Ground Alfalfa Hay as a Substitute For 50 Per Cent of the Concentrate Mixture In the Dairy Ration

By

Estes E. Firestone

Bachelor of Science

Panhandle Agricultural and Mechanical College

Goodwell, Oklahoma

1942

Submitted to the Faculty of the Graduate School of the Oklahoma Agricultural and Mechanical College in Partial Fulfillment of the Requirements for the Degree of

Master of Science

1951

Ground Alfalfa Hay as a Substitute For 50 Per Cent of the Concentrate Mixture In the Dairy Ration

Estes E. Firestone

Master of Science

1951

THESIS AND ABSTRACT APPROVED:

E. R. Berousek
Thesis Adviser

C. F. Norton
Faculty Representative

D. G. McIntosh
Dean of the Graduate School

ACKNOWLEDGMENT

The author wishes to express his appreciation and gratitude to the many persons who were of service in conducting this study. Those contributing valuable information and suggestions were Dr. C. L. Norton, Professor E. R. Berousek, and Professor H. W. Cave. Acknowledgment is due Mr. C. J. Flesner for his assistance in caring for the cattle.

TABLE OF CONTENTS

INTRODUCTION

Every dairy farmer is faced with the problem of decreasing the cost of milk production through better cows and more efficient feeding and management practices. Feed cost is the largest item in the cost of milk production comprising about one-half of the total cost. The protein supplement is the most costly part of a well balanced dairy ration. Good legume roughages are high in protein and are an economical source of total digestible nutrients. The nature of the digestive system of the dairy cow makes it possible for her to consume large amounts of roughages and convert the lower quality of protein supplied by roughage to the high quality of protein needed by her body for maintainence and milk production. Therefore, it is important that roughages supply a large per cent of the total digestible nutrients in the dairy ration.

The use of ground roughage as a part of the concentrate mixture for dairy cattle depends on the amount of roughage consumed as hay, kind of roughage, chemical composition, digestibility, balance of nutrients, and cost of the components of the concentrate mixture. A factor which should be kept in mind when substituting ground roughage for concentrates is the variability of the quality of the roughage. Only the highest quality of roughage available should be used. Roughages are low in total digestible nutrients and grain mixtures containing

ground hay will be lower in total digestible nutrients than a mixture consisting of concentrates only. Therefore, it is necessary that larger amounts of a grain mixture containing ground roughage be fed.

This feeding trial was conducted in an effort to determine the per cent of total digestible nutrients that could be obtained from roughage and the value of ground alfalfa hay when substituted for fifty per cent of the grain mixture.

REVIEW OF LITERATURE

When plenty of high quality roughage is available, the question which confronts the dairy farmer is the proper proportion of the total digestible nutrients to be obtained from the roughage and the amount of concentrates to be fed for the most economical milk production.

Monroe and Allen (27) made a study of the effect of increasing the rate of hay feeding on the amount of milk produced and the cost of production. A heavy hay ration consisted of 30 pounds of alfalfa-timothy hay, 15 pounds of corn silage, and a grain mixture of corn, oats, and wheat bran fed in limited amounts. This was compared to a light hay ration composed of 15 pounds of hay, 40-45 pounds of corn silage, and a grain mixture that was fed more liberally.

The cows on the heavy hay ration produced slightly less milk but almost as much butterfat as the cows on the light hay ration. The feed cost was lower and the return above feed cost was higher on the heavy hay ration.

Carncross and Hauck (2) made a study of the cost of milk production on two groups of farms. Cows in one group obtained 72 per cent of their total digestible nutrients from roughage and the other group obtained only 53 per cent of their total digestible nutrients from roughage. It was shown that the feed cost of producing 100 pounds of 4 per cent fat-corrected milk was 46 cents less for the group receiving 72 per cent of their total digestible nutrients from roughage.

Headley(14) conducted a feeding experiment designed to determine the effect of various rations on production, health, and breeding efficiency of the cows. He found that grain rations composed largely of barley fed with alfalfa hay caused bloating while the cows fed an all hay ration were seldon affected with bloat.

Grain feeding increased fat production 16.9 per cent and milk production 17.4 per cent. Cows on the all hay ration made the most economical production under the conditions of this experiment. Over a period of eight years, the cows on the all hay ration had relatively high production and showed no apparent detrimental physical effects.

Graves and associates (9) reported on an experiment comparing four levels of feeding dairy cattle. Twelve Holstein cows were fed for one complete lactation on each of the following rations: The control ration was a full grain ration consisting of 2 parts barley, 1 part oats, and 1 part wheat bran fed at the average rate of 1 pound for each 4.33 pounds of milk produced. The cows were pastured during grazing season and

when not on pasture they were fed alfalfa hay and corn silage. Ration 1 consisted of alfalfa hay alone and pasture. Ration 2 consisted of alfalfa hay and pasture in season and ground barley at the rate of 1 pound for each 6.03 pounds of milk produced. During the fourth lactation they were fed ration 3 which consisted of alfalfa hay, corn silage, and pasture during grazing season.

Comparing their production on the full grain ration, the cows produced 65.77 per cent as much butterfat and 69.75 per cent as much milk on ration 1; 80.24 per cent as much butterfat and 86.03 per cent as much milk on ration 2; 69.93 per cent as much butterfat and 73.57 per cent as much milk on ration 3. All records were converted to a mature equivalent basis.

On the alfalfa hay ration the cows consumed an average of 34.8 pounds of alfalfa hay per day during the part of the lactation that they were not on pasture.

Lindsey and Archibald (24) conducted an experiment using a ration high in roughage and a relatively small amount of grain in comparison to a ration containing a small amount of roughage and a larger amount of grain.

The cows in the low roughage group required 7 per cent less dry matter and 2.7 per cent less digestible nutrients for the production of 100 pounds of milk. The daily milk yield was 14.4 per cent more for the low roughage group. The feed cost for milk production was about the same for both groups.

Moseley and co-workers (29) studied the effect of three planes of feeding on milk production. Cows were fed a full grain ration of 1 pound of grain mixture for each 3 pounds of

milk produced daily, a limited grain ration of 1 pound of grain for each 6 pounds of milk produced, and the third ration was an all roughage ration consisting of alfalfa hay, corn silage, roots and irrigated pasture. The same kind of roughage was fed to the cows on the grain ration.

These workers concluded that cows with more than average producing ability have sufficient capacity to consume nutrients in excess of their requirements, if allowed all the good quality roughage they can consume and if fed grain at the rate of 1 pound for each 3 pounds of milk produced.

Bachtell and associates (1) made a comparison of milk production on a moderate and a light grain ration when meadow crops were fed liberally both as hay and pasture. The cows on the moderate grain ration consumed one pound of grain for every 4.55 pounds of milk produced. This included 2 pounds of grain daily throughout the dry period and 1 pound of grain for each 4 pounds of milk produced during the lactation period. The group on the light grain ration was fed at the rate of 1 pound of grain for every 3 pounds of milk produced over 20 pounds, and during the dry period they received no grain. This group averaged 1 pound of grain for each 6.5 pounds of milk produced. Both groups were fed hay ad libitum. The moderate grain fed group received 803 pounds more grain and 473 pounds less hay than the light grain fed group. They found no marked difference in the health, reproductive history, and milk production of the two groups studied.

According to Jensen (21), 15 to 20 per cent more milk was produced by cows fed at levels higher than the Haecker standard,

and 45 per cent more than cows fed at 70 to 80 per cent of this standard. The response to increased feed was less at the high levels than at the low levels; for the high levels production of 4 per cent fat-corrected milk was increased .6 pound for each additional pound of digestible nutrients and 1.7 pounds at the low levels. The cows returned on the average about 3 pounds of fat-corrected milk per pound of digestible nutrients consumed above maintenance. An increase of 1.0 to 1.5 pounds of 4 per cent milk was obtained for each pound of total digestible nutrients added to a normal ration. Feeding at different levels had no influence on the fat percentage of the milk.

Graves and associates (8) reported results of feeding experiments conducted over a period of several years with fifteen Holstein cows involving twenty-four lactations. All cows had previous production records made on full feed. On an all alfalfa hay ration the fifteen cows averaged 60 per cent as much butterfat and 57 per cent as much milk as they produced when on full feed. The decline in daily milk production for the entire lactation was more rapid when the cows were on the alfalfa hay ration. The cows consumed an average of 14,352 pounds of alfalfa hay for each lactation. They consumed an average of 1.3 pounds of alfalfa hay for each pound of milk produced and 38 pounds for each pound of butterfat produced. Under the conditions of this experiment, the cows refused approximately 15 per cent of the hay offered them. During the first, second, and third month of their lactations they obtained 74, 82, and 91 per cent respectively of the total digestible nutrient requirements for maintenance and production, but for the average

of the lactation they received 3.6 per cent more than was required.

The exclusive feeding of alfalfa hay over long periods did not lower the butterfat percentage and had no detrimental effect on the breeding performance and the condition of the cows at calving.

A study of heavy and light grain feeding was made by Woll and associates (36). The cows on a heavy grain ration received 1 pound of concentrates for each 3 pounds of milk produced while the other group received 1 pound grain for each 5 pounds of milk produced. The heavy fed cows produced 5 per cent more milk and butterfat than the light fed group. They concluded that under the conditions of their experiment, heavy grain feeding was not economical.

Dickson and Kopland (4) reported the results on an experiment by the United States Department of Agriculture conducted at Huntley, Montana, to determine to what extent a limited grain ration with roughage and a ration consisting of roughage alone would affect the quantity of milk produced by Holstein cows capable of fairly high production on a full grain ration. The grain mixture fed in the full and limited grain ration contained 12.9 per cent of digestible protein and 74.3 per cent of total digestible nutrients. The cows had previous lactation records averaging 619.9 pounds of butterfat made on a full grain ration of 1 pound of grain for each 3 pounds of milk produced. All production records were converted to a mature basis. When fed an all-roughage ration they produced 478 pounds of butterfat or 77.1 per cent as much as they did on the full grain ration. Adding a limited amount of grain, 1 pound for each 6 pounds of

milk produced, to the roughage increased the production to 584.1 pounds of butterfat or 94.2 per cent of that produced on the full grain ration. They concluded that the full grain ration was not economical and that the limited grain proved adequate and most economical when fed with all the roughage the cows would consume. Without any loss in weight, the cows in this investigation on roughage alone were able to produce healthy calves and an average of over 13,000 pounds of milk.

Work conducted by Hart and Humphrey (13) indicated that when dairymen have an abundance of alfalfa hay and cereal grains which included corn and barley or oats, they can compute rations which will meet requirements for maintenance and milk production up to 50 or more pounds daily.

Hodgson and associates (16) fed Holstein cows an all roughage ration which included good pasture in the summer and home grown hay and silage in the winter during a three year experiment. The cows maintained themselves, produced healthy calves, and produced 76 per cent as much milk and 72.5 per cent as much butterfat as they had previously produced when fed a grain mixture in addition to roughage.

Haag and associates (10) (11) (12) interpret the results of their studies to indicate that where cattle are restricted largely to alfalfa, attention should be given to supplements which will increase the phosphorus content of the ration, improve the biological value of the protein, and where high production is expected, supply sufficient total digestible nutrients.

Huffman (17) and Huffman and Duncan (18) (19) (20) supplemented an all-alfalfa hay ration with various feeds. They

found that adding l-cystine, starch, or glucose to an all-alfalfa ration did not increase milk production. Substituting a portion of the total digestible nutrients in alfalfa hay with equal amounts of total digestible nutrients in either corn, cottonseed meal, or corn gluten meal increased milk production.

Morrison (28) stated that when the only roughage is alfalfa hay, cowpea hay, or soybean hay, the protein supplied by the hay will be sufficient for a cow of ordinary productive capacity when corn or a mixture of corn and other grain is fed.

At the Missouri Station, McIntyre and Ragsdale (26) conducted an experiment using a roughage ration of alfalfa hay, silage, and pasture with cows that had previous lactation records on a full grain ration. On the roughage ration they produced 85 per cent as much milk and 80 per cent as much fat as they did on the full grain ration. On the roughage ration, the rate of decline in production was more rapid with advancing lactation.

They found no significant difference in milk production on a grain mixture fed at the rate of one pound of grain for each 6 pounds of milk produced during the lactation, and a grain mixture fed at the rate of 1 pound for each 3 pounds of milk produced during the first 100 days of the lactation, 1 pound for each 6 pounds of milk produced during the second 100 days and no grain during the rest of the lactation. Grain feeding throughout the lactation was more efficient.

Sherwood and Dean (30) fed a ration composed entirely of alfalfa and a ration of alfalfa hay and concentrates. The hay fed group consumed 31.7 pounds of hay per cow per day when not receiving pasture. The hay and grain fed group, when pasture

was not available, consumed 29.8 pounds of hay and 5 pounds of concentrates per cow per day.

The hay fed cows produced the mature equivalent of 5,875 pounds of 4 per cent fat-corrected milk as compared to 7,181 pounds for the hay and grain fed lot. The hay fed lot required 5.8 per cent more digestible nutrients to produce a pound of butterfat than the hay and grain fed lot.

Smith and associates (31) compared the value of alfalfa hay alone supplemented with minerals and alfalfa hay supplemented with concentrates, keeping the digestible protein intakes at the same level. Their results indicated that good producing cows did not utilize a ration of alfalfa hay supplemented with minerals as well as they did a ration where concentrates replace part of the alfalfa hay. They concluded that the total digestible nutrients system of feed evaluation overrated the feeding value of good alfalfa hay for milk production, when fed in large amounts and supplemented with salt and phosphorus.

According to Willard (34) 18 per cent more milk and 13 per cent more butterfat was produced on a ration of alfalfa hay and ground barley fed at the rate of 1 pound for each 5 pounds of milk produced, than was produced on an all alfalfa ration. The persistence in milk yield was greater in the group receiving grain. There was no evidence that the hay ration affected the breeding efficiency of the cows.

In a later report Willard (35) stated that feeding grain had little effect on the amount of hay consumed, and that it was questionable if cows with the ability to produce 30 to 40

pounds of milk at maximum production would benefit from feeding grain in addition to high quality alfalfa hay and irrigated pasture.

Soule and Barnes (33) found that alfalfa hay, when substituted pound for pound, was inferior to wheat bran. They recommended feeding 1.5 pounds of alfalfa hay for each pound of wheat bran replaced.

Mairs (25) made a study to compare alfalfa meal and wheat bran for milk and butterfat production. The control ration contained 50 per cent of wheat bran, 37.5 per cent of corn meal, and 12.5 per cent of cottonseed meal. In the experimental ration alfalfa meal was substituted pound for pound for the bran.

The cows did not eat the alfalfa meal ration as readily as they did the control ration. The cows decreased in milk production when changed from the control ration to the alfalfa meal ration and in some cases increased in production when changed back to the control mixture.

Lindsey (23) concluded that pound for pound wheat bran proved superior to alfalfa meal in a ration for dairy cows.

Snyder and Burnett (32) conducted an experiment to determine whether chopped alfalfa hay could be substituted for wheat bran in a ration consisting of 4 parts corn, 2 parts bran, and 1 part oil meal. Cows fed the ration containing the chopped alfalfa produced 145 pounds less milk and 7.5 pounds less butterfat but they gained 272 pounds in body weight. They concluded that chopped alfalfa hay was equal to bran when fed in this manner.

Kuhlman and Cave (22) fed a ration in which ground alfalfa hay replaced 30 per cent of the grain ration when prairie hay was used as the roughage. Approximately 10 per cent more of the experimental ration was fed to maintain the same total digestible nutrient intake as the control ration. Satisfactory milk production and body weight was maintained on the experimental ration.

Hills (15) substituted alfalfa meal for wheat bran when the mixture contained 62.5 per cent of bran. The mixture containing alfalfa produced 2 per cent less milk and 5 per cent less fat than the control. On another trial he substituted alfalfa meal for distillers' dried grains in a ration containing 62.5 per cent of distillers' dried grains and found an increase of 14 per cent more milk and 18 per cent more fat on the ration containing distillers' dried grains.

Fraser and Hayden (6) fed equal amounts by weight of alfalfa hay and wheat bran with a basal ration made up of 6 pounds of clover hay, 30 pounds of corn silage, and 6 pounds of corn meal. During the first period, cows in lot 1 received the basal ration and all the choice alfalfa hay they would eat, which was 8 pounds. The cows in lot 2 were fed the basal ration and 8 pounds of bran in the place of the 8 pounds of alfalfa hay. For the second period the rations were reversed. Their results indicated that for milk production a ration containing 8 pounds of alfalfa hay was equal to or a little better than the same ration when an equal amount of wheat bran was substituted for the alfalfa hay.

Davis (3) maintained satisfactory weight and milk production on cows fed a grain mixture composed of 30 per cent ground alfalfa hay. The same total digestible nutrient intake was maintained on both experimental and control rations.

In another trial it was found that the ground alfalfa included in the grain mixture of the preceding trial, when fed long in addition to the regular roughage produced equally good results.

Espe and Cannon (5) conducted two feeding trials with ground hay in the ration. In the first trial the cows were fed corn silage, alfalfa hay, and a grain mixture of 3 parts ground corn, 3 parts ground oats, and 1 part linseed oil meal. In alternate periods, the alfalfa hay was ground and fed with the grain. During alternate periods in the second trial, half of the silage was replaced with a mixture of 40 parts ground alfalfa and 60 parts ground corn fodder. The cows received between 10 and 15 pounds of ground roughage and 7.5 pounds of uncut hay per day. It was concluded that changing the physical character of the roughage did not materially influence the per cent of fat in the milk.

EXPERIMENTAL PROCEDURE

Selection of Cows and Formation of Lots.

In selecting the animals for this feeding trial the object was to provide two equal groups of individuals which had reached the peak of production, but which were either not bred or not sufficiently far along in gestation so that the accelerated

drop in milk production which occurs later in the gestation period would become a complicating factor. To accomplish this object, twenty purebred cows, including five Jerseys, five Holsteins, eight Ayrshires, and two Guernseys, which had recently freshened, were chosen and their performance observed during a ten-day pre-experimental period. During this period the cows were fed the herd grain mixture and the alfalfa hay used in the experiment. The twelve most suitable cows were selected and divided in two groups which were as nearly alike as possible on the basis of their performance during the preliminary period, their previous history, breed, number of lactations, stage of lactation, and body weight. Cows number 4 and 6 had been bred forty-five days when the experiment started and the rest were open. Table I shows the data on which the final selection and assignment were based.

Roughage and Concentrates Used.

The alfalfa hay used as roughage in this feeding trial was not of the quality desired, but due to the fact that better quality hay was not available at this time of the year, it was necessary to use a roughage that was slightly brown and a little coarse. However, the hay contained a high percentage of leaves. It was fed at the rate of 2 pounds per 100 pounds body weight.

The control grain mixture consisted of 500 pounds of ground No. 2 yellow corn, 250 pounds of ground oats, 250 pounds of wheat bran, 10 pounds of steamed bone meal, and 10 pounds of salt. Upon calculation, it was found to contain 9 per cent digestible protein and 74.13 per cent total digestible nutrients. The

TABLE I

Data on Cows Selected and Group Assignment

Cow No.	Breed	Number of Lactation	Days in Milk *	Weight Lbs.**	Daily Milk Production Lbs. ***	Daily Butterfat Production Lbs. ****
Lot I						
3	Jersey	3	117	851	25.89	1.1650
7	Holstein	2	108	1246.5	44.08	1.5868
11	Ayrshire	3	103	1012.5	34.47	1.2753
13	Ayrshire	3	104	1006.0	31.32	1.1901
15	Ayrshire	2	104	868	28.98	.9853
17	Guernsey	5	73	1011	25.45	1.2216
Total		18	609	5995.0	190.19	7.4241
Average		3	101.5	999.16	31.69	1.2373
Lot II						
2	Jersey	3	109	827	25.94	1.4526
4	Jersey	3	146	756	25.00	1.2000
6	Holstein	2	138	1263	42.59	1.5758
12	Ayrshire	6	94	1116.5	39.5	1.4220
14	Ayrshire	4	75	1125	43.07	1.6366
16	Ayrshire	2	153	969.5	29.51	1.0918
Total		23	715	6057.0	205.61	8.3788
Average		3.83	119	1009.5	34.26	1.3964

* From beginning of lactation to pre-experimental period.

** Average for ten-day pre-experimental period.

*** Average for ten-day pre-experimental period.

**** Fat tests used in making these calculations were taken from the previous month's test.

experimental mixture consisted of 250 pounds of ground No. 2 yellow corn, 125 pounds of ground oats, 125 pounds of wheat bran, 500 pounds of ground alfalfa hay, 10 pounds of steamed bone meal, and 10 pounds of salt. This mixture contained 11.37 per cent digestible protein and 61.88 per cent total digestible nutrients. The ground hay used in this mixture was purchased from the Stillwater Milling Company, and it was green and extra leafy. Table II shows the chemical analyses of the feeds and concentrate mixture used.

TABLE II

Chemical Analyses of Feeds and Concentrate Mixtures

Feed	Moisture %	Ash %	Protein %	Fat %	Fiber %	N.F.E. %
Alfalfa Hay	5.78	7.31	13.62	1.80	34.37	37.12
Wheat Bran	11.30	6.23	15.16	4.55	9.06	53.70
Ground Corn	13.14	1.25	8.96	3.82	1.64	71.19
Ground Oats	10.46	3.26	13.50	3.68	10.14	58.96
Ground Alfalfa	9.62	9.84	18.00	1.14	26.47	34.93
Experimental Mix No. 2	9.94	7.47	15.16	2.78	16.16	48.49
Control Mix No. 1	10.87	4.50	11.47	4.02	4.93	64.21

It may be noted from the above table that the ground alfalfa hay used in this feeding trial contained 18 per cent protein and 26.47 per cent fiber. This was 4.38 per cent more protein and 7.9 per cent less fiber than the long hay that was used as roughage, which indicates the high quality of the ground alfalfa used.

The composition of the concentrate mixture used is shown in Table III.

TABLE III

Formulas of the Concentrate Mixtures

and Their Digestible Protein

and Total Digestible Nutrients Contents. *

Ingredients	Amount Lbs.	Digestible Protein Lbs.	Total Digestible Nutrients Lbs.
Mixture No. 1			
#2 Yellow Corn	500	34.00	412.35
Wheat Bran	250	31.47	170.20
Ground Oats	250	26.33	173.58
Ground Alfalfa Hay	---	-----	------
Steamed Bone Meal	10	-----	------
Salt	10	-----	------
Total	1020	91.80	756.13
Percentage	---	9.0	74.13
Mixture No. 2			
#2 Yellow Corn	250	17.00	206.17
Wheat Bran	125	15.74	85.10
Ground Oats	125	13.16	86.79
Ground Alfalfa Hay	500	67.50	253.20
Steamed Bone Meal	10	-----	------
Salt	10	-----	------
Total	1020	103.40	631.26
Percentage	---	11.37	61.88

* A separate analysis was made of each feed in the mixture. The digestion coefficients from Morrison's "Feeds and Feeding", Twentieth Edition, were used to determine the digestible protein and the total digestible nutrients.

The nutritive requirements for the cows were based on Morrison's feeding standard (28). The cows were offered ten per cent more total digestible nutrients than their theoretical requirement in order to insure maximum production. The rations were calculated at the beginning of the experiment and the same amount was offered throughout the feeding trial. It was necessary to feed more of the experimental mixture, due to its lower total digestible nutrient content, in order to obtain the same nutrient intake as the control mixture.

Salt was available in a box in the dry lot.

Management of the Cows.

The ninety-day double-reversal system was used. Each period consisted of a ten-day preliminary period for reversing the ration, and twenty days for the experimental period. Lot I received the control ration during the first and third periods and the experimental ration during the second period. Lot 2 received the experimental ration during the first and third periods and the control ration the second period. The change from one ration to the other was made gradually.

The cows were milked twice daily in the milking parlor with a machine. Milk samples of each cow were taken for six consecutive milkings near the middle of each period and tested for butterfat content by the Babcock method.

The cows were kept out of doors in a dry lot when the weather was favorable, except when being fed or milked. The lot, half of which was paved, was north of and adjacent to the dairy barn. The cows were watered from a tank in the dry lot

and from watering cups at each stanchion. They were fed in individual stalls with special boxed-in mangers to permit an accurate check on the amount of feed consumed and refused. The evening hay allowance was weighed out and placed in the mangers after the cows had been turned out in the morning and the feed refused had been weighed back. The morning hay allowance was weighed and placed in the mangers as soon as the cows were turned out in the evening. The grain allowances were weighed out for the individual cows every afternoon for the evening and morning feedings. The evening allowance was placed directly in the mangers and the morning allowance was placed in individual sacks with the cow's name on it and placed in front of the manger to await the morning feeding. If the cows were kept inside, the morning hay allowance was handled in the same manner as the grain ration. Roughage was fed when the cows were brought in at 2 A.M. and 1 P.M.

The cows were weighed daily beginning about one o'clock and weighed in the same order each day. The average of three consecutive days' weights was used for the initial weight and the final weight for each experimental period.

DISCUSSION OF RESULTS

The data obtained during the last twenty days in each period were used in calculating the results of this feeding trial.

Body Weights.

The average daily weights of the lots throughout the experiment are shown in Figure I. Preliminary period I was started March 23, 1950, and on March 30 the weather turned very cold causing a drop in body weights of both lots, however, lot I on the control ration dropped more than lot II. The other sharp drop occurring on May 10 and 11 was caused by cool weather and heavy rainfall. There was some variation in weight throughout the experiment. Both lots seemed to vary in the same direction regardless of which ration they were on indicating that the marked changes in body weight were due to weather conditions.

Table IV is the summary of data comparing the control and the experimental rations. The body weights on the control ration are the average weights for lot I during periods I and III, plus the body weights of lot II during period II. The weights for the experimental ration are the average body weights of lot II during periods I and III, plus the body weights of lot I during period II.

The cows on the control ration lost on the average of 1.83 pounds for each twenty days of the trial. While the cows on the experimental ration gained 2.13 pounds for each twenty days.

Milk Production.

The summary of data in Table IV compares the production of milk and butterfat on each ration. The production on the control ration is the average production of lot I during periods I and III, plus the production of lot II during period II, and the production on the experimental ration is the average of

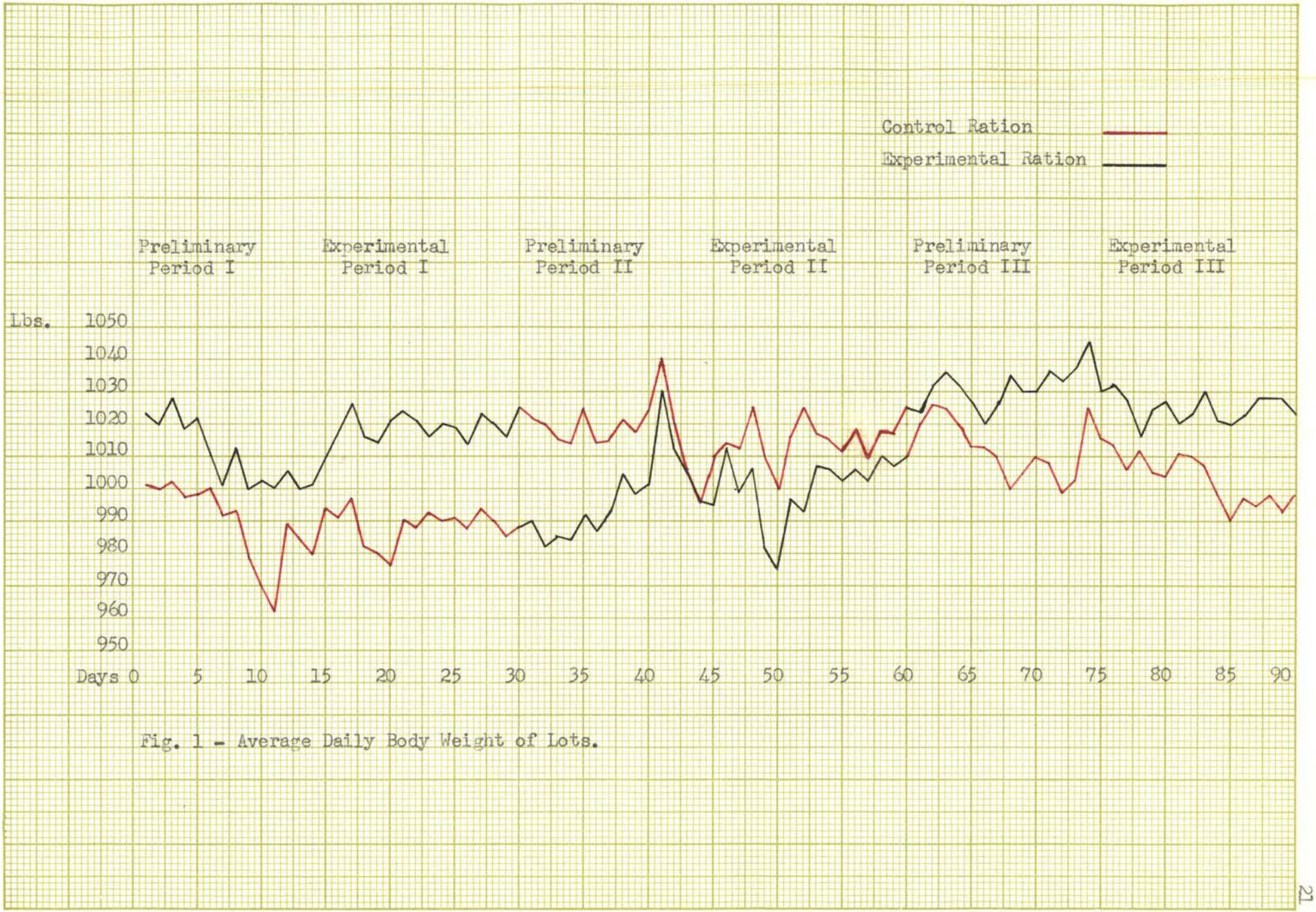

Fig. 1 - Average Daily Body Weight of Lots.

TABLE IV

Summary of Experimental Data

No. of Cows - Twelve	Control Mixture	Experimental Mixture
Body Weights		
Average initial weight lbs.	1009.08	1016.20
Average final weight lbs.	1007.25	1018.33
Average daily weight *	1005.52	1012.39
Average gain or loss per cow lbs.	-1.83	+2.13
Pounds of Milk Produced		
Total milk yield lbs.	6738.6	6440.2
Total butterfat yield lbs.	252.18	247.64
Total yield 4% F.C.M. lbs.	6478.10	6290.62
Average daily milk yield per cow lbs.	28.08	26.83
Average per cent butterfat	3.74	3.85
Average daily yield of butterfat per cow lbs.	1.05	1.03
Average daily yield 4% F.C.M. per cow lbs.	26.99	26.21
Total Pounds of Feed Used		
Concentrate mixture offered	3064.0	3632.0
Concentrate mixture refused	18.9	106.0
Concentrate mixture consumed	3045.1	3526.0
Per cent concentrate mixture refused	.62	2.92
Alfalfa hay offered	5140.0	5140.0
Alfalfa hay refused	101.75	118.85
Alfalfa hay consumed	5038.25	5021.15
Per cent alfalfa hay refused	1.98	2.31
Average Daily Ration per Cow, Pounds		
Concentrate mixture offered	12.77	15.13
Concentrate mixture refused	.08	.44
Concentrate mixture consumed	12.69	14.69
Alfalfa hay offered	21.41	21.41
Alfalfa hay refused	.42	.50
Alfalfa hay consumed	20.99	20.91
Pounds of Feed for 100 Pounds 4% F.C.M.		
Concentrate offered	47.77	58.25
Concentrate consumed	47.47	56.58
Alfalfa hay offered	81.29	83.82
Alfalfa hay consumed	79.61	81.79

* All cows weighed each day during the experiment.

lot II during periods I and III, plus the production of lot I during period II. The cows on the control ration produced a total of 6738.6 pounds of milk and 252.18 pounds of butterfat, or an average daily yield per cow of 28.08 pounds of milk and 1.05 pounds of fat. The production of the cows on the experimental ration was 6440.2 pounds of milk and 247.64 pounds of fat or an average daily yield per cow of 26.83 pounds of milk and 1.03 pounds of fat.

The production when corrected to a 4 per cent fat-corrected basis, using Gaines' (7) formula, was 6478.1 pounds of milk or an average daily yield of 26.99 pounds per cow on the control ration and 6290.62 pounds or an average daily yield of 26.21 pounds of milk per cow on the experimental ration. There was no marked difference in the milk and fat production on the two rations.

Figure 2 shows the average daily production of 4 per cent fat-corrected milk. The gradual decline in the production of 4 per cent fat-corrected milk as the experiment progressed was due to the advancing stage of lactation of the cows. The production was more persistent when the cows received the control ration.

Feed Consumption.

Both rations were consumed readily by all the cows except no. 12 which refused part of both rations. Cow no. 2 refused a part of the experimental mixture during the third period of the experiment. Most of the concentrates refused were by these two cows. This would indicate that there was little difference

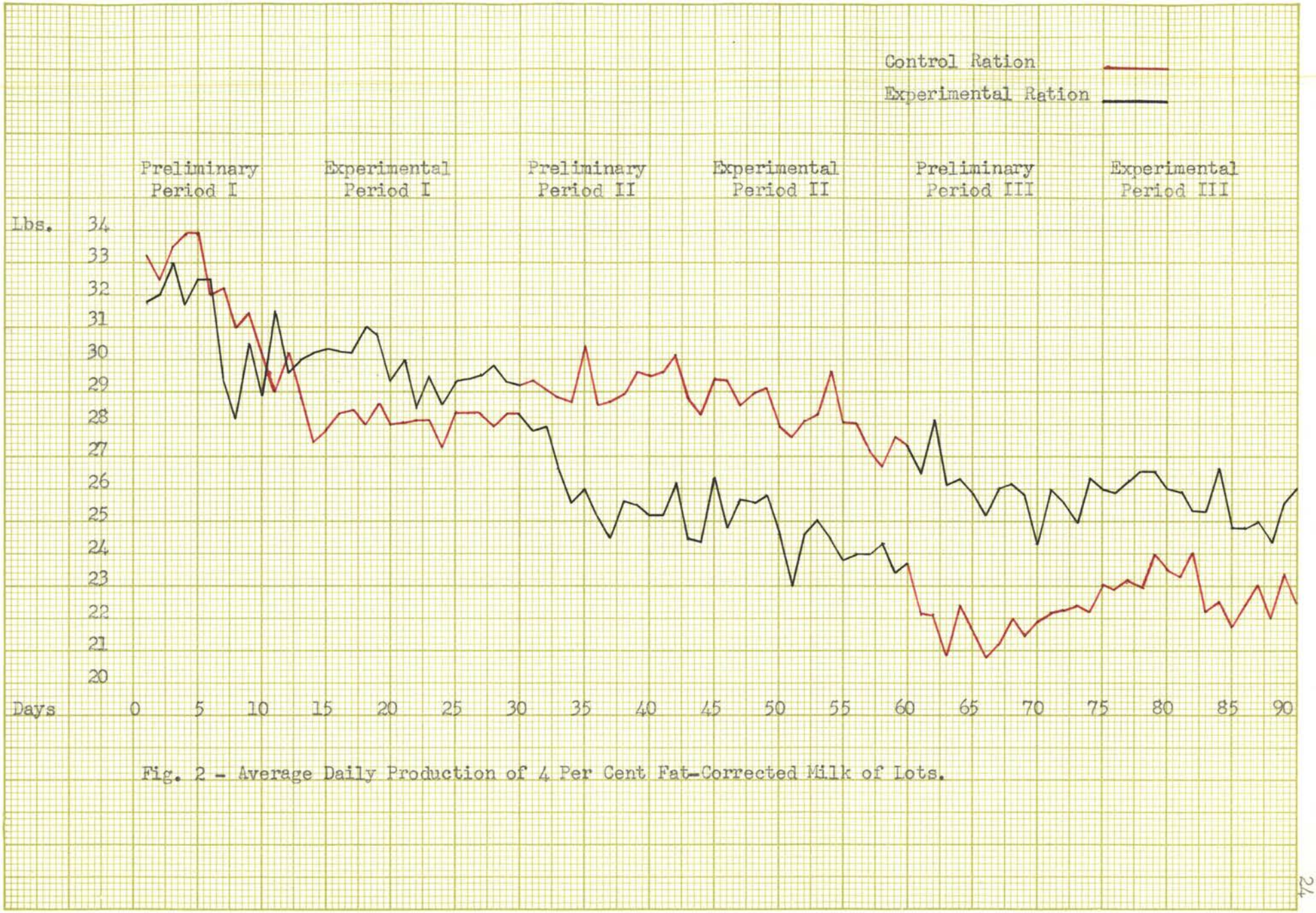

Fig. 2 - Average Daily Production of 4 Per Cent Fat-Corrected Milk of Lots.

in the palatability of the two rations. The summary of the data in Table IV shows that 0.62 per cent of the control mixture was refused and 2.92 per cent of the experimental mixture was refused. The amount of concentrates refused or consumed seemed to depend on the individual cow rather than on the nature of the ration. For example, cow no. 14 whose roughage consumption was the greatest, was offered 824 pounds of the experimental mixture and refused 29.9 pounds in 40 days of the feeding trial. During this same time she consumed 900.3 pounds of long hay or a total roughage consumption of 1297.35 pounds which included the ground hay in the experimental ration. The cows on the control mixture refused 1.98 per cent of the long hay offered, while the cows on the experimental mixture refused 2.31 per cent of the long hay offered.

The requirements for the production of 100 pounds of 4 per cent fat-corrected milk on the control mixture was 47.47 pounds of concentrates and 79.61 pounds of alfalfa hay. On the experimental mixture, the requirements for the production of 100 pounds of 4 per cent fat-corrected milk were 56.58 pounds of concentrates and 81.79 pounds of alfalfa hay. In this feeding trial 28.29 pounds of ground alfalfa hay replaced 19.18 pounds of the control grain mixture in the production of 100 pounds of 4 per cent fat-corrected milk or 1.47 pounds of ground alfalfa hay was equal to 1 pound of control grain mixture. The cows on the experimental consumed 30.47 pounds or 38.27 per cent more hay, in long hay and ground hay, and 40.4 per cent less actual grain for each 100 pounds of 4 per cent fat-corrected milk produced than the cows on the control mixture.

Table V shows the per cent of total digestible nutrients supplied by the hay and concentrate mixture in each ration. The cows on the control mixture obtained 47.19 per cent of their total digestible nutrients in the concentrate mixture and 52.81 per cent in the hay consumed which was all long hay. The cows on the experimental mixture obtained 46.87 per cent of their total digestible nutrients from the concentrate mixture and 53.13 per cent in the long hay consumed. In addition to the 53.13 per cent of the total digestible nutrients supplied in the form of long hay, the experimental ration supplied 18.8 per cent more total digestible nutrients in the ground hay in the concentrate mixture, making a total of 71.93 per cent of the total digestible nutrients supplied by the total hay in the ration. This was an increase of 19.12 per cent over the control mixture.

The Value of Ground Alfalfa Hay.

The method used in calculating the value of the ground alfalfa hay is shown in Table VI. The feed cost for the production of 100 pounds of 4 per cent fat-corrected milk for the control mixture was $2.19. The cost of the experimental mixture, less the cost of the ground alfalfa hay, for the production of 100 pounds of 4 per cent fat-corrected milk was $1.75 or $0.44 less than the feed cost of the control mixture. In this feeding trial 27.74 pounds of ground alfalfa hay were worth $0.44 or $31.80 per ton. The value of ground alfalfa hay will depend on the price of the hay and the other feeds used.

TABLE V

Per Cent of Total Digestible Nutrients Supplied by Hay and Concentrate Mixture in Each Ration

	Control Ration				Experimental Ration					
	Lbs. of Feed Consumed		% of T.D.N. Supplied		Lbs. of Feed Consumed			% of T.D.N. Supplied		
	Long Hay	Conc. Mix.	Long Hay	Conc. Mix.	Long Hay	Conc. Mix.	Total Hay*	Long Hay	Conc. Mix.	Total Hay*
Lot I										
Period I	2505.2	1460.0	53.46	46.53						
Period II					2488.5	1707.2	3342.1	53.90	46.10	72.40
Period III	2460.1	1449.6	53.19	46.81						
Lot II										
Period I					2558.5	1880.6	3498.8	52.18	47.82	71.37
Period II	2555.6	1590.3	51.83	48.17						
Period III					2506.8	1757.0	3384.9	53.37	46.63	72.08
Total	7520.9	4499.9	52.81	47.19	7553.8	5344.8	10225.8	53.13	46.87	71.93

* Total Hay = long hay consumed as roughage plus the ground hay in the concentrate mixture.

TABLE VI

Calculations Used in Determining the Value of Ground Alfalfa Hay

Ingredients	Pounds	Per cent of Mixture	Lbs. Needed to Produce 100 Lbs. of 4% F.C.M.	Feed Cost Per Lb.	Total Feed Cost
Control Mixture					
#2 Yellow Corn	500	49.02	23.2697	$0.0255	$0.5934
Wheat Bran	250	24.51	11.6348	0.0210	0.2443
Ground Oats	250	24.51	11.6348	0.0287	0.3339
Steamed Bone Meal	10	.98	.4652	0.0435	0.0202
Salt	10	.98	.4652	0.0075	0.0035
Total (Con. Mix.)	1020	100.00	47.4697		
Alfalfa Hay			79.61	0.0125	0.9951
Total Cost					$2.1904
Experimental Mixture					
#2 Yellow Corn	250	24.51	13.8678	$0.0255	$0.3536
Wheat Bran	125	12.25	6.9311	0.0210	0.1456
Ground Oats	125	12.25	6.9311	0.0287	0.1989
Ground Alfalfa Hay	500	49.02	27.7355		
Steamed Bone Meal	10	.98	.5545	0.0435	0.0241
Salt	10	.98	.5545	0.0075	0.0042
Total (Con. Mix.)	1020	99.99	56.5745		
Alfalfa Hay			81.79	0.0125	1.0224
Total Cost Excluding the Cost of the Ground Alfalfa Hay					$1.7488
Ground Alfalfa Hay Needed in this mixture					0.4416
Value of Ground Alfalfa Hay per Pound				$0.0159	

Assuming the cost of the ground hay to be the same as the long hay, the feed cost on the experimental mixture, excluding the cost of grinding the hay, was $0.08 less for each 100 pounds of 4 per cent fat-corrected milk produced. Since the ground alfalfa hay used in this feeding trial was a better quality hay and was purchased ground, the actual cost per ton was a little more than the cost per ton of the long hay.

The prevailing prices of the feeds at the start of the experiment were used in calculating the value of the ground alfalfa hay. The following were the prices quoted:

Yellow Corn No. 2	$1.43 per bu.
Oats	.92 per bu.
Wheat bran	2.10 cwt.
Steamed bone meal	4.35 cwt.
Salt	.75 cwt.
Alfalfa hay	21.00 per ton

SUMMARY OF EXPERIMENTAL DATA

Twelve cows were used in a double-reversal feeding trial to determine the per cent of the total digestible nutrients that could be obtained in alfalfa hay, and the value of ground alfalfa hay when it replaced fifty per cent of the grain mixture.

The rate of feeding on the experimental mixture was increased to supply the same total digestible nutrient intake that was supplied by the control mixture. The same level of feeding was maintained throughout the experiment.

The requirements for the production of 100 pounds of 4 per cent fat-corrected milk on the control mixture were 47.47 pounds of concentrates and 79.61 pounds of alfalfa hay. On the experimental mixture the requirements were 56.58 pounds of concentrates and 81.79 pounds of alfalfa hay. In this feeding trial 1.47 pounds of ground alfalfa hay were equal to 1 pound of the control mixture. The cows on the experimental mixture consumed 30.5 pounds or 38.27 per cent more total hay and 19.2 pounds or 40.4 per cent less actual grain mixture per 100 pounds of 4 per cent fat-corrected milk produced than the cows on the control mixture. The cows on the experimental mixture obtained 71.93 per cent of their total digestible nutrients from alfalfa hay which was 19.12 per cent more than the hay supplied when the cows were on the control mixture.

The value of the ground alfalfa hay used in this experiment was $31.80 per ton. In calculating the value of the ground alfalfa hay, the prices used were the local prices of feed at the time the experiment was started.

CONCLUSIONS

On the basis of the results of this experiment the following conclusions seemed warranted:

1. Body weight and milk production were maintained satisfactorily on a ration composed of alfalfa hay and a grain mixture containing 50 per cent ground alfalfa hay.

2. In this feeding trial 71.93 per cent of the total digestible nutrients were obtained from alfalfa hay when the

cows were on the experimental ration. The ground alfalfa hay was worth $31.80 per ton for milk production. One pound of the control mixture was equal to 1.47 pounds of the ground alfalfa hay. The value of alfalfa hay will vary with the prices of the other feeds. Grinding alfalfa does not increase its feeding value.

3. Additional work should be done to determine the maximum use of ground alfalfa hay as a substitute for concentrates in supplying total digestible nutrients in the dairy ration.

BIBLIOGRAPHY

1. Bachtell, M. A., Willard, C. J., Monroe, C. F., and Livezey, W. Dairy Farming Based on the Liberal Use of Meadow Crops. Ohio Agr. Expt. Sta. Bull. 662. Part II. 1946.

2. Carncross, John W. and Hauck, Joseph F. Roughage Makes Milk Profits. N. Jer. Agr. Expt. Sta. Cir. 505. 1947.

3. Davis, Albert O. Ground Alfalfa as a Substitute for a Part of the Concentrates in the Dairy Ration. Masters Thesis, Oklahoma A. & M. College. 1950.

4. Dickson, W. F. and Kopland, D. V. Feeding Dairy Cows With and Without Grain. Mont. Agr. Expt. Sta. Bull. 293. 1934.

5. Hope, D. and Cannon, C. Y. The Influence of the Physical Character of the Roughage on the Per Cent of Fat Secreted in the Milk. J. Dairy Sci. 22: 799-801. 1939.

6. Fraser, W. J. and Hayden, C. C. Alfalfa Hay vs. Timothy Hay and Alfalfa Hay vs. Bran for Dairy Cows. Ill. Agr. Expt. Sta. Bull. 146. 1910.

7. Gaines, W. L. and Davidson, F. A. Relation Between Percentage Fat Content and Yield of Milk. (Corrections of Milk Yield for Fat Content.) Ill. Agr. Expt. Sta. Bull. 245. 1923.

8. Graves, R. R., Dawson, J. R., Kopland, D. V., Watt, A. L., and Van Horn, A. G. Feeding Dairy Cows on Alfalfa Hay Alone. U.S.D.A. Tech. Bull. 610. 1938.

9. Graves, R. R., Bateman, G. Q., Shepherd, J. B., and Caine, C. B. Milk and Butterfat Production by Dairy Cows on Four Different Planes of Feeding. U.S.D.A. Tech. Bull. 724. 1940.

10. Haag, J. R. The Physiological Effect of Rations Restricted Principally or Solely to the Alfalfa Plant. II. Cystine as a Limiting Factor in the Nutritive Value of Alfalfa Proteins. J. of Nutr. 4: 363-370. 1931.

11. Haag, J. R., Jones, I. R., and Brandt, P. M. The Physiological Effect of Rations Restricted Principally or Solely to the Alfalfa Plant. III. The Influence

of Various Mineral Supplements on the Calcium, Phosphorus and Nitrogen Metabolism of Dairy Cattle. J. Dairy Sci. 15: 23-28. 1932.

12. Haag, J. R., Jones, J. S., Jones, I. R., and Brandt, P. M. The Physiological Effect of Rations Restricted Principally or Solely to the Alfalfa Plant. I. The Calcium, Phosphorus, and Nitrogen Metabolism of Dairy Cattle. J. Dairy Sci. 12: 445-455. 1929.

13. Hart, E. B. and Humphrey, G. C. Cut the Cost of Feeding Cows. Wisc. Agr. Expt. Sta. Bull. 417. 1930.

14. Headley, F. B. The Economics of Feeding Alfalfa Hay and Grain to Holstein Cows. Nev. Agr. Expt. Sta. Bull. 140. 1935.

15. Hills, J. L. Feeding Trials with Cows. Vt. Agr. Expt. Sta. Rpt. pp. 320-324; 473. 1906.

16. Hodgson, R. E., Knott, J. C., Miller V. L., and Murer, H. K. The Nutritive Value of Home Grown Roughage Rations for Dairy Cattle. Wash. Agr. Expt. Sta. Bull. 366. 1938.

17. Huffman, C. F. A Method of Studying the Deficiencies of Alfalfa Hay and the Feeding Value of Various Feeds as Supplements to Alfalfa Hay. J. Dairy Sci. 21: 101-102. 1938.

18. Huffman, C. F. and Duncan, C. W. The Nutritive Value of Alfalfa Hay I. Cystine as a Supplement to an All Alfalfa Hay Ration for Milk Production. J. Dairy Sci. 25: 507-515. 1942.

19. Huffman, C. F. and Duncan, C. W. The Nutritive Value of Alfalfa Hay II. Starch and Glucose as Supplements to an All Alfalfa Hay Ration. J. Dairy Sci. 27: 821-833. 1944.

20. Huffman, C. F. and Duncan, C. W. The Nutritive Value of Alfalfa Hay III. Corn as a Supplement to an All Alfalfa Hay Ration for Milk Production. J. Dairy Sci. 32: 465-474. 1949.

21. Jensen, E., Klein, J. W., Rauchenstein, E., Woodward, T. E., and Smith R. R. Input-output Relationships in Milk Production. U.S.D.A. Tech. Bull. 314. 1942.

22. Kuhlman, A. H., and Cave, H. W. The Value of Adding Ground Alfalfa Hay to a Concentrate Mixture Fed with Prairie Hay in a Ration for Dairy Cows. J. Animal Sci. 7: 537-538. 1948.

23. Lindsey, J. B. Work in Animal Feeding. Mass. Agr. Expt. Sta. Rpt. Part I. pp. 18-19. 1909.

24. Lindsey, J. B. and Archibald, J. G. Two Systems of Feeding Dairy Cows. Mass. Agr. Expt. Sta. Bull. 291. 1932.

25. Mairs, Thomas I. A Comparison of Alfalfa Meal and Wheat Bran for Dairy Cows. Penn. Agr. Expt. Sta. Bull. 80. 1906.

26. McIntyre, C. V. and Ragsdale, H. C. Milk Production on Roughage without Grain. Mo. Agr. Expt. Sta. Bull. 488. 1945.

27. Monroe, C. F. and Allen, Harold. Alfalfa-Timothy Hay for the Dairy Farm. Ohio Agr. Expt. Sta. Bull. 538. Part II. 1934.

28. Morrison, F. B. Feeds and Feeding. 21st Ed. Morrison's Publishing Company, Ithaca, New York. 1948.

29. Moseley, T. W., Duncan, S., and Graves, R. R. Dairy Work at the Huntley Field Station. Huntley, Mont. U.S.D.A. 116. 195. 1927.

30. Sherwood, D. H. and Dean, H. K. Feeding Alfalfa Hay Alone and with Concentrates to Dairy Cows. Oreg. Agr. Expt. Sta. Bull. 380. 1940.

31. Smith, V. R., Jones, I. R., and Haag, J. R. Alfalfa With and Without Concentrates for Milk Production. J. Dairy Sci. 28: 343-354. 1945.

32. Snyder, W. P. and Burnett, E. A. Chopped Alfalfa vs. Bran in Grain Ration for Dairy Cows. Neb. Agr. Expt. Sta. Bull. 164. 1918.

33. Soule, A. M. and Barnes, S. E. Replacing Grain with Alfalfa in a Ration for Dairy Cows. Tenn. Agr. Expt. Sta. Bull. 70. 1904.

34. Willard, H. S. Grain Vs. No Grain for Dairy Cows. Wyo. Agr. Expt. Sta. Bull. 202. 1934.

35. Willard, H. S. Roughage Feeding of Dairy Cattle. Wyo. Agr. Expt. Sta. Bull. 237. 1940.

36. Woll, F. W., Voorhies, E. C., and Castle, C. V. Heavy vs. Light Grain Feeding for Dairy Cows. Calif. Agr. Expt. Sta. Bull. 323. 1920.

THESIS TITLE: GROUND ALFALFA HAY AS A SUBSTITUTE FOR 50 PER CENT OF THE CONCENTRATE MIXTURE IN THE DAIRY RATION

NAME OF AUTHOR: ESTES E. FIRESTONE

THESIS ADVISER: E. R. BEROUSEK

The content and form have been checked and approved by the author and thesis adviser. "Instructions for Typing and Arranging the Thesis" are available in the Graduate School office. Changes or corrections in the thesis are not made by the Graduate School office or by any committee. The copies are sent to the bindery just as they are approved by the author and faculty adviser.

NAME OF TYPIST: FRANCES IRELAND STROMBERG