4.90	6.97	23.1	138.5	4.85	6.72	22.3	464.6
251A	97.4	5.10	4.96	16.2	110.4	4.95	5.46	18.0	104.3	4.75	4.95	16.6	355.4
Total	1604.3		67.17	235.6	1657.7		70.90	246.7	1635.9		70.92	245.4	5094.1
Av. per cow	178.2	4.18	7.46	26.1	184.2	4.27	7.87	27.4	181.7	4.33	7.88	27.3	566.0

Table 16. Production of milk, butterfat and four percent fat-corrected milk by weeks, Period 3.

Ear tag no.	1st week				2nd week				3rd week				Total lbs. 4% fat corrected milk
	Total lbs. milk	% test	Lbs. fat	Av. daily lbs. 4% f.c.m.	Total lbs. milk	% test	Lbs. fat	Av. daily lbs. 4% f.c.m.	Total lbs. milk	% test	Lbs. fat	Av. daily lbs. 4% f.c.m.	
Group I													
366A	211.5	3.85	8.14	29.5	211.6	4.10	8.67	30.7	210.0	3.85	8.08	29.3	626.6
373A	194.5	4.75	9.24	30.9	183.0	4.75	8.69	29.1	182.9	4.75	8.69	29.1	623.5
271A	174.0	3.45	6.00	22.8	173.1	3.55	6.14	23.0	170.6	3.50	5.97	15.4	478.7
262A	234.9	3.45	8.10	30.8	237.7	3.50	8.32	31.4	227.2	3.55	8.06	30.2	647.1
152A	286.4	3.05	8.73	35.1	274.9	3.30	9.07	35.1	283.7	3.10	8.79	35.0	736.8
305B	170.6	5.25	8.96	28.9	171.7	5.55	9.53	30.2	169.1	5.55	9.38	29.8	622.6
264A	179.5	4.40	7.90	27.2	174.9	4.40	7.69	26.5	165.0	4.40	7.26	25.0	550.5
261A	146.7	3.90	5.72	20.6	131.7	4.25	5.60	19.5	123.9	4.10	5.08	18.0	406.9
256A	70.2	4.50	3.16	10.8	65.5	4.55	2.98	10.1	61.6	4.55	2.80	9.5	213.0
Total	1668.3		65.95	236.6	1624.1		66.69	235.6	1594.0		64.11	221.3	4905.7
Av. per cow	185.4	3.95	7.33	26.3	180.4	4.1	7.41	26.2	177.1	4.02	7.12	24.6	545.1
Group II													
392A	149.0	5.15	7.67	23.5	142.1	5.55	7.88	25.0	143.0	4.95	7.08	23.3	513.1
139A	237.8	3.40	8.08	30.9	251.4	3.50	8.80	33.2	247.0	3.20	7.90	31.0	666.2
257A	237.1	4.50	10.67	36.4	237.0	4.45	10.54	36.1	238.8	4.30	10.27	35.6	757.4
137A	208.0	3.30	6.86	26.6	207.2	3.25	6.73	26.3	202.6	3.10	6.28	25.0	545.2
259A	241.9	3.50	8.47	32.0	239.3	3.55	8.49	31.9	238.8	3.50	8.36	31.6	667.8
498A	149.3	5.00	7.46	24.5	144.3	4.90	7.07	23.4	138.4	4.80	6.64	22.1	490.3
301B	158.3	4.95	7.83	25.8	149.8	5.20	7.79	25.2	152.2	4.80	7.30	24.3	527.9
255A	131.8	4.50	5.93	20.2	128.6	5.00	6.43	21.1	113.3	5.00	5.66	18.6	419.8
251A	108.5	4.50	4.88	16.6	103.7	4.75	4.93	16.5	100.7	4.25	4.28	14.9	336.0
Total	1621.7		67.85	236.5	1603.4		68.66	238.7	1574.8		63.77	226.4	4923.7
Av. per cow	180.2	4.18	7.54	26.2	178.1	4.28	7.63	26.5	175.0	4.05	7.08	25.1	547.1

Table 17. Average daily production four percent fat-corrected milk by period.

Cow's ear tag no.	Production at time cows were divided lbs.	Period 1		Period 2		Period 3	
		Preliminary	Experimental	Preliminary	Experimental	Preliminary	Experimental
		lbs.		lbs.		lbs.	
Group I							
366A	47.2	36.8	33.4	34.2	34.6	33.2	30.2
373A	50.2	37.3	37.1	36.4	37.1	33.8	29.7
271A	29.2	26.9	24.3	24.7	25.1	23.6	22.8
262A	43.7	35.4	35.1	35.1	36.1	34.7	30.8
152A	42.8	39.2	31.7	34.3	37.9	37.6	35.1
305B	35.5	33.0	31.5	30.1	32.9	32.2	29.6
264A	33.2	28.4	29.0	29.6	31.7	29.5	26.2
261A	23.9	20.3	21.0	22.2	23.3	23.3	19.4
256A	21.2	17.7	16.3	15.3	15.5	13.2	10.1
Total	326.9	275.0	259.4	261.7	274.7	261.1	233.7
Average	36.3	30.5	28.8	29.1	30.5	29.0	25.9
Group II							
392A	50.7	46.5	39.6	28.4	27.6	27.8	24.4
139A	45.2	48.7	38.8	35.6	33.1	32.1	31.7
257A	45.0	46.1	42.3	38.6	36.4	35.7	36.1
137A	38.4	35.9	32.9	27.6	25.3	26.9	25.9
259A	36.3	35.2	35.3	31.6	29.3	32.2	31.8
498A	30.8	31.1	28.2	27.1	25.7	25.2	23.3
301B	30.4	28.6	28.2	25.8	25.8	26.4	25.1
255A	27.8	25.2	25.1	22.8	22.1	21.9	20.0
251A	23.1	21.7	20.7	17.5	16.4	17.8	16.0
Total	327.3	319.0	291.1	255.0	241.7	236.4	234.3
Average	36.4	35.4	32.3	28.3	26.8	26.3	26.0

Table 18. Pounds T.D.N. consumed per 100 lbs. four percent fat-corrected milk.

Ear tag no.	T.D.N. Period 1 Intake (lbs.)	T.D.N. Period 1 lbs. per 100 lbs. 4% F.C.M.	T.D.N. Period 2 Intake (lbs.)	T.D.N. Period 2 lbs. per 100 lbs. 4% F.C.M.	T.D.N. Period 3 Intake (lbs.)	T.D.N. Period 3 lbs. per 100 lbs. 4% F.C.M.
			Group I			
366A	439.33	62.6	403.50	55.4	443.41	70.7
373A	487.62	62.4	449.34	57.5	473.38	75.9
271A	391.79	76.8	405.21	76.9	445.38	93.0
262A	429.91	58.2	428.95	55.7	470.22	72.6
152A	456.06	68.4	471.31	59.2	522.19	70.8
305B	403.66	61.0	428.73	62.1	456.95	73.3
264A	422.49	69.3	463.18	69.4	476.75	86.7
261A	352.88	79.8	390.65	79.9	413.70	101.6
256A	286.03	83.5	303.82	93.2	278.10	130.5
Total	3669.77	621.9	3744.69	609.3	3980.09	775.0
Av.	407.75	69.1	416.0	67.7	442.23	86.1
Daily av. per cow	19.41		19.81		21.06	
			Group II			
392A	486.38	58.4	383.20	66.1	344.19	67.0
139A	497.11	61.0	461.60	66.3	423.96	63.6
257A	435.91	49.1	398.59	52.0	405.23	53.5
137A	474.75	68.7	426.62	80.2	394.26	72.3
259A	472.66	63.8	435.17	70.7	443.86	66.4
498A	440.46	74.3	439.62	81.5	361.24	73.6
301B	393.31	66.5	395.19	72.9	393.11	74.4
255A	379.15	71.8	349.85	75.3	341.14	81.2
251A	334.64	76.9	305.62	88.9	289.49	86.0
Total	3914.37	590.5	3595.46	653.9	3396.48	638.0
Av.	434.9	65.6	399.49	72.6	377.4	70.9
Daily av. per cow	20.71		19.02		17.97	

Table 19. Pounds digestible protein consumed per 100 lbs. four percent fat-corrected milk.

Ear tag no.	Period 1		Period 2		Period 3	
	Intake (lbs.)	lbs. per 100 lbs. 4% F.C.M.	Intake (lbs.)	lbs. per 100 lbs. 4% F.C.M.	Intake (lbs.)	lbs. per 100 lbs. 4% F.C.M.
			Group I			
366A	45.44	6.477	69.74	9.583	54.63	8.719
373A	52.48	6.728	75.21	9.638	58.23	9.339
271A	42.86	8.413	70.66	13.415	52.76	11.021
262A	46.72	6.328	72.20	9.390	56.49	8.729
152A	48.42	7.272	72.26	9.083	62.98	8.547
305B	42.86	6.485	81.93	11.870	51.78	8.316
264A	44.72	7.339	77.04	11.551	56.07	10.185
261A	39.34	8.906	65.36	13.368	50.14	12.322
256A	32.23	9.418	37.35	11.467	36.72	17.239
Total	395.06	67.366	621.75	99.365	479.80	94.417
Av.	43.89	7.48	69.08	11.04	53.31	10.49
Daily av. per cow	2.09		3.29		2.54	
			Group II			
392A	94.24	11.333	41.50	7.166	58.76	11.451
139A	84.70	10.396	49.77	7.151	67.26	10.096
257A	80.94	9.118	42.96	5.612	72.50	9.572
137A	74.12	10.734	47.35	8.903	62.22	11.412
259A	83.21	11.235	46.98	7.632	76.79	11.498
498A	75.33	12.711	46.72	8.664	62.13	12.671
301B	75.01	12.683	42.77	7.899	73.12	13.851
255A	52.76	9.996	39.18	8.434	46.92	11.176
251A	47.17	10.843	34.26	9.967	36.14	10.739
Total	667.48	99.049	391.49	71.408	555.84	102.466
Av.	74.16	11.00	43.50	7.934	61.76	11.38
Daily av. per cow	3.53		2.07		2.94	

Table 20. Summary of production resulting from the two rations fed.

	Period 1	Period 2	Period 3	Total production	Relative production Percent
Sorgo silage milk production	6106.7	5770.9	4923.7	16,801.3	100.0
Alfalfa silage milk production	5449.8	5094.1	4905.7	15,449.6	91.9

Table 21. Summary by groups showing average production, feed ingested, nutrient intake, and percentage results on one ration as of the other.

	Period 1		Period 2		Period 3	
	Group I	Group II	Group I	Group II	Group I	Group II
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Body weight	931	980	936	970	975	987
Nutrient intake (protein)	2.09	3.53	3.29	2.07	2.54	2.94
Nutrient intake (T.D.N.)	19.41	20.71	19.81	19.02	21.06	17.97
Actual milk production	29.7	31.7	30.6	25.9	25.8	25.4
Actual fat production	1.13	1.30	1.22	1.10	1.04	1.06
Four percent fat-corrected milk	28.8	32.3	30.5	26.8	25.9	26.0
Pounds protein per 100 lbs. milk	7.48	11.00	11.04	7.93	10.49	11.38
Pounds T.D.N. per 100 lbs. milk	69.1	65.6	67.7	72.6	86.1	70.9
Milk produced per pound protein intake	13.8	9.2	9.3	12.9	10.2	8.8
Milk produced per pounds T.D.N. intake	1.48	1.55	1.54	1.41	1.23	1.45

Table 22. Production of four percent fat-corrected milk in pounds and difference in production during these three experimental periods.

Cow no.	Period 1	Period 2	Period 3	Differences
	X_1	Y_2	X_3	$X_1 - 2Y_2 + X_3$
366A	701.5	727.7	626.5	- 127.4
373A	780.0	780.3	623.5	- 157.1
271A	509.4	526.7	478.7	- 65.3
262A	738.2	768.9	647.1	- 152.5
152A	665.8	795.5	736.8	- 188.4
305B	660.9	690.2	622.6	- 96.9
264A	609.3	636.9	550.5	- 174.0
261A	441.7	488.9	406.9	- 129.2
256A	342.2	325.7	213.0	- 96.2
Sums	5449.0	5770.8	4905.6	-1187.0
392A	831.5	579.1	513.1	+ 186.4
139A	814.7	695.9	666.2	+ 89.1
257A	887.6	765.4	757.4	+ 114.2
137A	690.5	531.8	545.2	+ 172.1
259A	740.6	615.5	667.8	+ 177.4
498A	592.6	539.2	490.3	+ 4.5
301B	591.4	541.4	527.9	+ 36.5
255A	527.8	464.5	419.8	+ 18.6
251A	435.0	343.7	336.5	+ 84.1
Sums	6111.7	5076.5	4924.2	+ 882.9

Table 23. Statistical analyses of differences in production responses from the two rations used (t-test used as method of analysis).

	Group I	Group II
Sd	- 1187.0	882.9
$\bar{d}$	- 131.89	98.10
Sd^2	169,538.76	125,585.85
$\frac{(Sd)^2}{n}$	156,552.10	86,612.49
$S(d-\bar{d})^2$	12,986.66	38,973.36

$$s = \sqrt{\frac{12,986.66}{8} + \frac{38,973.36}{8}}$$

$$= \sqrt{\frac{51,960.02}{16}} = \sqrt{3,247.50} = 56.9868$$

$$s = 56.99$$

$$t = \frac{98.10 - (-131.89)}{56.99} \sqrt{\frac{(9)\,(9)}{9 + 9}}$$

$$= \frac{229.99}{56.99} \times 2.12$$

$$= 4.0356 \times 2.12$$

$$t = 8.555 \qquad D.F = 16$$

$P = < .01$

highly significant.