THE EFFECT OF LEVEL OF GRAIN FEEDING UPON THE EFFICIENCY OF MILK PRODUCTION

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INTRODUCTION

There are considerable differences of opinion among dairymen in regard to the amount of concentrates that should be fed for economical and efficient production of milk. The best recommendations at the present time for the feeding of concentrates to lactating dairy cows for maximum production of milk are those of Morrison (49).

The variations in the advocated "thumb" rule systems of feeding lactating dairy cows (6, 7, 11, 14, 18, 21, 29, 40, 43, 57) indicate the lack of agreement among dairymen as to what constitutes economical and efficient feeding.

Due to the fact that feed is the largest single item of cost in milk production (25, 31, 37, 40, 47) and feeds in a more concentrated form are normally higher in price, additional data need to be obtained relative to the optimum levels of concentrate feeding for economical and efficient milk production.

The purpose of this study was to secure additional data relative to the optimum level of concentrate feeding for efficient milk production by studying the effects of three levels of grain feeding on milk production and the effect of increased grain feeding upon the consumption and digestibility of roughage.

REVIEW OF LITERATURE

GRAIN FEEDING LEVELS AS RELATED TO ECONOMICAL AND EFFICIENT MILK PRODUCTION

Efficiency in milk production is largely concerned with the efficient utilization of the feed supplied in excess of maintenance (1). It is often assumed that roughages provide largely for maintenance and concentrates for production (25).

Various research workers (5, 17, 19, 30, 48, 49, 67) have shown that cows can produce from 60% to 90% as much milk on roughage alone as with supplemental grain feeding. It is generally recognized, however, that high producing cows cannot consume enough roughage to furnish adequate amounts of nutrients needed and therefore must be supplied in a more concentrated form (20, 21, 29, 37, 49, 52, 59, 65).

Dickson and Kopland (12) in a study of milk production at three different levels of feeding found that cows fed an all-roughage ration were most efficient in converting feed into milk. A group of ten Holstein cows, during their first lactation, were fed grain at the rate of 1.0 lb. per 3.0 lb. milk produced. During the second lactation an all-roughage diet was fed, and during the third lactation grain was fed at the rate of 1.0 lb. for each 6.0 lb. of milk produced. Considering the production made on the full grain ration as maximum, the amount of milk produced on roughage alone and on limited grain feeding were 77.1% and 94.2% of the maximum, respectively. The groups fed the limited and full grain rations were 92.2% and 77.5%, respectively, as efficient as the roughage fed group in converting feed into milk. The roughage fed group lost weight rather steadily until the end of the fifth month of lactation, after which they gained consistently for the remainder of the lactation period. The full-grain fed group and the limited grain fed group had slight losses in bodyweight in the early part of their lactations, but had made considerable gains over their initial weights by the end of the lactation period.

Autrey et al. (3) reported that the addition of grain to the ration enhanced the total nutrient consumption but decreased considerably the amount of digestible nutrients consumed from the roughage portion. Cows on an all roughage diet and those fed grain at the rate of 1.0 lb. per 8.0 lb. milk produced consumed insufficient nutrients to meet their calculated requirements and as a result lost weight. Cows receiving 1.0 lb. grain per 4.0 lb. milk produced showed a consistent bodyweight gain. The average daily rates of hay consumption per cow when fed an all-roughage diet, and grain at the rate of 1.0 lb. per 8.0 lb. and 4.0 lb. of milk produced were 14.5 lb., 13.7 lb. and 11.2 lb., respectively. A statistical analysis of the efficiency ratios of fat-corrected milk per unit of digestible nutrients consumed above maintenance showed the difference between the rations to be highly significant and in favor of the low grain levels of feeding. However, the greater efficiency of the low grain rations decreased considerably as the stage of lactation advanced so that after 18 weeks of observation there was very little difference between the rations with respect to efficiency of milk production.

Headley (19) states that apparently the average efficiency in converting food into butterfat is not materially affected by grain feeding and that the full benefit derived from grain feeding is not immediate.

He found that when cows were fed 1.0 lb. of grain for each 5.0 lb. milk produced, 22% more milk and 18% more butterfat were obtained than when a similar group of cows were fed an all-roughage ration. Feeding records indicated that each pound of grain reduced hay intake by approximately one-half pound.

Johnson and Strangeland (30) state that limited concentrate feeding usually stimulates the appetite so that more forage is consumed than when no concentrates are fed; but, that if appreciable amounts of concentrates are fed, forage consumption declines.

Sherwood and Dean (56) reported that cows fed grain seemed able to utilize feed more efficiently than those not fed grain. This conclusion was based on data secured by feeding one group of grade Jersey cows of average productivity an all-roughage diet and a comparable group of cows hay plus concentrates for four lactation periods. A limited amount of pasture was available the last two summers. The cows which were fed solely on hay consumed 31.7 lb. of hay per cow per day during the first two years and 26.1 lb. per cow per day when pasture was available. The group that received hay and concentrates consumed an average of 29.8 lb. hay and 5.0 lb. concentrates daily during the first two years, and 24.2 lb. hay and 4.0 lb. concentrates daily when pasture was available. The TDN required to produce one pound of butterfat was 18.2 lb. and 17.2 lb. for the all-roughage and the hay-concentrate groups, respectively.

McIntyre and Ragsdale (46) found no significant difference in total production, as related to previous production, of two groups of cows fed at different rates of grain feeding. One group was fed during the entire lactation period at the rate of 1.0 lb. grain for each 6.0 lb. milk produced. The second group was fed 1.0 lb. grain per 3.0 lb. milk produced during the first 100 days, 1.0 lb. grain per 6.0 lb. milk produced during the second 100 days, and no grain for the remainder of the lactation.

Baker and Tomhave (4) fed five groups of Holstein cows at maintenance levels plus allowances of TDN for milk production at 82.2%, 100%, 105.3%, 122.4% and 131.0% of the Haecker Standard, respectively. Substantial increases in production were obtained by feeding in excess of the Haecker Standard; however, the amount of milk produced for each pound of TDN fed was greatest at the lowest feeding level. These findings are in agreement with those of Hilton et al. (23) who state that the Haecker Standard is apparently inadequate as a means of adjustment of nutrients required to maintain milk production and bodyweight. These workers also found that the milk output per pound of TDN consumed above maintenance requirements was apparently larger for less liberally fed cows.

Jensen et al. (28) used a total of 346 individual cows over a three-year period to obtain 469 yearly records of milk production and feed intake. They reported 15% to 20% more milk from cows fed high levels of grain than from cows fed according to the Haecker Standard, and 45% more milk than from cows fed at 70% to 80% of the Haecker Standard. The average daily production of 4% FCM for cows fed 1.0 lb. grain for each 2 lb. milk produced was 45.6 lb. An average of 39.2 lb. 4% FCM per day was obtained when cows were fed at the rate of 1.0 lb. grain for each 6.0 lb. milk produced. The trend downward from the peak of production was much the same and very uniform for all groups, regardless of the intensity of grain feeding. A fairly constant increase in bodyweight occurred as the level of grain feeding increased.

These workers observed that if the cows were fed all the good quality roughage they would eat, the average decrease in hay consumption for each 100 lb. increase in grain appeared to lie between 50 lb. and 70 lb.

Kitchen et al. (38) obtained 15.8% and 22.6% more milk when cows were fed concentrates at the rate of 1.0 lb. per 6.0 and 8.0 lb. milk produced, respectively, than when fed solely on roughage. Roughage consumption appeared to be decreased as grain feeding increased.

Lush (44) stated that grain feeding apparently tends to maintain or increase bodyweight and checks decline in milk production. His conclusions were based on data secured from feeding a limited grain ration to a group of eight cows, four of which had been previously fed a low-grain ration and four which had been fed a high-grain ration. Their respective production was 111.4% and 109.3% of that of the previous year, and the average gain in bodyweight was 2 lb. per cow.

Willard (67) found that cows fed barley as the sole concentrate at the rate of 1.0 lb. per 5.0 lb. milk produced gave 18% more milk and 13% more butterfat, on a mature equivalent basis, than when fed an all-roughage ration. The cows fed grain showed a greater persistency in milk yield.

Lindsay and Archibald (42) secured a 14.4% increase in milk production from a group of high grade Holstein cows fed a low roughage-high grain ration over a similar group of cows fed a high roughage-low grain ration. The low roughage-high grain group received 1.0 lb. of concentrates containing 17.9% digestible protein for each 2.5 lb. of milk produced. The high roughage-low grain group was fed a concentrate mixture containing 12.8% digestible protein at the rate of 1.0 lb. per 4.5 lb.

milk produced. The high roughage-low grain group was slightly more persistent in milk flow as evidenced by an average lactation period two weeks longer than the average for the low roughage-high grain group. It was concluded that in order to keep cows looking well and producing near the limit of their ability that reasonably liberal grain feeding must be practiced.

Wylie and Neel (71) concluded that good cows may produce reasonably well with a limited amount of grain if adequate pasture and roughage are provided. Over a four-year experimental period, a group of seven cows on a limited grain ration consumed approximately one-half as much concentrates, 554 lb. less hay, and 655 lb. less corn silage per cow than did a similar group of cows fed a full grain ration. The full grain fed group produced slightly more milk and butterfat but the difference was too small to be considered of any significance. The income over feed cost was $8.63 more per cow per year in favor of the limited grain feeding.

Moseley et al. (50) found that cows were more profitable when fed a limited grain ration than when fed an all-roughage ration or a full grain ration.

Thompson and Holdaway (59) found that the feeding of a limited amount of grain to cows producing 20 lb. to 30 lb. of milk per day on good pasture was profitable.

Hewitt (22) reported that cows produced milk and butterfat more economically on pasture that was supplemented with grass-clover hay than on pasture that was supplemented with concentrates.

Hoglund (24) and Jawetz (27) maintain that the point of most economical efficiency is reached when the cost of the last input of feed just equals the value of the additional milk produced.

DIGESTIBILITY AS AFFECTED BY THE COMPOSITION AND QUANTITY OF THE RATION

Armsby (1) stated that it seems well established that the percentage of digestibility of mixed rations decreases more or less as the quantity consumed increases. He attributed this lower digestibility of heavier rations to their greater bulk and relatively more rapid passage through the digestive tract, and in part to the resulting decrease in the degree of the bacterial fermentations.

According to Bull (8), a full-feed ration containing a fairly large proportion of roughage to concentrates is not digested as thoroughly as a smaller ration.

Forbes and Swift (15) concluded that combinations of feeding stuffs did not directly affect apparent digestibility, but affected the action of the alimentary microorganisms that grow at the expense of food nutrients and are then digested by the animal.

Mumford et al. (51) maintained that the differences in the amounts of feed eaten influence digestibility only when the quantity of crude fiber in the ration is large.

At the Missouri Agricultural Experiment Station, Eckles (13) found that when two Jersey cows were producing at their maximum capacity and fed a full ration they digested 66.27% and 66.95% of their total ration. The same cows when dry and fed a maintenance ration digested 73.79% and

72.19%, respectively, of the entire ration.

Watson et al. (65) concluded that the digestibility of barley was the same when fed with timothy hay, alfalfa hay, or when fed alone to sheep and steers.

When grade Shorthorn steers were fed a mixed ration of 3-4 kg. oats and 5-7 kg. hay, Watson et al. (62) found, except for nitrogen and ether extract, that the calculated values were significantly less than the values obtained when oats were fed alone. A drop in the feeding value in the order of 5% was reported.

It was concluded by Watson et al. (63) that there was no effect of associative digestibility between hay and wheat bran, gluten feed, or soybean oil meal when fed singly or in a mixture of equal parts with a basal hay ration to grade Shorthorn steers. The same workers (61) found no associative effect of digestibility between hay and barley or oats when fed singly or in combination with a basal hay ration.

Swift et al. (58) found that the addition of 34 g. of corn oil per day to the ration of sheep fed 420 g. mixed hay, 420 g. cornmeal and 48 g. of linseed oil meal caused an increased digestibility of each feed constituent. Additions of 68 g. of corn oil per day resulted in the opposite effect.

Varying the nutritive ratio from approximately 1:2 to 1:9 in mixed rations of timothy hay, barley and soybean oil meal did not affect the digestibility of mixed rations (66).

Watson et al. (64) fed 1.0, 2.0, 3.0, 4.0 and 4.6 kg. of oats with basal hay rations of 3.0 kg. to grade Shorthorn steers and found that the digestibility of the TDN of the oats decreased in the order of 5 absolute per cent from the lowest to the highest level of oats. A decrease in the digestibility of protein occurred but the carbohydrate fraction of the ration accounted for most of the decrease.

CHROMIUM OXIDE TECHNIQUE OF DETERMINING DIGESTIBILITY

It is necessary that an indicator or index material used in digestibility studies be completely indigestible, and it is desirable that it be evenly mixed with the ingesta and uniformly excreted in the feces (54).

According to Schurch *et al.* (55), the use of chromium oxide (Cr_2O_3, chrome green, chromic oxide, chromium sesquioxide) as an index material in the determination of digestibility was first proposed by Edin in 1918.

Schurch *et al.* (55) stated that the main advantage in the use of the chromium oxide technique is that it is a simplified experimental procedure which avoids the necessity of a quantitative record of either feed intake or feces output. However, the chemical work is increased by the necessary determination of chromium oxide of the feed and feces.

Kane *et al.* (36) listed the following advantages of the chromium oxide technique in determining digestibility: (a) eliminates the necessity of total collection of feces, (b) permits digestion trials to be conducted in ordinary barn stalls, and (c) effects a saving of time, labor and expense. These workers stated that the accuracy of this method depends on the validity of the assumption that: (a) the inert substance becomes evenly distributed with the ingesta, and (b) that it passes through the digestive tract in a manner similar to that of the ingested nutrients.

The main problem in chromium oxide determination appears to be in sample collection. Analysis of variance by Kane et al. (34) revealed a highly significant difference between cows and between a.m. and p.m. samples. Direct comparison showed that digestion coefficients obtained with the chromium oxide technique were in excellent agreement with those determined by the standard total fecal collection method.

Hardison and Reid (16) found extremely variable results in the chromium oxide content of feces voided at various intervals of the day.

Lancaster et al. (41) found that afternoon "grab" samples tended to contain less chromium oxide than did morning samples.

Woolfolk et al. (70) found chromium oxide to be inaccurate as a reference material for determining digestibility due to the variation in recovery from the feces.

Schurch et al. (55) stated that the successful use of chromium oxide as an index of the digestibility of a diet demands that only random samples of feces need be retained for analysis of the concentration of the index.

Kane et al. (32) obtained comparable digestion coefficients with the standard total collection method and the chromium oxide technique when calculated with both total collection samples and averages of three-day partial collection or "grab samples."

Mahaffey et al. (45) collected total feces from four Jersey steers at two hour intervals for the last three of seven days in which feed intake was stabilized and 10 g. of chromium oxide were given daily. Each steer received four different roughages, four different feeding schedules, and chromium oxide in four different forms. The greatest range of chromium oxide concentration in the feces occurred when the steers were fed six times daily and smallest when fed once daily. When chromium oxide was given in the pure form or dried with collodion, the range of fecal concentration was smaller than when it was given as a gelatin suspension or as a baked flour paste mixed with the grain.

Kane et al. (33) have suggested four collections during a 24-hour period of 4-6 a.m., 8-10 a.m., 1-3 p.m., and 7-9 p.m. to avoid errors due to diurnal variation of chromium oxide excretion.

Kane et al. (33, 35) found that the determination of digestibility by the chromium oxide technique was equally valid with the standard total collection procedure when chromium oxide was combined with flour, mixed to a stiff dough, baked hard, reground and added to the concentrate portion of the ration so that the intake per animal was 15 g. chromium oxide per day. The chromium oxide content of the feces was determined by titration (35).

Schurch et al. (55) have modified the methods of Paloheimo and Paloheimo and Barnicoat which are the colorimetric determinations of chromium oxide. The colorimetric method is quicker and less expensive than the titration method of Kane et al. (35).

All workers are not in agreement regarding the rate of recovery of chromium oxide in the feces. Kane et al. (35) reported recovery rates of 100.0%, 100.4%, 99.3% and 99.7%. Later work by Kane et al. (33) reported the average recovery rates to be 98.1%.

Lancaster et al. (41) administered 7.5 g. of chromium oxide by capsule daily to three cows and obtained recovery rates of 102%, 100% and 102%, respectively.

Woolfolk et al. (70), using a modification of Barnicoat's and Barnicoat's method of analysis, found the average recovery rate in trials with calved to be 99.63%, and with sheep to be 97.11%. Chanda et al. (9) found the recovery rate in goats to be 100.0%, 99.1%, 99.1% and 96.0%. With human subjects, Irwin and Crampton (26) found that chromium oxide was uniformly mixed with the feces following the first defecation after chromium oxide ingestion, and reported recovery rates of 95%, 102% and 103%.

Crampton and Lloyd (10) state that with an unground, all-roughage ration, chromium oxide administered as such tends to be retained in the digestive tract thus leading to unreliable and low estimates of digestibility. They found the average recovery rate on an all-roughage ration to be 92%.

Administration of chromium oxide in gelatin capsule form proved inconvenient, uncertain and laborious (10).

EXPERIMENTAL

Fifteen purebred Ayrshire and Holstein cows were selected from the Oklahoma Agricultural and Mechanical College dairy herd to study the effect of rate of concentrate feeding upon the efficiency of milk production.

The cows were divided into three groups of five cows each in such a manner that all three groups were as nearly balanced as possible with respect to breed, size and previous lactation history. After reaching her peak of production under normal herd conditions each cow was placed on trial for the remainder of her lactation period.

The cows were milked twice daily under the same system of management as the regular herd. Daily milk weights were recorded. Butterfat percentage was determined once monthly by the Babcock test.

The cows were stanchioned in the main dairy barn in individual stalls which were equipped with drinking cups and bedded with straw. Each animal was fed individually in a solid-partitioned, box-type manger. The cows received approximately five hours exercise daily in an outside lot.

A grain mixture consisting of one-half ground oats and one-half ground milo was fed with alfalfa hay and sorghum silage. Steamed bonemeal, finely ground limestone and salt were added to the concentrate mixture at the rate of 1% each.

Grain was fed at the rate of 1.0 lb. per 3.0, 5.0 and 8.0 lb. milk produced in groups I, II and III, respectively. Hay and silage were offered in a ratio of 1:3.9 with the total amount of roughage consumed being determined by total silage consumption.

Weekly adjustments in the levels of concentrates were made each Saturday in accordance with the previous week's production. Hay and silage were offered to each animal in such amounts that maximum roughage consumption was obtained.

After going on trial each cow was weighed on the succeeding Saturday morning and weekly thereafter until completion of her lactation period. All weights were taken at approximately the same time each Saturday.

Another group of five Guernsey dry cows were selected to study the effect of grain feeding upon the consumption and digestibility of roughage. Four digestion trials were conducted using the chromium oxide technique.

The rations fed during the series of digestion trials were as follows: Trial I, alfalfa hay alone; and during Trials II, III and IV grain was fed at the rates of 1.0, 4.0 and 7.0 lb. per day, respectively, in addition to alfalfa hay. Hay was offered in amounts which would be eaten readily. Rations were fed in approximately equal portions twice daily.

The concentrate mixture was the same as that used during the feeding trials.

Chromium oxide was mixed thoroughly with flour and water to make a stiff dough which was baked until completely dry. After baking, the chromium oxide-bread was ground through a medium mesh screen in a Wiley Mill and mixed with the concentrate portion of the ration so that each cow received 15 g. chromium oxide per day. In Trial I, the chromium oxide-bread was mixed with approximately 1/4 lb. of ground alfalfa hay.

Each trial consisted of a 5-day collection period preceded by a 10-day preliminary period, with the exception of the preliminary phase of Trial IV which needed to be 12 days in order to establish a constant hay intake. Daily feed intakes were maintained as nearly constant as possible throughout the preliminary and collection periods of all four trials.

Fecal collection consisted of composites of four daily "grab" samples for the duration of the collection period. The "grab" samples were collected from 6-8 a.m., 10-12 a.m., 2-4 p.m. and 7-9 p.m. and were placed in 2-quart jars with tight fitting lids with thymol crystals added for preservative and refrigerated at approximately 37°F.

Proximate analyses of feed and fecal samples were conducted according to A.O.A.C. official methods (2). Chromium oxide contents of the feces and coefficients of digestibility were determined by the method of Schurch _et al_. (55).

RESULTS

GRAIN FEEDING LEVELS AS RELATED TO EFFICIENCY OF MILK PRODUCTION

The average daily production of 4% FCM per 15-day periods for each group of cows as related to the level of grain feeding is presented in Figure 1. Data relative to total and average daily production, prior to and while on trial, are presented in Table 1. The rate of production, calculated on a cow-day basis, in the group fed 1.0 lb. grain per 3.0 lb. milk produced was 27.5 lb. 4% FCM per day. The production of the cows fed 1.0 lb. grain per 5.0 lb. milk produced was 23.1 lb. per day, or 84.0% as much as in group I. The production of the cows fed grain at the rate of 1.0 lb. per 8.0 lb. milk produced was 25.7 lb. per day, or 93.5% as much as in group I. Due to mechanical injuries as indicated in Figure 1, it was necessary to remove one cow from group II, and one from group III.

The data relative to feed and TDN consumption for the cows fed 1.0 lb. grain per 3.0, 5.0 and 8.0 lb. milk produced are presented in Tables 2, 3, and 4, respectively. The high-grain fed group consumed an average of 9.5 lb. of grain, 9.9 lb. hay and 35.0 lb. of silage per day. The cows fed grain at the rate of 1.0 lb. per 5.0 lb. milk produced consumed an average of 5.0 lb. grain, 10.2 lb. hay and 40.0 lb. of silage daily. The average daily feed consumption for the limited-grain fed group was 3.6 lb. grain, 13.6 lb. hay and 44.9 lb. of silage. An average of 10.7% and 34.8% more TDN from roughage was con-

Figure 1

Milk Production As Related To Level Of Grain Feeding

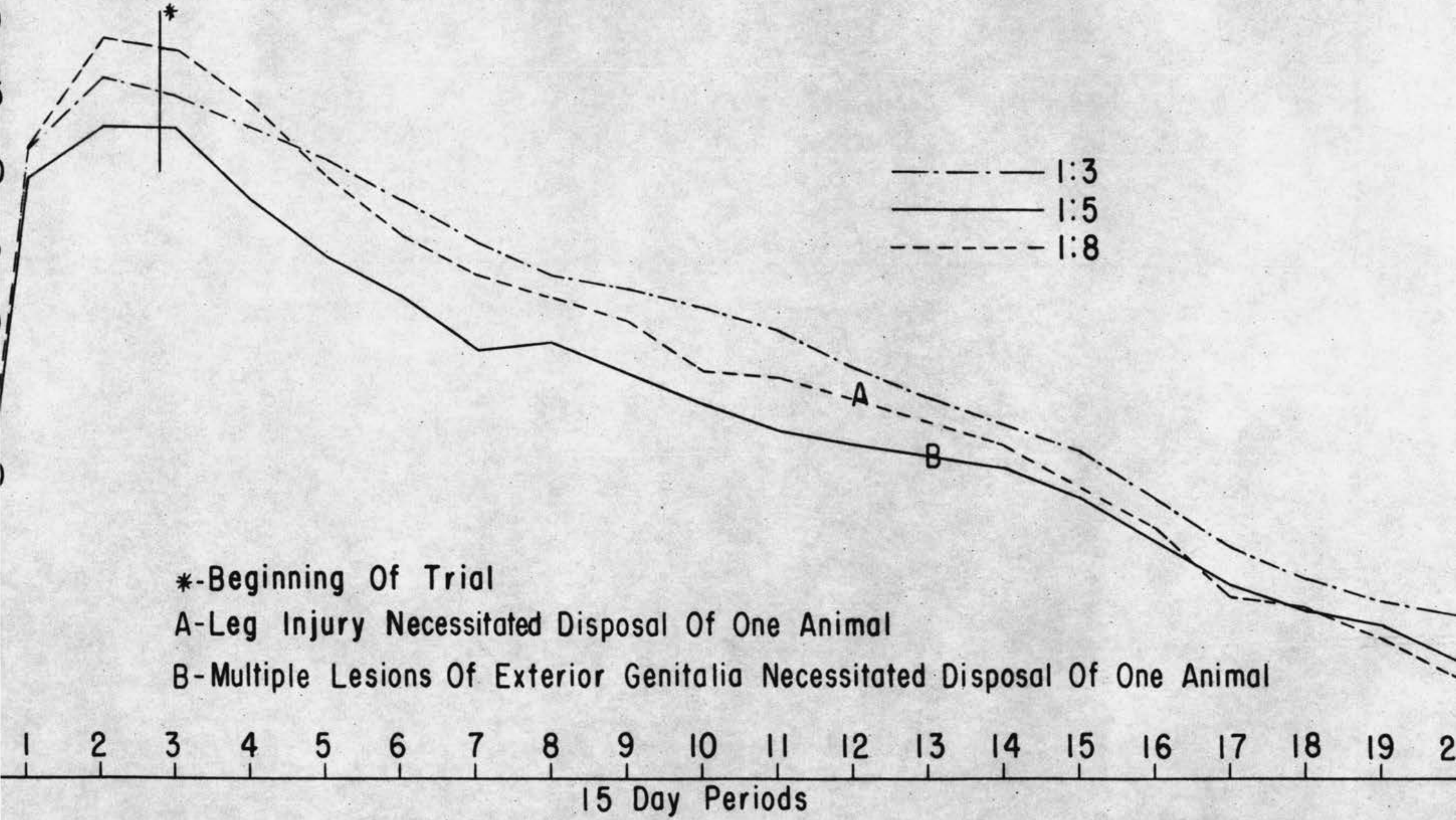

TABLE 1.

MILK PRODUCTION, BODYWEIGHT CHANGE AND RETURN OVER FEED COSTS FOR COWS FED DIFFERENT LEVELS OF GRAIN

Cow No.	Age at Calving	Days Milked before Trial	Days on Trial	4% FCM before Trial	4% FCM on Trial	Bwt. Change	Returns over Feed Costs Per cwt. 4% FCM
	Year-Mo.			lb.	lb.	lb.	
GROUP I							
3	7-11	39	265	1959.3	8030.0	+1	
4	7- 9	60	243	2470.6	4285.3	+54	
8	6- 3	30	275	1256.8	8958.0	+44	
11	7- 6	35	270	1463.2	7218.2	+6	
15	8- 7	35	226	1654.5	6633.9	+98	
Ave.	7- 7	40	256	1760.9	7025.1	+41	$3.31
Ave. Daily				44.2	27.5		
GROUP II							
1	6- 9	62	273	1768.1	3392.5	+129	
2	4- 7	50	256	2389.3	6658.0	+163	
9	7- 9	27	243	1153.7	5004.0	-45	
10	8- 1	34	271	1983.2	8728.6	+86	
12*	8-10	35	174	1124.0	4302.9	-1	
Ave.	6- 8	42	243	1683.7	5617.2	+66	$3.46
Ave. Daily				40.5	23.1		
GROUP III							
5**	6- 2	53	134	3387.6	5302.5	-7	
6	6- 9	39	257	1448.8	4276.0	+110	
7	7- 9	38	257	2080.3	7362.6	+101	
13	3-11	42	263	1798.1	6690.1	+54	
14	8- 9	37	268	1250.0	6623.1	-128	
Ave.	6- 8	42	236	1993.0	6050.8	+26	$3.49
Ave. Daily				47.7	25.7		

*Removed from trial due to multiple lesions of exterior genitalia.

**Removed from trial due to leg injury.

TABLE 2.

FEED AND TDN CONSUMPTION OF COWS FED 1.0 LB. GRAIN PER 3.0 LB. MILK PRODUCED

Cow No.	Days Milked before Trial	Days on Trial	Feed Consumed				TDN Consumed *	
			Hay	Silage	Hay Equiv.	Conc.	Roughage	Conc.
			lb.	lb.	lb.	lb.	lb.	lb.
3	39	265	2648.8	9405.4	6072.9	2669.1	3053.5	2004.5
4	60	243	2398.6	6504.7	4363.2	1520.5	2193.2	1141.9
8	30	275	3106.0	11685.9	7337.1	3050.7	3700.8	2291.1
11	35	270	2228.2	8444.8	5241.7	2476.8	2666.2	1860.1
15	35	226	2231.1	8728.9	5288.1	2394.6	2719.6	1798.3
Total	199	1279	12612.7	44769.7	28303.0	12111.7	14333.3	9095.9
Ave.	40	256	2522.5	8953.9	5660.6	2422.3	2866.7	1819.2
Daily Ave.			9.9	35.0	22.1	9.5	11.2	7.1

*Calculated according to Morrison's Tables (49).

TABLE 3.

FEED AND TDN CONSUMPTION OF COWS FED 1.0 LB. GRAIN PER 5.0 LB. MILK PRODUCED

Cow No.	Days Milked before Trial	Days on Trial	Feed Consumption Hay	Silage	Hay Equiv.	Conc.	TDN Consumption* Roughage	Conc.
			lb.	lb.	lb.	lb.	lb.	lb.
1	62	273	2249.0	8562.0	5507.6	769.7	2698.0	578.1
2	50	276	2661.0	10101.0	6477.7	1391.2	3182.0	1044.8
9	27	243	2819.1	12110.1	7121.8	1057.2	3634.1	794.0
10	34	271	3318.1	11841.7	7542.1	1900.9	3836.0	1427.6
12**	35	174	1344.3	6090.0	3426.2	978.6	1790.6	734.9
Total	208	1217	12391.5	48704.8	30075.4	6097.6	15140.7	4579.4
Ave.	42	243	2478.3	9741.0	6015.1	1219.5	3028.1	915.9
Daily Ave.			10.2	40.0	24.7	5.0	12.4	3.8

*Calculated according to Morrison's Tables (49).

**Removed from trial due to multiple lesions of exterior genitalia.

TABLE 4.

FEED AND TDN CONSUMPTION OF COWS FED 1.0 LB. GRAIN PER 8.0 LB. MILK PRODUCED

Cow No.	Days Milked before Trial	Days on Trial	Feed Consumed: Hay	Feed Consumed: Silage	Feed Consumed: Hay Equiv.	Feed Consumed: Conc.	TDN Consumed*: Roughage	TDN Consumed*: Conc.
			lb.	lb.	lb.	lb.	lb.	lb.
5**	53	134	1972.3	7357.4	4674.3	809.6	2338.5	607.3
6	39	257	2750.0	8715.9	5940.5	589.0	2978.3	442.3
7	38	257	3925.7	13604.8	8863.1	1061.9	4464.3	797.5
13	42	263	3090.3	10268.9	6695.9	882.9	3433.6	663.1
14	37	268	4296.6	12943.7	8810.1	927.9	4529.9	697.0
Total	209	1179	16034.9	52890.7	34983.9	4271.3	17744.6	3207.2
Ave.	42	236	3207.0	10578.1	6996.8	854.3	3548.9	641.4
Daily Ave.			13.6	44.9	29.7	3.6	15.1	2.7

*Calculated according to Morrison's Tables (49).

**Removed from experiment due to leg injury.

sumed in the medium and low-grain fed groups, respectively, than in the high-grain fed group.

The returns above feed costs per hundred pounds of 4% FCM, summarized in Table 1, was $3.31, $3.46 and $3.49 in the high, medium and low grain fed groups, respectively. The feed prices used in calculating costs are presented in Table 5. Milk was calculated to be worth $5.00 per hundred pound of 4% FCM.

As shown in Table 6, the average amount of TDN utilized for the production of each pound of 4% FCM was 0.3039 lb., 0.2893 lb. and 0.3124 lb. in groups I, II and III, respectively. The TDN requirements for maintenance were calculated according to Morrison's Tables (49), and the amount of TDN required for bodyweight gain, or furnished by bodyweight loss, was computed in accordance with the calculated factors of Knott *et al.* (39). These workers used the following reasoning in calculating these factors: Using Armsby's estimated energy content of 1 lb. of fat, the energy value of 1 lb. of liveweight gain was determined. The relationship of the amount of TDN required to produce 1 lb. of 4% FCM to the amount of bodyweight gain that the same amount of TDN would produce was then used to determine the TDN requirement for producing 1 lb. of bodyweight gain. This was found to be 3.53 lb. The amount of TDN replaced in the feed by a bodyweight loss of 1 lb., assuming that the conversion of bodyweight energy into milk to be perfect, was found to be 2.73 lb.

The average gain or loss in bodyweight per group is presented graphically in Figure 2. The average bodyweight gain per cow at the end of 32 weeks on trial was 27.7 lb., 29.5 lb. and 36.5 lb. for groups I, II and III, respectively. Average bodyweight gains beyond 32 weeks

TABLE 5.

PRICES OF FEEDS USED IN FEEDING TRIAL

Feed	Price Per Ton
Alfalfa Hay	$25.00
Sorghum Silage	4.50
Oats	59.40
Milo	50.60

TABLE 6.

EFFICIENCY OF MILK PRODUCTION AS RELATED TO LEVEL OF GRAIN FEEDING

Cow No.	Total TDN Intake	TDN Required for Maintenance*	TDN for Gain or Loss**	TDN Available for Production	4% FCM Produced	Lb. TDN/ Lb. Milk
	lb.	lb.	lb.	lb.	lb.	lb.
			GROUP I			
3	5058.0	2544.0	-3.5	2510.5	8030.0	0.3126
4	3335.1	2089.8	-190.6	1054.7	4285.3	0.2461
8	5991.9	2667.5	-155.3	3169.1	8958.0	0.3538
11	4526.3	2430.0	-21.2	2075.1	7218.2	0.2875
15	4517.9	2305.2	-345.9	1866.8	6633.9	0.2814
Ave.	4685.8	2407.3	-143.3	2135.2	7025.1	0.3039
			GROUP II			
1	3276.1	2566.2	-455.4	254.5	3392.5	0.0750
2	4226.8	1971.2	-575.4	1680.2	6658.0	0.2524
9	4428.1	2502.9	+122.9	2048.1	5004.0	0.4093
10	5263.6	2764.2	+234.8	2734.2	8728.6	0.3132
12	2521.5	1200.6	+2.7	1323.6	4006.0	0.3304
Ave.	3943.2	2201.0	-134.1	1608.1	5557.8	0.2893
			GROUP III			
5	2945.8	1179.2	+19.1	1785.7	4726.0	0.3778
6	3420.6	2056.0	-383.3	981.3	4276.0	0.2295
7	5261.8	2672.8	-356.5	2232.5	7362.6	0.3032
13	4096.7	2182.9	-190.6	1723.2	6690.1	0.2576
14	5226.9	3028.4	+349.4	2547.9	6623.1	0.3847
Ave.	4190.4	2223.9	-112.4	1854.1	5935.6	0.3124

*Calculated according to Morrison's Tables (49).

**Computed in accordance with the calculated factors of Knott _et al_. (39)

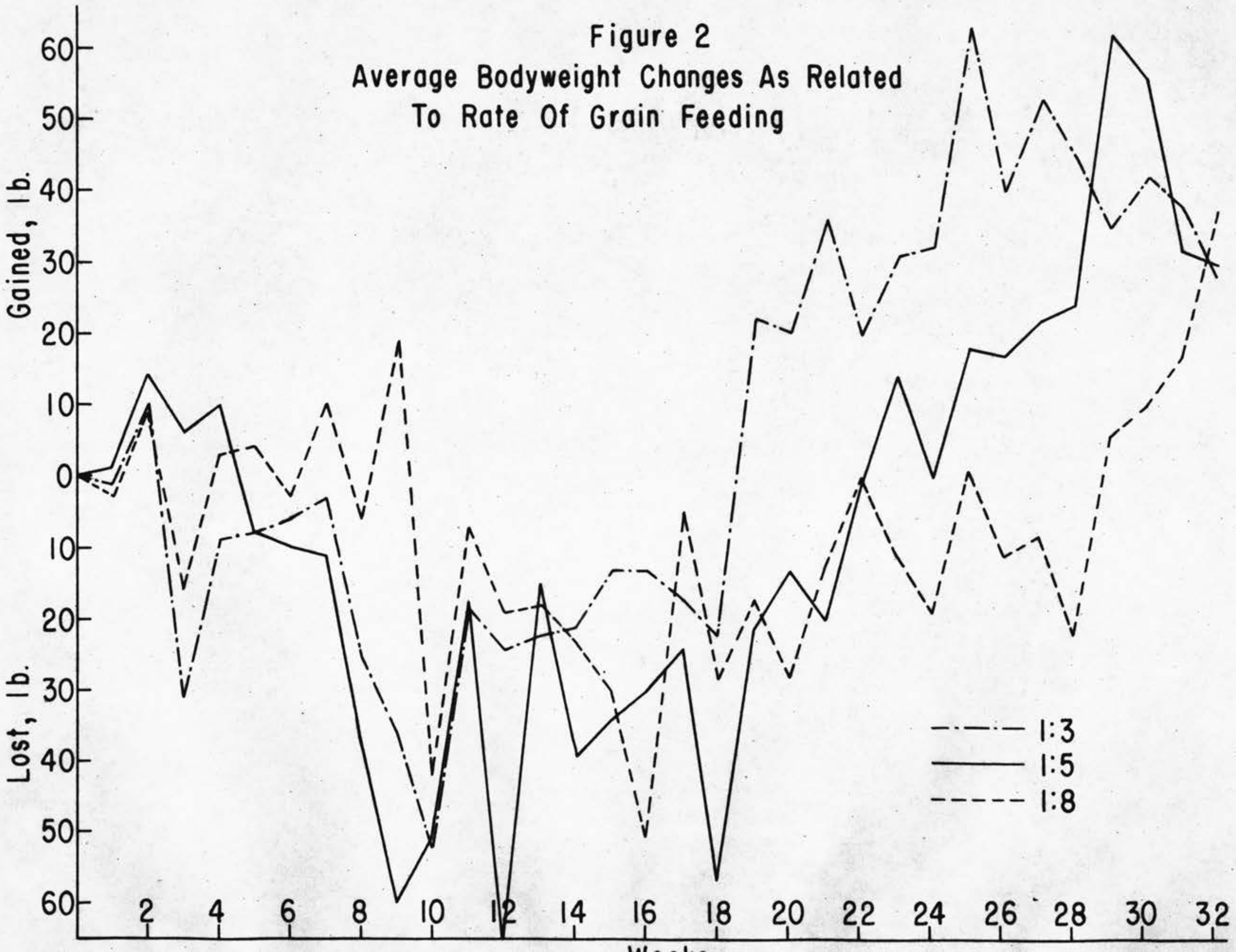
Figure 2
Average Bodyweight Changes As Related
To Rate Of Grain Feeding
Gained, lb.
Lost, lb.
60
50
40
30
20
10
0
10
20
30
40
50
60
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
Weeks
1:3
1:5
1:8

are not included in this figure due to variations in the length of lactation of several individuals which caused a lack of uniformity of numbers in the groups beyond the 32-week period. Average gain in bodyweight was most pronounced in the high-grain fed group, beginning after the 18th week on trial. The medium-grain fed group began gaining in bodyweight between the 22nd and 24th week on trial but the gain was not as rapid as in the high-grain fed group. The low-grain fed group did not gain materially in bodyweight until after 28 weeks on trial, after which the gain was quite rapid.

DIGESTION TRIALS

The chemical composition of the hay and grain fed and of the weigh-back samples from the digestion trials are shown in Table 7. The variation in hay composition is apparently due to the lack of uniformity in the hay fed. The grain mixture was prepared in two separate mixes. This, also, is the only apparent explanation for the differences in the composition of the grain mixtures.

On the average, a loss in bodyweight occurred during each collection period of the digestion trials with the exception of Trial II. This is quite surprising because there was a gain in bodyweight for all but one cow between each trial. Bodyweights and net daily feed intakes are recorded in Table 8. The wide variations in the digestion coefficients obtained between Trial II and the remaining three trials cannot be explained. The digestion coefficients for each fraction in Trial II, excepting ether extract, was considerably lower than in Trials I, III and IV. The reverse situation existed for ether extract.

Fecal analyses and digestion coefficients of all trials are presented in Tables 9 and 10, respectively.

The data relative to the digestible protein and TDN of the rations are presented in Table 11. The apparent digestibility of the protein of the total ration appears to have no certain trend in relation to the level of grain fed in Trials II, III and IV. The TDN values, except in Trial II, appear to increase as the level of grain feeding increases to a maximum of 7.0 lb.

TABLE 7.

ANALYSES OF HAY, GRAIN AND WEIGHBACKS FOR TRIALS I, II, III AND IV.

Description	% Dry Matter	Percentage Composition of Dry Matter				
		Protein	Fat	Fiber	Ash	N.F.E.
TRIAL I						
Hay-421	91.0	19.4	2.37	34.6	8.60	35.0
Hay-oth.	91.0	17.6	2.61	33.6	6.62	39.6
TRIAL II						
Hay	92.1	20.9	4.68	26.3	8.95	39.2
Grain	90.4	14.1	4.57	6.5	6.16	68.7
Hay Weighbacks						
1305-1	23.7	24.7	4.34	17.3	18.00	35.7
1305-2	41.4	25.9	4.52	24.2	19.63	25.7
1305-3	48.9	24.9	3.49	21.9	18.21	31.5
1405-1	86.2	26.4	3.49	17.9	12.58	39.6
TRIAL III						
Hay	90.7	16.3	3.45	33.4	8.58	38.3
Grain	88.9	11.7	4.22	6.1	11.51	66.5
Hay Weighbacks						
1404-1	91.0	17.4	1.79	34.4	9.63	36.8
TRIAL IV						
Hay	91.0	18.1	2.85	30.0	8.48	40.6
Grain	89.5	13.0	3.71	7.5	11.24	64.5

TABLE 8.

BODYWEIGHT AND NET DAILY FEED INTAKE OF COWS DURING DIGESTION TRIALS

			Feed Intake	
Cow No.	Initial Weight	Ending Weight	Hay	Conc.
	lb.	lb.	lb.	lb.
		TRIAL I		
421	782	773	16.0	-
1305	824	832	14.0	-
1321	753	747	16.0	-
1404	714	721	16.0	-
1405	741	727	16.0	-
Ave.	763	760	15.6	-
		TRIAL II		
421	821	819	16.0	1.0
1305	840	841	10.6	1.0
1321	799	791	16.0	1.0
1404	773	770	16.0	1.0
1405	759	773	15.5	1.0
Ave.	798	799	14.8	1.0
		TRIAL III		
421	858	847	16.0	4.0
1305	888	887	12.0	4.0
1321	849	831	16.0	4.0
1404	768	762	13.9	4.0
1405	821	820	16.0	4.0
Ave.	837	829	14.8	4.0
		TRIAL IV		
421	857	843	10.0	7.0
1305	890	873	6.0	7.0
1321	873	870	16.0	7.0
1404	814	794	14.0	7.0
1405	832	826	12.0	7.0
Ave.	853	841	11.6	7.0

TABLE 9.

FECES ANALYSES

Cow No.	% Dry Matter	Percentage Composition of Dry Matter					
		Cr_2O_3	Protein	Fat	Fiber	Ash	N.F.E.
			TRIAL I				
421	21.6	0.760	15.1	4.00	34.0	15.6	31.3
1305	22.6	0.785	13.5	4.81	38.1	16.0	27.6
1321	22.0	0.674	13.4	4.89	40.4	15.5	26.8
1404	19.8	0.753	13.7	4.99	37.6	14.8	28.9
1405	22.7	0.823	13.1	4.95	39.3	15.7	26.9
			TRIAL II				
421	21.0	0.503	13.7	3.48	34.8	15.3	32.7
1305	22.4	0.715	13.9	3.80	36.3	15.8	30.2
1321	20.2	0.515	14.2	4.90	34.4	16.8	29.7
1404	18.4	0.718	14.5	4.71	36.0	18.8	26.0
1405	19.7	0.509	13.9	4.17	36.3	13.7	31.9
			TRIAL III				
421	19.9	0.496	12.4	4.97	36.7	22.9	23.0
1305	20.2	0.927	12.6	5.24	33.8	19.5	28.9
1321	20.9	0.583	13.0	4.68	37.2	19.6	25.5
1404	19.7	0.845	13.1	5.69	35.4	18.6	27.2
1405	19.9	0.637	13.3	5.21	36.2	17.8	27.5
			TRIAL IV				
421	22.1	0.803	11.7	4.54	35.4	17.4	31.0
1305	22.5	0.898	12.2	4.15	33.9	18.6	31.1
1321	21.0	0.601	12.0	4.95	33.3	17.5	32.2
1404	20.4	0.730	13.2	4.77	33.8	16.0	32.2
1405	21.2	0.731	13.0	4.96	33.7	17.6	30.7

TABLE 10.

DIGESTION COEFFICIENTS OF RATIONS FED IN TRIALS I, II, III AND IV

Cow No.	Dry Matter	Protein	Fat	Fiber	N.F.E.
	%	%	%	%	%
		TRIAL I			
421	70.2	76.7	49.5	70.6	73.3
1305	67.1	74.7	39.3	62.7	77.0
1321	66.4	74.4	37.0	59.6	77.2
1404	70.0	76.6	42.5	66.3	78.0
1405	72.5	79.5	47.6	67.7	81.3
		TRIAL II			
421	58.3	71.6	68.6	41.9	66.3
1305	65.3	76.2	71.9	49.7	75.0
1321	58.9	71.4	56.7	44.0	70.0
1404	70.6	79.1	70.2	57.8	81.2
1405	57.2	70.8	62.1	37.8	66.9
		TRIAL III			
421	63.3	71.6	49.1	51.7	80.3
1305	75.4	80.6	64.4	68.6	83.9
1321	68.8	74.7	59.2	58.6	81.4
1404	77.6	81.7	65.2	70.9	86.4
1405	71.4	76.3	58.4	63.0	81.7
		TRIAL IV			
421	73.4	80.4	61.9	54.4	83.5
1305	68.5	75.1	60.8	41.0	81.7
1321	73.6	80.8	57.9	62.0	82.2
1404	78.3	82.5	66.9	67.3	85.5
1405	73.7	78.9	58.7	59.2	83.6

TABLE 11.

DIGESTIBLE PROTEIN AND TDN OF RATIONS

Cow No.	Dry Matter Intake	D.P.* lb.	D.P.* %	TDN* lb.	TDN* %
		TRIAL I			
421	14.6	2.17	13.4	9.87	60.8
1305	12.7	1.67	11.8	8.51	60.3
1321	14.6	1.91	11.8	9.62	59.3
1404	14.6	1.97	12.1	10.10	62.3
1405	14.6	2.04	12.6	10.47	64.5
Group	71.1	9.76	12.4	48.57	61.5
		TRIAL II			
421	15.6	2.29	13.2	9.29	53.6
1305	11.4	1.76	13.9	7.63	60.3
1321	15.6	2.28	13.2	9.39	54.2
1404	15.6	2.53	14.6	11.11	64.1
1405	15.2	2.19	13.0	8.80	52.1
Group	73.4	11.05	13.5	46.21	56.7
		TRIAL III			
421	18.1	2.08	10.3	11.7	58.2
1305	14.4	1.85	11.6	10.6	66.2
1321	18.1	2.17	10.8	12.4	61.7
1404	15.6	1.94	11.2	11.8	68.1
1405	18.1	2.22	11.0	12.6	62.7
Group	84.3	10.26	11.0	59.1	63.1
		TRIAL IV			
421	15.4	1.98	11.6	10.9	63.7
1305	11.7	1.35	10.4	7.8	60.0
1321	20.8	2.79	12.1	14.8	64.0
1404	19.0	2.57	12.2	14.2	67.3
1405	17.2	2.20	11.5	12.2	63.8
Group	84.1	10.89	11.7	59.9	64.1

*On a 10% moisture basis.

The data relative to the digestibility of grain, determined by difference, when fed at different levels are given in Table 12. The values calculated for grain in Trial II are obviously illogical, but cannot be fully explained on the basis of this preliminary study. Wide hay-grain ratios have been shown to yield absurd results in this type of study (1). As the level of grain feeding increased from 4.0 lb. per day to 7.0 lb. per day, the apparent digestible protein and TDN of the grain increased from 10.0% and 72.5% to 10.3% and 69.7%, respectively. Total dry matter intake was essentially the same in Trials III and IV.

As shown in Table 13, very little difference was found between the digestible protein and TDN values of the hay when calculated by difference in Trial IV using the digestibility of grain as determined in Trial III, and those determined directly.

TABLE 12.

DIGESTIBILITY OF GRAIN AT DIFFERENT LEVELS OF FEEDING

	Dry Matter Intake	D.P.* lb.	D.P.* %	TDN* lb.	TDN* %
		TRIAL II			
Total	73.4	11.05		46.21	
Hay	68.8	11.00	14.4	46.93	61.3
Grain	4.5	0.05	1.0	-0.72	---
		TRIAL III			
Total	84.3	10.26		59.10	
Hay	66.3	8.26	11.2	44.63	60.6
Grain	18.0	2.00	10.0	14.50	72.5
		TRIAL IV			
Total	84.1	10.89		59.94	
Hay	52.6	7.28	12.5	35.57	60.5
Grain	31.5	3.61	10.3	24.39	69.7

*On a 10% moisture basis.

TABLE 13.

DIGESTIBILITY OF ALFALFA HAY CALCULATED BY DIFFERENCE IN TRIAL IV USING DIGESTIBILITY OF GRAIN DETERMINED IN TRIAL III.

	Dry Matter Intake	D.P.*		TDN*	
		lb.	%	lb.	%
Total	84.1	10.89		59.94	
Grain	31.5	3.50		25.37	
Hay	52.6	7.39	12.6	34.57	59.2

*On a 10% moisture basis.

DISCUSSION

GRAIN FEEDING LEVELS AS RELATED TO EFFICIENCY OF MILK PRODUCTION

The management of the individual cows prior to being placed on trial was the same as that of the regular college dairy herd. The average daily production while on trial was highest for the high-grain fed group; however, the persistency of production was approximately parallel for all three groups after the third 15-day period. During the first three 15-day periods after going on trial, the low-grain fed group showed a sharper decline from the peak of production which might indicate that higher levels of grain feeding during higher levels of production would result in an advantage in persistency of production. In regard to the persistency of production, these results compare very favorably with those of Jensen _et al_. (28) and with those of Dickson and Kopland (12).

Some difficulty was experienced with sickness and "off-feed" conditions of one or two individuals in each group which not only affected the rates of production, but bodyweight changes as well. These "off-feed" conditions were apparently not the result of any definite level of grain feeding. Due to the influence of cows number 9 and 10, group II was affected to a greater extent than the other two groups as the result of "off-feed" conditions and the subsequent loss in milk yield and bodyweight. This apparently accounts for the decreased TDN intake of group II as compared to groups I and III. It is quite evident that the lower TDN intake in group II is the primary factor responsible for the lower rate of production than that obtained by feeding even a lower level of grain. A secondary factor might have been a lower productive capacity than that of groups I and III as evidenced by a lower level of production prior to being placed on trial.

On the basis of the feeding conditions of this trial, decreases in the hay equivalent intake appeared to be between 0.6 lb. and 0.8 lb. for each additional pound of concentrate fed. The minimum hay decrease observed in this study was essentially the same while the maximum was considerably higher than that reported by Headley (19). The range in amounts of hay reduction associated with grain feeding increases was comparable to that reported by Jensen et al. (28).

Calculation of average efficiency ratios of 4% FCM per pound of TDN available for milk production, after adjustments for maintenance and bodyweight changes had been made, revealed only slight differences in the efficiency of production at the three levels of grain feeding. It could not be determined with any degree of accuracy whether or not the efficiency of the utilization of TDN available for production was affected as the stage of lactation advanced. This is not in accord with the findings of Autrey et al. (3) who found that the relatively high efficiency of high roughage-low grain rations decreased as the stage of lactation advanced. However, this disagreement could be explained possibly on the basis of the different rates of feeding prior to the peak of production in the two investigations.

Although the calculated average ratios between groups in this study showed only slight differences, the range between individuals of the same group was more variable. This was especially true of group II in which the range was 0.0750 to 0.4093 lb. TDN per pound of 4% FCM. The cause of these variations appears to be related to the level of production and the gain in bodyweight.

If the average daily TDN intake had been the same in the medium and low grain fed groups as in the high grain fed group, the average daily production of 4% FCM should have been 33.4 lb. and 31.9 lb. 4% FCM, respectively. If such had been the case production would have been 16.0% higher in the medium and low grain fed groups, respectively, than in the high grain fed group. This is based on the assumption that the requirements for maintenance, adjustments for bodyweight gain or loss, and the calculated efficiency ratios would remain the same at higher levels of TDN intake.

In terms of economic efficiency, the lower grain fed groups showed a greater return over feed cost per 100 lb. 4% FCM than did the high-grain fed group. Had a higher priced concentrate mixture been fed, the returns over feed cost would have been even more in favor of the low-grain fed groups. It should be borne in mind that no certain level of grain feeding will always result in greater economic returns, but will be influenced by the hay-grain-milk price ratio and the inherent capacity of the cows. During periods of low grain and high hay prices, and favorable milk prices, it seems only logical to assume that increased grain feeding with a subsequent increase in milk production would yield greater profits over feed cost.

On the basis of the results secured in this study and the comparable results of other workers (3, 28), it appears that the most critical periods concerned with feeding the lactating dairy cow for maintaining persistency of production is prior to and immediately following the peak of production. Therefore, it seems apparent that dairy cows of moderate productive ability may maintain equal efficiency and persistency of production, and have greater economic efficiency when fed a full grain ration until after reaching their peak of production and then a limited grain ration for the remainder of the lactation period.

Recovery in bodyweight appeared to be somewhat slow at lower levels of grain feeding.

DIGESTION TRIALS

The digestibility of grain added to the basal hay ration at the rate of 1.0 lb. per day, when determined by difference and assuming that the digestibility of the hay remained the same, yielded unreasonable results. According to Armsby (1) absurd digestion coefficients are often obtained when determining the digestibility of grain by difference when rations which have wide hay-grain ratios are used. As the level of grain feeding increased from 4.0 lb. to 7.0 lb. per day, it appeared that the TDN value of the grain decreased somewhat.

The wide variations in the digestion coefficients obtained between Trial II and Trials I, III, and IV cannot be explained as the same methods and procedures were used in all four trials, with the exception of the preparation of the chromium oxide-bread used in Trial I. Chromium oxide-bread was prepared in daily portions and baked in 600 ml. beakers for use in Trial I. In Trials II, III and IV, the chromium oxide-bread was prepared in quantities such as to provide 20 to 25 cow-day samples of 15 g. each. However, in Trial II the bread was over-baked to the extent that charring occurred. The possibility exists that this charring may have affected the recovery of chromium oxide and thereby causing errors in the coefficients of digestibility obtained in Trial II. It is believed that with the experience gained in the conduction of digestion trials involving the chromium oxide technique better results would be obtained in a repetition of these observations.

On the basis of this study, it appears that there are no definite trends in changes of protein digestibility and TDN values of hay when fed alone or in combination with grain at the rate of 1.0, 4.0 or 7.0 lb. per day.

While it was evident that roughage intake was decreased as grain intake increased in the digestion trials, there were no definite trends. Further study of the optimum feeding levels of hay and hay and grain combinations for the determination of digestibility, and the effect of increased grain feeding on roughage consumption will be necessary before final conclusions can be drawn.

SUMMARY

A feeding trial was conducted to study the efficiency of milk production at different levels of concentrate feeding with three groups of five cows each. Each cow was placed on trial after reaching her peak of production under regular herd conditions and remained on trial for the remainder of her lactation period.

A grain mixture consisting of one-half oats and one-half milo was fed with alfalfa hay and sorghum silage. Steamed bone meal, finely ground limestone and salt were added to the grain mixture at the rate of 1% each.

Grain was fed at the rates of 1.0 lb. per 3.0, 5.0 and 8.0 lb. milk produced in groups I, II and III, respectively. Hay and silage were offered in a ratio of 1:3.9 with the total amount being determined by total silage consumption.

Digestion trials were conducted with five Guernsey dry cows to study the effect of variable grain feeding levels upon the consumption and digestibility of roughage.

The rate of production, calculated on a cow-day basis, in group I was 27.5 lb. 4% FCM per day. Group II produced an average of 23.1 lb. 4% FCM per day, or 84.0% as much as in group I. The average daily production of 4% FCM in group III was 25.7 lb., or 93.5% as much as in group I.

On the basis of the results obtained during the feeding trial, decreases in the hay equivalent intake appeared to be between 0.6 lb. and 0.8 lb. for each additional pound of concentrates fed.

Calculation of average efficiency ratios of 4% FCM per pound of TDN available for milk production, after adjustments for maintenance and bodyweight changes had been made, revealed only slight differences in the efficiency of production at the three levels of grain feeding.

In terms of economic efficiency, the lower grain fed groups showed a greater return over feed cost per 100 lb. 4% FCM than did the high grain fed group.

On the basis of the results of the feeding trial it appears that feeding concentrates at relatively liberal rates to dairy cows for a period after the peak of lactation would favor persistency of production. This may also be advantageous in promoting faster bodyweight recovery.

When determined by difference with the assumption that the digestibility of the hay remained the same, the digestibility of grain when added to the basal hay ration at the rate of 1.0 lb. per day, yielded unreasonable results. As the level of grain feeding increased from 4.0 lb. to 7.0 lb. per day, it appeared that the TDN value of grain decreased somewhat.

On the basis of the results of the digestion trials, it appears that no definite trends in differences of protein digestibility and TDN values of hay resulted when fed alone or in combination with grain at the rate of 1.0, 4.0 or 7.0 lb. per day.

Although no definite trends were shown it was evident that the roughage intake decreased as grain intake increased in the digestion trials.

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APPENDIX

APPENDIX

TABLES PAGE

TABLE I

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 1.*

Month-Year	Feed Consumption				4%
	Hay	Silage	Hay Equiv.	Conc.	FCM
	lb.	lb.	lb.	lb.	lb.
11-53	270.4	980.3	689.6	153.2	633.7
12-53	252.9	1261.1	792.7	155.0	651.6
1-54	292.0	1238.2	798.8	112.3	478.3
2-54	264.7	1028.2	685.5	78.6	367.0
3-54	291.4	1127.3	605.6	74.4	373.8
4-54	266.3	926.3	584.9	72.0	345.3
5-54	272.9	967.6	609.0	68.8	311.5
6-54	282.0	873.0	620.9	49.4	203.2
7-54	56.4	160.0	121.2	6.0	28.1
Total	2249.0	8562.0	5507.6	769.7	3392.5

*Ayrshire, Group II, 6 yr. 9 mo. at calving, 9-2-53.

TABLE II

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 2.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
11-53	260.0	864.4	630.0	211.3	1113.7
12-53	322.4	1208.2	839.7	285.2	1022.2
1-54	322.4	1363.7	880.6	193.7	1000.7
2-54	291.2	1250.0	802.8	147.4	793.8
3-54	322.4	1328.3	692.7	153.8	815.1
4-54	312.0	1234.5	736.7	144.0	736.2
5-54	321.0	1266.5	760.9	126.8	609.6
6-54	312.0	1036.0	714.3	91.4	417.4
7-54	197.6	549.4	420.0	37.6	169.3
Total	2661.0	10101.0	6477.7	1391.2	6658.0

*Ayrshire, Group II, 4 yr. 7 mo. at calving, 9-15-53.

TABLE III

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 3.*

	Feed Consumption				4%
Month-Year	Hay	Silage	Hay Equiv.	Conc.	FCM
	lb.	lb.	lb.	lb.	lb.
11-53	245.2	856.2	611.7	413.6	1372.1
12-53	320.5	1120.2	788.9	457.1	1324.7
1-54	318.4	1242.1	826.7	421.3	1184.2
2-54	280.0	1093.8	598.2	303.2	898.1
3-54	310.0	1193.5	642.7	294.9	900.1
4-54	300.0	1106.3	680.6	255.4	765.6
5-54	309.2	1136.6	704.0	233.2	725.4
6-54	300.0	970.2	676.7	168.8	551.1
7-54	265.5	686.5	543.4	121.6	308.7
Total	2648.8	9405.4	6072.9	2669.1	8030.0

*Ayrshire, Group I, 7 yr. 11 mo. at calving, 9-23-53.

TABLE IV

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 4.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
11-53	213.2	745.3	532.3	304.9	889.2
12-53	264.3	927.5	652.2	310.0	909.4
1-54	273.6	943.6	659.8	285.6	768.1
2-54	217.8	794.1	448.8	194.4	564.0
3-54	235.6	857.6	474.7	177.6	494.0
4-54	228.0	761.8	490.1	128.8	381.5
5-54	235.6	754.5	497.7	88.4	213.9
6-54	279.9	576.3	503.7	27.2	59.3
7-54	45.6	144.0	103.9	3.6	5.9
Total	2398.6	6504.7	4363.2	1520.5	4285.3

*Ayrshire, Group I, 7 yr. 9 mo. at calving, 9-3-53.

TABLE V

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 5.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
11-53	380.0	1120.6	859.7	217.7	1511.0
12-53	469.1	1666.1	1165.7	254.2	1317.4
1-54	446.4	1797.6	1182.1	174.9	1082.8
2-54	403.2	1637.8	879.6	101.0	870.8
3-54	273.6	1135.3	587.2	60.8	520.5
Total	1972.3	7357.4	4674.3	809.6	5302.5

*Ayrshire, Group III, 6 yr. 2 mo. at calving, 9-10-53.

Removed from trial due to leg injury.

TABLE VI

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 6.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
11-53	314.4	943.4	718.3	119.9	885.5
12-53	399.3	1210.1	905.3	117.8	836.5
1-54	365.8	1399.0	938.3	99.5	770.0
2-54	279.4	1144.7	612.5	72.8	530.5
3-54	303.8	1112.4	613.9	65.0	473.1
4-54	294.0	834.3	581.0	54.4	395.8
5-54	303.3	836.0	593.6	40.0	229.0
6-54	294.0	771.1	593.4	15.2	136.0
7-54	196.0	464.9	384.2	4.4	19.6
Total	2750.0	8715.9	5940.5	589.0	4276.0

*Ayrshire, Group III, 6 yr. 9 mo. at calving, 9-23-53.

TABLE VII

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 7.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
11-53	403.3	1356.6	984.1	190.4	1136.1
12-53	510.1	1723.4	1230.7	198.4	1366.5
1-54	477.4	1777.1	1204.8	155.7	1097.3
2-54	418.5	1595.8	882.8	119.6	867.7
3-54	465.0	1826.7	974.2	124.0	1000.3
4-54	450.0	1679.3	1027.7	114.4	867.8
5-54	459.6	1676.0	1041.7	95.6	670.7
6-54	450.0	1342.5	971.3	54.0	316.0
7-54	291.8	627.4	545.8	9.8	40.2
Total	3925.7	13604.8	8863.1	1061.9	7362.6

*Holstein, Group III, 7 yr. 9 mo. at calving, 9-27-53.

TABLE VIII

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 8.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
11-53	202.9	781.7	537.5	281.0	856.2
12-53	322.5	1229.1	836.4	465.0	1167.5
1-54	359.6	1381.9	925.2	385.7	1170.5
2-54	324.8	1249.0	688.1	317.2	976.3
3-54	359.6	1485.9	773.8	351.6	1139.6
4-54	348.0	1442.2	836.6	331.2	958.7
5-54	355.5	1502.1	882.6	311.2	924.3
6-54	345.7	1245.2	829.2	289.2	779.6
7-54	356.1	965.6	747.0	233.4	702.0
8-54	131.3	403.2	280.7	85.2	283.3
Total	3106.0	11685.9	7337.1	3050.7	8958.0

*Holstein, Group I, 6 yr. 3 mo. at calving, 10-9-53.

TABLE IX

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 9.*

Month-Year	Feed Consumption: Hay	Silage	Hay Equiv.	Conc.	4% FCM
	lb.	lb.	lb.	lb.	lb.
12-53	332.9	1278.3	867.4	194.5	979.3
1-54	421.6	1704.7	1119.3	211.2	927.0
2-54	313.6	1558.6	767.0	154.0	733.8
3-54	347.2	1806.7	850.8	141.1	733.6
4-54	336.0	1602.6	887.3	126.0	571.0
5-54	339.8	1641.0	909.8	112.6	563.5
6-54	336.0	1332.3	853.3	83.8	370.0
7-54	347.2	1035.2	766.3	32.4	121.4
8-54	44.8	150.7	100.6	1.6	4.4
Total	2819.1	12110.1	7121.8	1057.2	5004.0

*Holstein, Group II, 7 yr. 9 mo. at calving, 11-7-53.

TABLE X

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 10.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
12-53	181.0	682.3	466.3	158.4	864.3
1-54	381.6	1387.1	949.3	329.5	1362.6
2-54	345.2	1300.9	723.6	245.8	1213.4
3-54	383.6	1494.3	800.1	258.4	1232.6
4-54	369.9	1383.9	846.0	231.2	1030.5
5-54	379.8	1448.6	883.0	217.2	930.8
6-54	360.2	1260.0	849.4	185.8	769.8
7-54	374.6	1130.7	832.3	126.6	564.3
8-54	381.0	1173.4	815.8	106.4	559.8
9-54	161.2	580.5	376.3	41.6	200.5
Total	3318.1	11841.7	7542.1	1900.9	8728.6

*Holstein, Group II, 8 yr. 1 mo. at calving, 11-13-53.

TABLE XI

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 11.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
12-53	142.1	501.0	351.6	189.6	616.6
1-54	291.4	1084.0	735.0	414.9	1153.4
2-54	229.0	950.4	505.5	313.8	882.2
3-54	248.0	1064.4	544.7	305.4	919.8
4-54	240.0	999.3	583.8	279.6	783.0
5-54	245.7	1024.5	601.5	277.8	830.9
6-54	240.0	894.7	587.3	244.9	704.0
7-54	248.0	771.3	560.2	207.0	559.2
8-54	248.0	799.0	544.1	176.6	572.3
9-54	96.0	356.2	228.0	67.2	196.8
Total	2228.2	8444.8	5241.7	2476.8	7218.2

*Ayrshire, Group I, 7 yr. 6 mo. at calving, 11-9-53.

TABLE XII

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 12.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
12-53	105.5	406.2	275.3	149.7	532.5
1-54	241.8	1076.0	682.2	213.3	943.4
2-54	218.4	1032.2	518.7	161.6	725.7
3-54	241.8	1148.1	561.8	156.0	719.4
4-54	234.0	1048.9	594.8	138.4	609.5
5-54	240.4	1091.1	619.4	132.4	627.1
6-54	62.4	287.5	174.0	27.2	145.3
Total	1344.3	6090.0	3426.2	978.6	4302.9

*Ayrshire, Group II, 8 yr. 10 mo. at calving, 11-9-53.

Removed from trial due to multiple lesions of exterior genitalia.

TABLE XIII

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 13.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
1-54	363.2	1388.5	931.5	171.3	1113.6
2-54	330.4	1250.2	694.1	119.6	852.1
3-54	365.8	1395.4	754.8	124.0	1136.1
4-54	351.3	1289.7	794.9	103.2	852.5
5-54	362.3	1308.4	816.8	101.4	796.8
6-54	353.5	1027.1	752.3	91.6	662.8
7-54	364.2	891.8	725.3	76.6	518.7
8-54	363.6	983.1	727.9	62.0	482.8
9-54	236.0	734.7	508.3	33.2	274.7
Total	3090.3	10268.9	6695.9	882.9	6690.1

*Ayrshire, Group III, 3 yr. 11 mo. at calving, 11-17-53.

TABLE XIV

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 14.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
1-54	489.2	1793.8	1223.4	174.7	1087.3
2-54	453.6	1742.5	960.5	122.0	832.9
3-54	502.2	1957.7	1047.9	117.8	924.4
4-54	486.0	1662.3	1057.9	114.0	843.4
5-54	479.4	1699.0	1069.5	117.8	826.2
6-54	484.1	1190.3	946.3	103.6	708.6
7-54	494.9	833.3	832.2	82.8	620.0
8-54	502.2	968.1	861.0	51.2	473.0
9-54	405.0	1096.7	811.4	44.0	307.3
Total	4296.6	12943.7	8810.1	927.9	6623.1

*Holstein, Group III, 8 yr. 9 mo. at calving, 11-22-53.

TABLE XV

FEED CONSUMPTION AND MILK PRODUCTION, COW NO. 15.*

Month-Year	Feed Consumption				4% FCM
	Hay	Silage	Hay Equiv.	Conc.	
	lb.	lb.	lb.	lb.	lb.
1-54	310.0	1263.2	827.1	477.0	1352.5
2-54	280.0	1172.7	621.2	375.2	1174.2
3-54	310.0	1336.1	682.5	394.6	1116.5
4-54	298.9	1248.7	728.5	365.4	1065.8
5-54	296.0	1258.5	733.1	354.0	950.8
6-54	288.7	1027.6	687.7	277.4	650.2
7-54	307.5	979.0	703.8	139.0	302.5
8-54	140.0	443.1	304.2	12.0	21.4
Total	2231.1	8728.9	5288.1	2394.6	6633.9

*Holstein, Group I, 8 yr. 7 mo. at calving, 11-24-53.

TABLE XVI

WEEKLY BODYWEIGHTS OF ALL COWS ON FEEDING TRIAL
lb.

	Cow Number														
Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1226	925	1216	1103	1138	1006	1365	1275	1364	1345	1147	860	1035	1520	1322
2	1225	985	1245	1090	1125	1025	1380	1228	1355	1337	1136	848	1060	1505	1327
3	1189	976	1265	1100	1129	1023	1366	1300	1354	1311	1167	860	1063	1490	1326
4	1215	989	1247	1090	1160	1027	1370	1284	1368	1307	1196	857	1026	1495	1266
5	1245	1000	1292	1107	1195	1093	1351	1242	1381	1305	1164	869	1034	1450	1328
6	1233	992	1235	1080	1165	1046	1317	1217	1407	1210	1096	818	1026	1445	1301
7	1218	1048	1260	1082	1206	1058	1385	1292	1350	1228	1110	834	1000	1445	1292
8	1238	1017	1266	1087	1203	1066	1385	1276	1276	1235	1142	825	1022	1443	1270
9	1231	1020	1293	1100	1200	1058	1400	1291	1284	1216	1082	822	974	1429	1286
10	1238	1017	1292	1086	1216	1058	1411	1275	1286	1219	1101	816	1039	1400	1312
11	1250	1018	1245	1085	1209	1040	1380	1251	1284	1187	1080	806	1018	1402	1296
12	1182	985	1202	1048	1175	1010	1357	1241	1281	1164	1062	819	1060	1468	1351
13	1209	1000	1223	1062	1149	1018	1316	1237	1270	1173	1070	822	989	1395	1230
14	1215	964	1200	1040	1150	1010	1315	1240	1283	1238	1132	843	1069	1499	1380
15	1192	975	1205	1033	1140	1000	1321	1239	1281	1126	1109	826	1072	1451	1375
16	1155	981	1200	1025	1116	1000	1307	1241	1299	1267	1126	850	1074	1491	1383
17	1157	972	1203	1039	1154	1008	1274	1239	1214	1239	1125	852	1077	1480	1371
18	1148	965	1191	1054	1104	1000	1281	1222	1301	1277	1170	866	1075	1470	1380
19	1160	981	1207	1032	1114	970	1248	1277	1311	1279	1149	847	1053	1471	1355
20	1204	1023	1241	1078	*	1021	1346	1218	1296	1243	1134	841	1066	1491	1325

*Removed from trial due to leg injury.

TABLE XVI (concluded)

WEEKLY BODYWEIGHTS OF ALL COWS ON FEEDING TRIAL
lb.

Week	Cow Number														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
21	1155	935	1208	1026	—	977	1312	1311	1266	1242	1103	847	1071	1450	1326
22	1213	1023	1269	1097	—	1018	1360	1337	1260	1274	1148	856	1067	1435	1345
23	1211	1049	1268	1101	—	1016	1349	1332	1278	1270	1135	857	1046	1423	1346
24	1225	1052	1282	1105	—	1021	1380	1351	1260	1256	1142	846	1061	1437	1383
25	1260	1073	1276	1079	—	1029	1412	1348	1282	1253	1132	862	1074	1430	1358
26	1252	1069	1278	1090	—	1014	1400	1358	1310	1296	1167	*	1067	1422	1345
27	1249	1069	1262	1090	—	1015	1383	1335	1301	1246	1200	—	1054	1418	1339
28	1271	1064	1282	1111	—	1026	1426	1338	1345	1263	1177	—	1072	1425	1392
29	1274	1079	1270	1102	—	1041	1457	1340	1341	1245	1163	—	1047	1356	1398
30	1290	1076	1263	1117	—	1056	1443	1354	1280	1238	1157	—	1070	1344	1437
31	1309	1102	1257	1140	—	1030	1449	1373	1290	1236	1158	—	1073	1305	1383
32	1325	1138	1285	1144	—	1081	1474	1331	1330	1249	1161	—	1083	1330	1429
33	1340	1106	1262	1142	—	1075	1480	1307	1305	1227	1140	—	1090	1340	1457
34	1332	1116	1243	1148	—	1078	1463	1352	1308	1239	1165	—	1101	1370	—
35	1355	1132	1256	1167	—	1138	1485	1365	1326	1257	1161	—	1102	1391	—
36	—	1147	1251	—	—	1116	1498	1326	—	1276	1166	—	1095	1362	—
37	—	1122	1246	—	—	1130	1429	1333	—	1252	1152	—	1100	1359	—
38	—	—	1233	—	—	—	—	1305	—	1251	1155	—	1125	1369	—
39	—	—	—	—	—	—	—	1308	—	1233	1160	—	—	1404	—
40	—	—	—	—	—	—	—	1324	—	—	—	—	—	—	—

*Removed from trial due to multiple lesions of exterior genitalia.

VITA

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Master of Science

Thesis: THE EFFECT OF LEVEL OF GRAIN FEEDING UPON THE EFFICIENCY OF MILK PRODUCTION

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THESIS TITLE: THE EFFECT OF LEVEL OF GRAIN FEEDING UPON THE EFFICIENCY OF MILK PRODUCTION

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