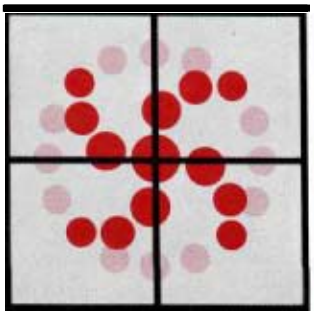

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CORNELL UNIVERSITY AGRICULTURAL EXPERIMENT STATION, NEW YORK STATE COLLEGE OF AGRICULTURE AND LIFE SCIENCES, A STATUTORY COLLEGE OF THE STATE UNIVERSITY, CORNELL UNIVERSITY, ITHACA, NEW YORK

# Effects of Liberal Concentrate Feeding on Health, Reproductive Efficiency, Economy of Milk Production, and Other Related Responses of the Dairy Cow*

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An increasing supply of grain at lower prices has encouraged dairymen to feed more concentrates to cows bred for high production. Some dairymen have experienced phenomenal changes in levels of production resulting from liberal grain feeding, but most of these were due to a change from low to moderate, or from moderate to high, rates of grain feeding. Many such situations involved individual cows of exceptional appetite and unusual tolerance to digestive stress, as well as special catering by an expert dairyman.

Research has shown that milk production can be markedly improved by increased energy intake during single lactations, but results from long-term feeding trials over successive lactations have not been reported. Because the cumulative effects of a continuous liberal-grain-feeding program had not been adequately tested, and because this system of feeding reduces the intake of forage, and may reduce the intake of certain minerals and vitamins, we thought it essential to obtain such information. Therefore we planned and conducted a detailed study of reproductive health, ovarian function, rate of conception, longevity (especially wearability of the udder, legs, and feet), and maintenance of continued high production over successive years. This included proper management of cows to overcome any bad effects on health and a search for further information on efficiency of feed utilization and economic considerations.

The research described here had the following objectives:

1. To study the time of peaking, the type of lactation curve, and the influence of previous production levels on cows fed liberal amounts of grain as compared with control cows allowed moderate amounts of grain and *ad lib.* feeding of high quality forage.
2. To compare levels of production, efficiency of feed utilization, and economy of production of liberal grain feeding to the results with the control cows.
3. To study the association between the appetite for forage and that for concentrates as measured by intake of forage and grain fed *ad lib.* under challenge feeding conditions.
4. To determine the effects on milk fat, protein, and solids-not-fat of milk produced from the 2 systems of feeding.
5. To determine the effects of continued maximum-concentrate and minimum-forage feeding on postpartum reproductive health, especially ovarian function, regularity of estrus, frequency of ovarian cysts

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and other ovarian abnormalities, rate of conception and/or breeding efficiency.

6. To study the effects of liberal grain feeding on wear-ability, general health, and incidence of mastitis over 3 consecutive lactations in high-producing cows.

## EXPERIMENTAL PLANS

The 50 Holstein cows originally put on the experiment were selected as 4 groups of 10 cows each, with established production levels in groups 1 to 4, and 5 additional young cows (4 first-lactation and 1 second-lactation) were allotted by pairs to groups 1 and 3. Thus, there were 10 comparable cows in each of groups 1 to 4, and 15 comparable cows in each of groups 1 and 3. The results presented in tables and graphs are divided in the same way. Selection of cows was based upon previous levels of production, age, number of previous lactations, expected date of calving, size, and similarity of breeding. The average previous production of the 40 cows (10 in each of groups 1 to 4) on a 2X, 305-day, ME (mature equivalent) basis was 17,607 pounds of milk, 3.7 percent test, and 648 pounds of butterfat. All but 2 cows had exceeded 14,000 pounds of milk and 8 cows had exceeded 19,000 pounds, including 1 with records that averaged over 21,000 pounds of milk. Groups of 4 similar cows were assigned at random to 1 of 4 treatment groups as follows:

*Treatment group 1 — control.* Fifteen cows were fed moderate levels of grain through 3 lactation periods, plus good quality alfalfa and grass hay *ad lib.* and 36 pounds of corn silage per day. During the dry period, 6 pounds of grain was fed per day unless cows were overconditioned; if so, grain was adjusted from 0 to 6 pounds according to body condition: 6 pounds of grain per day for 3 weeks prepartum and 10 pounds of grain the first day post-partum, followed by increases of 1 pound per day to a maximum of 20 pounds total fed twice daily with an allowance of 10 pounds per feeding. Grain was continued at this rate until milk production peaked and declined to approximately 75 pounds of 4 percent FCM for 2 consecutive weeks. For the remainder of the lactation, grain was fed in accordance with the amounts listed in a table based on specified amounts (appendix table 1) for different butterfat tests that allowed approximately 1 pound of grain for each 3 pounds of milk (4% FCM) above 16 pounds of milk per day. No further adjustment was made for fat tests below 3.6 percent or above 4.6 percent.

*Treatment group 2 — liberal grain.* Ten cows were fed liberal amounts of grain through 3 lactation periods, plus good quality alfalfa and grass hay *ad lib.* and 36 pounds of corn silage per day (no grain was fed during the dry period). Starting 3 weeks before parturition, 4 pounds of grain was fed, and increased at the rate of 1 pound per day to allow a possible total of 20 pounds per day. Starting 1 day after parturition grain was increased 1.5 pounds per day (0.5 pound for 3X daily feeding )and fed *al lib.* up to 6 weeks after parturition during the first year. When milk production declined for 2 successive weeks, grain allowance was adjusted in accordance with a previously prepared table. Because the amount of grain suggested in the predetermined schedule of feeding for year 1 was too low — especially at milk-production levels below 60 pounds—, larger amounts were recommended for years 2 and 3. The amounts allowed after this adjustment are listed in appendix table 2.

During years 2 and 3 a maximum of 36 pounds per day was fed until the start of the sixth week of lactation, when grain was fed *ad lib.* for 3 weeks to characterize the cow's appetite and to establish the potential response in milk production. Grain allowance was adjusted to amounts specified in a prepared feeding table based upon TDN requirements by Moe, Tyrrell, and Reid (1963), and as adjusted for years 2 and 3 in appendix table 2. Total daily grain allowances of more than 30 pounds per day were fed 3 times rather than twice daily. The specified amount of grain was fed even if cows became too fat during lactation.

*Treatment group 3 — restricted forage, liberal grain.* Fifteen cows were fed through 3 lactation periods on the same forage specified for treatment groups 1 and 2, but with amounts limited to 8 pounds of alfalfa and grass hay and 12 pounds of corn silage per day, in addition to the basic grain amounts specified for treatment group 2 plus 15 pounds as forage-replacement grain. This forage-replacement grain, calculated to provide approximately the same TDN as for treatment 2, was fed as a base to compensate for the restricted forage during the dry period and lactation. Thus, during years 2 and 3 a maximum of 45 pounds of grain per day was allowed until the *ad lib.* grain feeding during the 6th week was started. Above this base, grain allowances and treatments were the same as for group 2. Grain allowances for group 3 are listed in appendix table 3.

*Treatment group 4 — all silage, liberal grain.* Ten cows were fed through 3 lactation periods on all-corn silage *ad lib.,* supplemented with soybean meal to supply the estimated protein difference between an all-corn-silage forage and the forage provided in treatment 2, plus grain fed in the same amounts as specified for treatment group 2 (appendix table 2). The specification to feed the amounts of grain listed even if cows became too fat during lactation applied to group 4, but the amount of corn silage fed was to be decreased and adjusted in accordance with the condition of any cow that tended to fatten during lactation or the dry period.

The protein substitution with 44 percent protein soybean meal to allow for the difference in the protein content between the hay and silage is listed in appendix table

4. To facilitate the hand-feeding of a protein supplement, soybean meal was fed in a ratio of one-half pound to each 10 pounds of silage (i.e., 0.5, 1.0, 1.5, 2.0). To help offset added energy from the soybean meal protein supplement, and also to consider the protein value of the normal grain replaced by the soybean meal, the substitution rate of 0.875 seemed appropriate (i.e., for each pound of soybean meal added, the allowance of the normal grain mixture was reduced by 0.875 pound).

## EXPERIMENTAL PROCEDURE

*Grain feeding.* The same grain mixture (table 1) was fed to all treatment groups throughout the experiment. The grain mixture was computed to contain 16 percent of crude protein, and 72 percent of total digestible nutrients; 1000 IU of vitamin A per pound was added to ensure sufficient vitamin A for cows on restricted forage. Grain was fed twice daily in equal amounts, but when the total amount fed exceeded 30 pounds per day 3 feedings were given. Grain allowances were adjusted weekly, using as a basis milk production during the last 3 days of the previous week (unless abnormal) and the milk fat concentration of the previous week. For abrupt decreases in grain allowance the rate of decrease was the same as the rate of increase (0.5 pound per feeding) at the start of the lactation. Grain was weighed as it was fed to each cow and any refusals were removed and weighed once daily. Grain offered was limited to no more than 10 percent refusal of the daily allowance when a cow did not completely consume her calculated allowance. When cows showed signs of going off feed or were already off feed, the grain allowance was adjusted according to appetite. The same applied to sick cows. The 30-pound limit for feeding 2 or 3 times daily did not apply to this temporary situation because it was in line with good management.

In September 1965 (after the study had been under way for one year) an agreement was reached and the USDA cooperators approved a change in the grain feeding schedule to permit a greater intake of concentrates for cows on liberal grain feeding schedules, especially after the cows decreased in production to 60 pounds or below. This allowed a greater difference in intake of concentrates between groups 1 and 2, which complied with the objectives of the study. Further, it was specified that for use of the grain feeding tables no adjustment would be made for fat content of milk below a test of 3.6 percent. This adjustment was made because the fat test may drop when forage intake is low in comparison to the intake of concentrates. The adjustment for low test, as originally outlined in the contract, was inconsistent with plans for liberal grain feeding because cows with high yields responsive to a good appetite for grain temporarily dropped in test and were then penalized too much in terms of lowered intake of concentrates.

Table 1. *Ingredients used in grain mixture fed to all cows throughout the experiment*

| Ingredient | Amount |
|---|---|
| | pounds |
| Ground corn | 500 |
| Ground oats | 300 |
| Wheat bran | 400 |
| Corn distillers dried grains without solubles | 400 |
| Soybean meal (44% protein, solvent process) | 160 |
| Cane molasses | 200 |
| Mineralized salt (Morton's formula L)* | 20 |
| Dicalcium phosphate | 20 |
| Cobalt sulfate | 2 gms. |
| Vitamin A | 1000 IU/lb. |

*A mixture of salt, cobalt carbonate, potassium iodide, manganous oxide, iron carbonate, copper carbonate, and zinc carbonate. The mixture was specified to provide not less than the following percentages: salt 98.5, manganese 0.15, iron 0.078, copper 0.015, cobalt 0.01, iodine 0.007, and zinc 0.005. When 1 percent of the mineralized salt mixture is added to the grain ration, the following parts per million (ppm) are present: manganese 1500, iron 780, copper 150, cobalt 100, iodine 70, and zinc 50. A mineral box with dicalcium phosphate and iodized salt was also provided in the exercise lot.

We planned to make these changes after all cows had completed the first lactation. It was also specified that grain feeding rates for groups 2, 3, and 4 were to be maintained even though the cows became too fat. But for group 4 the corn silage allowance was limited for cows that tended to fatten. In making this adjustment in rate of grain feeding, no changes were made for control group 1.

***Hay** feeding.* The hay fed in this experiment was cut from similar legume and grass forage on a second- or third-year meadow and harvested as crushed barn-dried hay from June 12 to 22 (cutting dates). It was considered important to limit the total time interval for harvesting to 10 days. It was estimated (Reid *et al.*, 1959) that the hay should average about 60 percent TDN on dry basis, depending on distribution of cutting dates and degree of mild or moderate weathering during the curing period. Hay that was badly weather-damaged was not included in hay stored for experimental feeding.

For *ad lib.* feeding, the hay was weighed once daily and fed twice daily in approximately equal amounts. Cows receiving restricted forage were fed hay once daily. Hay refusals were removed and weighed once daily.

***Silage feeding.*** The corn silage was harvested from similar stands of corn all of one variety (Cornell M-3), harvested at the early dent stage of maturity in year 1, and at the advanced dent stage for years 2 and 3 Enough silage was made each year for feeding throughout the year during the 4 years of the experiment. Silage was fed twice daily in equal amounts to treatment groups 1, 2, and 4,

and once daily to treatment group 3. Silage refusals were removed and weighed once daily.

*Body weights and body condition scores.* The experimental cows were weighed between 8 and 10 a.m. on the same day of each week. In addition, body condition of each cow was evaluated once a month by a panel of 4 judges using a special evaluation form for recording these ratings.

*Fertility, reproductive, and health records.* The genital organs of each cow were examined *per rectum,* starting within a week after calving and continued twice weekly, or more frequently if necessary, until 75 days after conception. Then each cow was examined monthly through the fifth month of pregnancy. The following information was recorded at each examination: diameter of cervix, diameter of each uterine horn, and location and size of follicles and corpora lutea on both ovaries. The same veterinarian, co-author Dr. Morrow, made all of these examinations but called in an associate veterinarian to treat any abnormalities noted.

Each cow whose genital organs were normal was bred during the first estrous period 60 days after freshening. The experimental cows were turned out at least once each day and observed for signs of estrus for approximately 20 minutes each time. Special attention was given to those expected to be in estrus; they were turned out twice or more per day if signs of estrus were not noted during the routine exercise period. Each estrous period was verified by palpation *per rectum.* The presence or absence of a corpus luteum on the ovary after the development and rupture of a follicle was determined by routine examination.

The service sire for all cows during a particular lactation was the same. In addition, each cow was bred with frozen semen from the same ejaculate to eliminate semen quality as a variable affecting fertility across treatment groups within a particular lactation.

In addition to reproductive health, complete health records were kept on each cow throughout the experiment. Health disorders treated were: mastitis by udder quarter, both clinical and acute; various "off-feed" conditions such as ketosis, indigestion, scours, milk fever, foreign bodies, or abomasal displacement; lameness due to hoof rot, cracked heel, bruise, or unknown cause; and various types of udder injuries.

*Feed samples and analysis.* Each feed was sampled weekly for the determination of dry-matter content, and weekly samples were compounded over either monthly or 3-month intervals for chemical analysis. Also digestion trials, with steers at maintenance level of intake were conducted each year of the experiment to characterize the nutritive value of all feeds given to the lactating cows.

During the first year only, digestibility for selected cows was determined at various levels of intake above maintenance, but not for the cows on the main experiment.

A weighback sample was kept each day in a plastic can for each cow. The amount of the sample was taken in proportion to the weighback each day, with 0.1 pound taken for each pound of weighback. Dry-matter determinations were made on these samples at weekly intervals. A composite sample of weighback was kept for each cow, and at intervals of 6 months these were used for proximate analyses including crude protein, ether extract, nitrogen-free extract, and ash.

*Milk records, milk samples, and analysis.* Milk yield of each cow was recorded at each milking and used for the computation of milk production records. Tests were made from a composite milk sample, taken 2 days a week from each cow, to determine milk fat, protein (by dye binding), and solids-not-fat (by lactometer) content.

Milk from each cow was sampled once a month for taste and flavor characteristics. The susceptibility of milk to the development of oxidized flavor was determined both by chemical and taste-panel analyses, and the presence of any other abnormal flavor characteristic was determined by a panel of experienced judges.

*Housing and handling.* Throughout the experiment all cows were confined in individual tie stalls at Cornell's main dairy cattle barn. Special feed mangers were constructed to prevent adjacent cows from having access to any feed source other than that intended. Wood shavings were used as the bedding material in the stalls at all times. When this facility was destroyed by fire on June 22, 1968, all cows had completed the experiment except one in treatment group 2. This cow should have had 14 days of additional observation to complete her third lactation period on experiment, but this information could not be obtained under the circumstances.

All experimental cows were turned out for exercise and observation for estrus once daily and were allowed to lie down for several hours in a dirt lot free of vegetation. The cows were policed carefully while going out or coming into the barn to prevent them from stealing feed from the mangers of other cows. Cows due in estrus were usually turned out twice daily for observation to detect estrus and to work out a timing for AI service conducive to a good conception rate.

## RESULTS AND DISCUSSION

Some excellent publications are available on the subject of liberal grain feeding: Reid (1956, 1964), Huffman (1961), Lassiter and Brown (1962), Loosli (1963), Kesler and Spahr (1964), and Moore (1964). A review of literature is not included in this publication, but we consulted many references and compared the results reported with those obtained in our research.

In presenting our results, the order followed is: feed intake; milk and fat production; milk composition; milk flavor; body weight, including gains and losses; reproductive efficiency; and health aspects. Results from the 50 experimental cows are given under each point considered: first the 40 cows in groups 1 to 4, next the 5 additional young cows in groups 1 and 3, and finally a summary for the 15 cows in groups 1 and 3.

Cow losses comprised 1, 2, 3, and 9 cows for groups 1 to 4, respectively; a detailed discussion of this is given in the section *Cow Losses.* All cows in groups 1 to 4 completed the first year, and the 5 additional cows in groups 1 and 3 completed all 3 years of the experiment. Thus, averages for groups 1 to 4 represent 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3. Groups 1 (control) and 3 (restricted forage, liberal grain) had a total of 15 cows each during year 1; group i had 14 for years 2 and 3; and group 3 had 13 and 12, respec tively, for years 2 and 3. All averages include totals for all cows for all 3 years, or are weighted in accordance with the number of cows included in overall averages or daily averages for a 44-week lactation.

*Feed intakes.* In tables 2 to 5 the average daily feed intakes, by weeks, are listed for groups 1 to 4 for each year, plus the 3-year average. The average daily feed intakes for 44 weeks of lactation were: Group 1 (control) and group 2 (liberal grain) which were fed hay *ad lib.* averaged 20.6, 23.6, 19.3, 21.1 and 17.1, 14.6, 11.8, 14.7 pounds of hay for years 1, 2, 3, and the 3-year average, respectively. The cows in group 3 on restricted forage usually consumed all of the 8.0 pounds of hay offered, with an average in take of 7.8 pounds of hay during the 3 years on experi ment. The cows on the all-corn silage and liberal grain in group 4 consumed an average of 77.9, 63.5, and 52.5 pounds of corn silage, respectively, for years 1, 2, and 3. The 3-year average for this group was 71.3 pounds. Groups 1, 2, and 3, which had a fixed allowance of silage, usually consumed their respective allowances and had an average intake of 35.5, 34.4, and 12.0 pounds daily for the 3 years on experiment.

*Grain consumption.* The average daily grain consumption followed a definite pattern. The control cows in group 1 with a top limit of 20 pounds of grain daily averaged 12.5, 13.1, and 12.7 pounds of grain intake daily during years 1, 2, and 3 for a 44-week lactation, respectively. The cows on liberal grain feeding in group 2 averaged 17.5, 25.4, and 25.8 pounds. The cows in group 4 — fed liberal grain corresponding to group 2 but with forage comprising only corn silage — averaged 19.0, 26.0, and 24.6 pounds, respectively. The cows on restricted forage in group 3 averaged 28.5, 28.2, and 27.9 pounds of grain for years 1, 2, and 3, respectively. These cows received a base grain allowance of 15 pounds to substitute for the forage withheld on the restricted-forage-feeding program. A corn-

Table 2. *Average daily feed intake, by weeks, 10 cows in groups 1 to 4, year 1**

| Week | Feed intake | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group 1 | | | Group 2 | | | Group 3 | | | Group 4 | | |
| | Hay | Silage | Grain | Hay | Silage | Grain | Hay | Silage | Grain | Silage | Grain | S.O.M. |
| | pounds | | | | | | | | | | | |
| −4 | 11.1 | 36.0 | 5.3 | 20.2 | 31.6 | 6.8 | 17.1 | 12.0 | 8.8 | 19.7 | 8.4 | 0.0 |
| −3 | 11.0 | 30.6 | 5.9 | 15.1 | 32.2 | 8.5 | 15.7 | 12.0 | 16.7 | 41.2 | 8.5 | 0.0 |
| −2 | 10.9 | 27.9 | 6.0 | 13.5 | 28.5 | 14.3 | 9.0 | 12.0 | 22.1 | 44.2 | 11.3 | 0.0 |
| −1 | 9.8 | 27.7 | 5.9 | 8.3 | 25.5 | 18.0 | 6.8 | 11.8 | 19.7 | 34.5 | 15.1 | 0.0 |
| 1 | 11.4 | 26.0 | 10.9 | 8.6 | 24.1 | 20.7 | 7.2 | 11.7 | 24.6 | 53.2 | 19.8 | 0.5 |
| 2 | 11.1 | 29.2 | 15.9 | 7.5 | 24.4 | 29.6 | 7.1 | 11.8 | 29.5 | 39.4 | 29.1 | 1.0 |
| 3 | 11.7 | 30.9 | 17.7 | 7.0 | 27.3 | 31.5 | 7.0 | 11.9 | 36.7 | 38.9 | 33.0 | 1.5 |
| 4 | 13.0 | 34.1 | 18.4 | 7.0 | 27.9 | 32.7 | 6.9 | 11.7 | 36.2 | 45.3 | 34.9 | 1.3 |
| 5 | 13.9 | 34.9 | 19.0 | 8.0 | 26.1 | 30.9 | 7.0 | 12.0 | 35.1 | 48.4 | 36.5 | 1.4 |
| 6 | 15.3 | 34.7 | 18.7 | 9.3 | 29.4 | 31.4 | 7.4 | 12.0 | 36.5 | 47.4 | 36.8 | 1.4 |
| 7 | 15.6 | 33.0 | 17.5 | 9.1 | 30.1 | 34.7 | 7.3 | 12.0 | 38.8 | 51.5 | 34.0 | 1.2 |
| 8 | 15.3 | 33.8 | 19.0 | 7.8 | 31.7 | 36.7 | 7.3 | 11.9 | 37.0 | 50.9 | 33.4 | 1.5 |
| 9 | 16.6 | 33.3 | 19.1 | 7.7 | 32.1 | 34.4 | 7.6 | 11.9 | 38.0 | 54.8 | 32.7 | 1.5 |
| 10 | 17.0 | 32.9 | 18.5 | 8.0 | 32.3 | 31.3 | 7.5 | 12.0 | 38.3 | 60.7 | 31.5 | 1.7 |
| 11 | 19.6 | 35.3 | 17.8 | 10.0 | 32.7 | 28.2 | 7.6 | 12.0 | 39.3 | 57.9 | 30.5 | 1.6 |
| 12 | 19.8 | 35.4 | 17.7 | 10.2 | 32.8 | 30.4 | 7.5 | 12.0 | 38.5 | 59.2 | 29.1 | 1.5 |
| 13 | 20.4 | 35.9 | 17.2 | 10.9 | 33.5 | 29.3 | 7.6 | 12.0 | 34.0 | 65.5 | 26.9 | 1.6 |
| 14 | 20.2 | 35.7 | 16.6 | 12.1 | 33.0 | 26.7 | 7.6 | 11.9 | 34.3 | 70.2 | 27.4 | 1.8 |
| 15 | 20.9 | 36.0 | 16.5 | 12.8 | 32.8 | 25.7 | 7.7 | 12.3 | 33.3 | 78.3 | 26.0 | 2.1 |
| 16 | 21.6 | 35.9 | 16.3 | 14.6 | 33.8 | 24.1 | 8.0 | 12.3 | 34.5 | 72.5 | 23.3 | 2.2 |
| 17 | 20.0 | 35.9 | 15.4 | 15.2 | 35.2 | 23.9 | 8.0 | 12.0 | 34.3 | 71.6 | 20.7 | 2.3 |
| 18 | 20.6 | 35.9 | 15.1 | 16.0 | 34.7 | 25.4 | 8.0 | 12.0 | 32.8 | 77.0 | 20.1 | 2.2 |
| 19 | 21.4 | 36.0 | 14.6 | 15.9 | 33.4 | 22.2 | 8.0 | 12.0 | 32.6 | 79.1 | 19.2 | 2.3 |
| 20 | 20.6 | 36.0 | 14.6 | 15.3 | 34.7 | 20.5 | 8.0 | 12.0 | 32.9 | 85.0 | 17.7 | 2.6 |
| 21 | 20.5 | 35.9 | 14.4 | 16.5 | 35.1 | 18.4 | 7.9 | 12.0 | 31.3 | 84.5 | 16.1 | 2.8 |
| 22 | 21.0 | 36.0 | 13.7 | 17.7 | 35.7 | 17.9 | 7.9 | 12.0 | 28.8 | 83.3 | 15.8 | 2.9 |
| 23 | 20.8 | 35.8 | 13.7 | 18.9 | 35.9 | 16.1 | 8.0 | 12.0 | 29.7 | 83.2 | 14.2 | 2.7 |
| 24 | 21.7 | 36.0 | 13.8 | 19.5 | 35.5 | 15.1 | 8.0 | 12.0 | 28.4 | 83.7 | 13.1 | 2.7 |
| 25 | 21.4 | 36.0 | 12.9 | 19.3 | 35.5 | 14.0 | 8.0 | 12.0 | 28.8 | 83.6 | 11.2 | 2.8 |
| 26 | 22.0 | 36.0 | 11.4 | 18.9 | 35.4 | 14.2 | 8.0 | 12.0 | 27.9 | 85.8 | 10.7 | 2.7 |
| 27 | 22.8 | 36.0 | 11.4 | 18.8 | 35.5 | 12.3 | 8.0 | 12.0 | 26.9 | 85.3 | 9.5 | 2.8 |
| 28 | 22.5 | 36.0 | 10.8 | 20.2 | 35.7 | 10.5 | 8.0 | 12.0 | 25.4 | 85.9 | 9.6 | 2.7 |
| 29 | 23.8 | 36.0 | 10.4 | 22.5 | 35.9 | 9.6 | 8.0 | 12.0 | 24.0 | 89.4 | 8.4 | 2.8 |
| 30 | 23.5 | 35.9 | 10.5 | 23.4 | 35.8 | 9.3 | 8.0 | 12.0 | 23.8 | 93.1 | 7.8 | 2.9 |
| 31 | 23.8 | 36.0 | 10.1 | 25.2 | 35.9 | 8.5 | 8.0 | 12.0 | 23.0 | 92.6 | 6.4 | 3.0 |
| 32 | 24.6 | 36.0 | 9.6 | 25.8 | 35.8 | 7.5 | 7.9 | 12.0 | 22.5 | 93.6 | 5.7 | 3.2 |
| 33 | 25.3 | 36.0 | 9.0 | 25.9 | 35.2 | 6.3 | 8.0 | 12.0 | 22.0 | 99.2 | 5.5 | 3.1 |
| 34 | 24.7 | 36.0 | 8.7 | 22.3 | 35.4 | 5.8 | 8.0 | 12.0 | 21.5 | 99.7 | 5.0 | 3.4 |
| 35 | 24.5 | 36.0 | 8.9 | 24.3 | 36.0 | 5.6 | 8.0 | 12.0 | 20.6 | 102.9 | 4.3 | 3.5 |
| 36 | 24.8 | 36.0 | 8.1 | 25.1 | 35.6 | 5.2 | 8.0 | 12.0 | 20.2 | 100.5 | 3.9 | 3.6 |
| 37 | 24.4 | 36.0 | 7.8 | 25.2 | 35.7 | 6.7 | 8.0 | 12.0 | 20.1 | 99.1 | 3.5 | 3.6 |
| 38 | 24.7 | 35.9 | 7.2 | 25.9 | 35.8 | 5.8 | 8.0 | 12.0 | 19.8 | 101.6 | 3.5 | 3.5 |
| 39 | 25.0 | 36.0 | 6.1 | 25.4 | 35.8 | 3.7 | 8.0 | 12.0 | 19.5 | 99.9 | 3.2 | 3.4 |
| 40 | 24.5 | 36.0 | 6.1 | 25.2 | 35.7 | 3.5 | 8.0 | 12.0 | 19.4 | 100.4 | 2.7 | 3.5 |
| 41 | 24.1 | 36.0 | 5.1 | 25.0 | 35.6 | 2.7 | 8.0 | 12.0 | 18.1 | 98.1 | 3.7 | 3.4 |
| 42 | 23.8 | 36.0 | 4.5 | 25.2 | 35.2 | 2.8 | 8.0 | 12.0 | 18.9 | 100.4 | 3.3 | 3.4 |
| 43 | 23.5 | 36.0 | 3.8 | 24.4 | 35.4 | 2.5 | 8.0 | 12.0 | 18.7 | 98.1 | 3.6 | 3.5 |
| 44 | 23.1 | 36.0 | 3.0 | 25.3 | 35.4 | 1.9 | 8.0 | 12.0 | 18.2 | 98.0 | 3.2 | 3.4 |
| Average, 44 weeks | 20.6 | 35.1 | 12.5 | 17.1 | 33.5 | 17.5 | 7.8 | 12.0 | 28.5 | 77.9 | 16.7 | 2.3 |

*Average for grain consumed toward end of lactation includes all cows in milk, whether or not they received grain, but does not include dry cows (unless they received grain within 44-week lactation) in groups 1, 2, and 4. In contrast, average in table on milk production was calculated by including all cows, whether milking or dry, during first 44 weeks of lactation.

Table 3. *Average daily feed intake, by weeks, groups 1 to 4, year 2**

| Week | Feed intake | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group 1 | | | Group 2 | | | Group 3 | | | Group 4 | | |
| | Hay | Silage | Grain | Hay | Silage | Grain | Hay | Silage | Grain | Silage | Grain | S.O.M. |
| | pounds | | | | | | | | | | | |
| −8 | 23.1 | 36.0 | 3.8 | 25.8 | 36.0 | 0.0 | 8.0 | 12.0 | 16.6 | 105.8 | 0.0 | 3.7 |
| −7 | 22.1 | 36.0 | 4.0 | 24.3 | 35.7 | 0.0 | 8.0 | 12.0 | 15.9 | 103.8 | 0.0 | 3.8 |
| −6 | 21.4 | 36.0 | 4.2 | 23.3 | 35.9 | 0.0 | 7.9 | 12.0 | 15.5 | 98.9 | 0.0 | 3.8 |
| −5 | 20.2 | 36.0 | 5.7 | 23.0 | 36.0 | 0.0 | 8.0 | 12.0 | 15.1 | 94.4 | 0.0 | 3.5 |
| −4 | 19.0 | 36.0 | 6.0 | 22.7 | 36.0 | 6.5 | 7.9 | 12.0 | 16.1 | 91.5 | 0.0 | 3.3 |
| −3 | 18.4 | 36.0 | 6.0 | 18.8 | 35.9 | 8.5 | 7.8 | 12.0 | 19.9 | 82.5 | 5.9 | 3.1 |
| −2 | 18.3 | 35.9 | 6.0 | 16.0 | 35.5 | 12.9 | 7.4 | 12.0 | 21.7 | 63.4 | 10.8 | 2.9 |
| −1 | 16.1 | 35.1 | 6.0 | 13.0 | 32.7 | 16.6 | 6.1 | 11.9 | 19.2 | 40.2 | 13.2 | 2.4 |
| 1 | 13.9 | 33.5 | 8.6 | 8.7 | 29.8 | 18.0 | 7.1 | 11.6 | 18.7 | 28.7 | 13.8 | 1.8 |
| 2 | 14.1 | 34.0 | 16.4 | 6.8 | 31.5 | 25.5 | 6.7 | 11.5 | 22.4 | 34.0 | 20.7 | 2.0 |
| 3 | 16.9 | 35.4 | 19.9 | 8.4 | 32.5 | 30.6 | 7.4 | 11.9 | 28.2 | 35.9 | 27.9 | 1.3 |
| 4 | 16.8 | 35.5 | 20.0 | 10.9 | 33.7 | 32.0 | 7.6 | 12.0 | 28.6 | 43.9 | 30.6 | 1.4 |
| 5 | 18.1 | 35.4 | 20.0 | 10.6 | 34.5 | 30.8 | 7.7 | 12.0 | 32.4 | 48.8 | 25.8 | 1.8 |
| 6 | 19.9 | 34.5 | 20.0 | 11.1 | 34.5 | 33.8 | 7.6 | 12.0 | 32.2 | 52.2 | 23.6 | 1.5 |
| 7 | 18.4 | 34.4 | 19.7 | 9.2 | 34.3 | 35.0 | 7.8 | 12.0 | 33.5 | 55.2 | 27.2 | 1.4 |
| 8 | 20.2 | 35.2 | 18.3 | 9.9 | 34.8 | 35.8 | 7.5 | 12.0 | 34.8 | 54.8 | 30.4 | 1.5 |
| 9 | 20.9 | 35.7 | 18.6 | 10.8 | 35.1 | 36.3 | 7.5 | 12.0 | 37.5 | 55.6 | 31.0 | 1.7 |
| 10 | 22.4 | 36.0 | 19.1 | 10.5 | 35.0 | 35.8 | 7.6 | 12.0 | 36.4 | 57.4 | 32.8 | 1.9 |
| 11 | 23.1 | 35.8 | 18.6 | 11.3 | 35.2 | 34.4 | 7.7 | 12.0 | 35.8 | 59.1 | 34.2 | 1.8 |
| 12 | 24.9 | 36.0 | 17.9 | 11.3 | 35.4 | 34.2 | 7.9 | 12.0 | 35.1 | 62.0 | 34.6 | 1.8 |

*(continued)*

Table 3. (Concluded)

| Week | Feed intake | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group 1 | | | Group 2 | | | Group 3 | | | Group 4 | | |
| | Hay | Silage | Grain | Hay | Silage | Grain | Hay | Silage | Grain | Silage | Grain | S.O.M. |
| | pounds | | | | | | | | | | | |
| 13 | 24.4 | 35.9 | 17.6 | 10.8 | 35.6 | 33.7 | 7.9 | 12.0 | 37.5 | 68.4 | 35.1 | 1.7 |
| 14 | 23.4 | 36.0 | 17.3 | 11.6 | 35.6 | 32.8 | 7.8 | 12.0 | 37.0 | 66.3 | 30.8 | 1.9 |
| 15 | 24.4 | 35.9 | 17.3 | 13.9 | 35.4 | 31.4 | 7.8 | 12.0 | 36.9 | 61.1 | 32.0 | 1.9 |
| 16 | 25.2 | 35.9 | 16.5 | 14.7 | 35.5 | 31.6 | 7.9 | 12.0 | 35.9 | 60.7 | 32.1 | 1.6 |
| 17 | 25.4 | 36.0 | 15.7 | 14.8 | 35.6 | 32.1 | 8.0 | 12.0 | 36.9 | 59.0 | 30.9 | 1.7 |
| 18 | 25.2 | 36.0 | 15.9 | 15.4 | 36.0 | 30.0 | 8.0 | 12.0 | 34.0 | 58.9 | 31.4 | 1.6 |
| 19 | 25.9 | 36.0 | 15.1 | 16.2 | 35.8 | 28.9 | 8.0 | 12.0 | 35.6 | 58.5 | 31.3 | 1.7 |
| 20 | 26.0 | 36.0 | 14.9 | 16.4 | 36.0 | 28.1 | 7.9 | 12.0 | 36.0 | 59.9 | 30.2 | 1.7 |
| 21 | 24.9 | 35.8 | 14.8 | 16.9 | 35.9 | 27.5 | 8.0 | 12.9 | 33.7 | 62.3 | 28.9 | 1.8 |
| 22 | 25.8 | 35.9 | 14.3 | 17.1 | 35.9 | 27.2 | 8.0 | 12.0 | 34.5 | 66.0 | 27.5 | 1.9 |
| 23 | 25.9 | 36.0 | 14.1 | 17.7 | 35.9 | 27.0 | 8.0 | 12.0 | 33.2 | 69.1 | 27.2 | 2.0 |
| 24 | 26.0 | 36.0 | 13.5 | 18.1 | 35.9 | 25.9 | 8.0 | 12.0 | 31.4 | 71.0 | 26.9 | 2.1 |
| 25 | 26.1 | 36.0 | 13.2 | 18.8 | 35.9 | 25.3 | 8.0 | 12.0 | 29.7 | 70.9 | 25.1 | 2.2 |
| 26 | 26.2 | 36.0 | 12.2 | 19.4 | 35.9 | 24.0 | 8.0 | 12.0 | 28.5 | 69.7 | 24.5 | 2.3 |
| 27 | 26.5 | 36.0 | 12.1 | 18.3 | 35.7 | 22.7 | 8.0 | 12.0 | 26.9 | 69.4 | 23.2 | 2.3 |
| 28 | 26.2 | 36.0 | 11.7 | 18.1 | 36.0 | 23.3 | 8.0 | 12.0 | 26.3 | 69.8 | 22.1 | 2.2 |
| 29 | 25.3 | 36.0 | 11.7 | 18.2 | 36.0 | 22.6 | 8.0 | 12.0 | 24.9 | 69.7 | 21.7 | 2.2 |
| 30 | 25.4 | 36.0 | 11.8 | 17.2 | 36.0 | 21.7 | 8.0 | 12.0 | 24.0 | 69.0 | 21.5 | 2.2 |
| 31 | 25.2 | 36.0 | 10.9 | 17.5 | 36.0 | 21.4 | 8.0 | 12.0 | 23.4 | 71.4 | 22.3 | 2.1 |
| 32 | 24.7 | 35.9 | 10.2 | 16.7 | 36.0 | 20.8 | 8.0 | 12.0 | 23.2 | 70.7 | 23.1 | 2.3 |
| 33 | 26.0 | 36.0 | 10.5 | 15.9 | 36.0 | 20.6 | 8.0 | 12.0 | 20.8 | 70.7 | 21.9 | 2.2 |
| 34 | 24.9 | 35.8 | 10.0 | 16.3 | 36.0 | 20.0 | 8.0 | 12.0 | 20.8 | 71.0 | 21.2 | 2.3 |
| 35 | 25.3 | 35.8 | 9.0 | 16.1 | 35.8 | 19.4 | 8.0 | 12.0 | 21.0 | 70.5 | 20.6 | 2.3 |
| 36 | 23.9 | 36.0 | 8.3 | 15.4 | 36.0 | 18.7 | 8.0 | 12.0 | 21.2 | 68.9 | 18.3 | 2.3 |
| 37 | 24.0 | 36.0 | 7.6 | 16.4 | 35.9 | 17.8 | 8.0 | 12.0 | 19.9 | 69.4 | 17.7 | 2.3 |
| 38 | 24.1 | 36.0 | 6.8 | 16.3 | 36.0 | 17.1 | 7.9 | 11.9 | 18.9 | 73.5 | 16.6 | 2.4 |
| 39 | 25.0 | 36.0 | 5.7 | 16.4 | 36.0 | 16.5 | 8.0 | 12.0 | 19.8 | 77.9 | 16.7 | 2.4 |
| 40 | 25.2 | 36.0 | 4.9 | 16.6 | 35.8 | 15.8 | 8.0 | 12.0 | 19.7 | 79.0 | 15.5 | 2.7 |
| 41 | 25.7 | 35.7 | 4.0 | 17.0 | 36.0 | 14.5 | 8.0 | 12.0 | 19.3 | 76.1 | 14.1 | 2.8 |
| 42 | 26.5 | 35.5 | 3.5 | 16.9 | 36.0 | 13.3 | 8.0 | 12.0 | 19.0 | 73.9 | 13.6 | 2.6 |
| 43 | 24.6 | 35.7 | 3.2 | 16.5 | 35.9 | 12.4 | 8.0 | 12.0 | 18.5 | 76.2 | 12.1 | 2.6 |
| 44 | 23.5 | 36.0 | 3.7 | 15.8 | 35.7 | 12.0 | 8.0 | 12.0 | 18.2 | 79.0 | 12.5 | 2.6 |
| Average, 44 weeks | 23.6 | 35.7 | 15.1 | 14.6 | 35.3 | 25.4 | 7.8 | 12.0 | 28.2 | 63.5 | 24.1 | 1.9 |

*There were 10 cows in each group during year 1 and 9, 9, 8, and 6, respectively, during year 2. Average for grain consumed toward end of lactation includes all cows in milk but not dry cows in groups 1, 2, and 4, unless they received grain while dry within 44-week lactation.

Table 4. *Average daily feed intake, by weeks, groups 1 to 4, year 3**

| Week | Feed intake | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group 1 | | | Group 2 | | | Group 3 | | | Group 4 | | |
| | Hay | Silage | Grain | Hay | Silage | Grain | Hay | Silage | Grain | Silage | Grain | S.O.M. |
| | pounds | | | | | | | | | | | |
| −8 | 22.6 | 36.0 | 4.2 | 17.8 | 35.8 | 8.1 | 8.0 | 12.0 | 15.3 | 73.4 | 12.7 | 2.4 |
| −7 | 21.8 | 36.0 | 4.7 | 17.0 | 35.0 | 6.4 | 8.0 | 12.0 | 15.0 | 70.5 | 10.0 | 2.5 |
| −6 | 21.0 | 36.0 | 5.4 | 18.7 | 35.7 | 0.0 | 8.0 | 12.0 | 15.0 | 66.1 | 9.0 | 2.5 |
| −5 | 20.3 | 35.8 | 5.7 | 18.6 | 35.5 | 3.0 | 8.0 | 12.0 | 15.0 | 70.8 | 0.0 | 2.5 |
| −4 | 19.4 | 35.1 | 5.8 | 17.5 | 35.8 | 6.2 | 7.9 | 12.0 | 15.0 | 63.2 | 0.0 | 2.5 |
| −3 | 18.0 | 35.1 | 5.7 | 16.1 | 34.7 | 8.7 | 7.9 | 12.0 | 17.3 | 69.2 | 0.0 | 2.1 |
| −2 | 17.4 | 35.6 | 6.0 | 13.3 | 33.6 | 12.2 | 7.7 | 11.9 | 17.7 | 69.4 | 2.8 | 2.1 |
| −1 | 15.7 | 33.8 | 5.9 | 10.6 | 27.4 | 14.0 | 6.9 | 11.6 | 12.9 | 41.1 | 7.9 | 2.5 |
| 1 | 11.4 | 28.4 | 9.1 | 8.4 | 23.8 | 17.5 | 7.4 | 11.5 | 15.8 | 45.9 | 13.9 | 1.4 |
| 2 | 12.7 | 32.8 | 16.8 | 7.3 | 28.5 | 24.7 | 7.8 | 12.0 | 23.9 | 53.0 | 21.4 | 1.4 |
| 3 | 12.9 | 35.5 | 19.6 | 7.8 | 30.6 | 29.9 | 7.6 | 12.0 | 28.5 | 50.7 | 27.2 | 1.5 |
| 4 | 14.8 | 35.6 | 19.5 | 7.7 | 29.3 | 29.5 | 6.9 | 11.4 | 29.9 | 50.1 | 34.5 | 1.9 |
| 5 | 16.0 | 34.7 | 19.4 | 7.5 | 28.9 | 29.5 | 7.5 | 11.8 | 28.6 | 49.2 | 36.0 | 1.6 |
| 6 | 15.8 | 35.6 | 19.5 | 8.9 | 32.7 | 32.9 | 7.7 | 11.9 | 32.1 | 43.7 | 37.6 | 1.5 |
| 7 | 16.1 | 35.9 | 19.2 | 8.6 | 33.6 | 32.6 | 7.7 | 11.9 | 33.6 | 37.4 | 40.5 | 1.5 |
| 8 | 17.1 | 36.0 | 19.0 | 9.3 | 34.4 | 35.7 | 7.4 | 11.9 | 37.0 | 27.5 | 38.5 | 1.1 |
| 9 | 16.9 | 35.9 | 18.9 | 9.4 | 32.9 | 36.7 | 7.7 | 12.0 | 38.6 | 32.5 | 41.0 | 1.0 |
| 10 | 18.5 | 36.0 | 19.2 | 9.1 | 33.6 | 38.6 | 7.9 | 12.0 | 38.4 | 41.6 | 38.5 | 1.0 |
| 11 | 18.8 | 36.0 | 18.8 | 8.9 | 33.2 | 37.3 | 8.0 | 12.0 | 41.4 | 33.4 | 42.1 | 1.0 |
| 12 | 19.5 | 35.9 | 18.8 | 10.1 | 33.6 | 36.2 | 7.9 | 12.0 | 40.1 | 30.7 | 34.6 | 0.6 |
| 13 | 19.5 | 34.7 | 17.8 | 11.4 | 34.2 | 34.9 | 7.8 | 12.0 | 38.2 | 45.8 | 32.8 | 0.5 |
| 14 | 18.0 | 34.0 | 16.4 | 11.3 | 33.8 | 33.8 | 7.9 | 12.0 | 37.3 | 51.1 | 32.7 | 1.2 |
| 15 | 17.8 | 36.0 | 16.8 | 12.5 | 33.3 | 33.2 | 7.7 | 12.0 | 34.7 | 44.4 | 31.2 | 1.1 |
| 16 | 18.8 | 36.0 | 16.4 | 12.7 | 35.2 | 34.3 | 8.0 | 12.0 | 34.2 | 59.7 | 29.6 | 1.4 |
| 17 | 20.3 | 36.0 | 15.4 | 13.0 | 35.5 | 32.2 | 8.0 | 12.0 | 36.1 | 62.0 | 28.6 | 1.9 |
| 18 | 20.4 | 36.0 | 14.6 | 13.8 | 35.3 | 30.1 | 8.0 | 12.0 | 34.7 | 63.1 | 28.4 | 2.0 |
| 19 | 21.6 | 36.0 | 13.9 | 13.6 | 35.8 | 29.1 | 8.0 | 12.0 | 33.6 | 66.6 | 25.1 | 2.0 |
| 20 | 21.5 | 36.0 | 13.5 | 14.6 | 35.7 | 28.0 | 8.0 | 12.0 | 31.9 | 72.2 | 23.9 | 2.4 |
| 21 | 21.7 | 36.0 | 13.5 | 13.7 | 35.6 | 26.4 | 7.9 | 12.0 | 29.9 | 71.0 | 23.3 | 2.5 |
| 22 | 21.0 | 36.0 | 13.4 | 14.9 | 35.7 | 26.4 | 7.9 | 12.0 | 30.0 | 71.6 | 22.6 | 2.5 |
| 23 | 22.8 | 36.0 | 12.8 | 14.2 | 35.8 | 25.3 | 7.7 | 12.0 | 29.0 | 72.2 | 20.7 | 2.5 |
| 24 | 21.6 | 36.0 | 12.6 | 15.6 | 36.0 | 25.5 | 7.8 | 12.0 | 28.2 | 73.6 | 20.9 | 2.5 |
| 25 | 20.7 | 36.0 | 12.2 | 15.3 | 35.6 | 26.2 | 8.0 | 12.0 | 27.0 | 72.7 | 20.6 | 2.5 |
| 26 | 21.2 | 36.0 | 11.6 | 12.4 | 35.9 | 24.9 | 8.0 | 12.0 | 25.8 | 70.8 | 20.1 | 2.5 |
| 27 | 20.6 | 36.0 | 11.4 | 12.7 | 36.0 | 24.4 | 8.0 | 12.0 | 26.7 | 71.0 | 19.4 | 2.5 |
| 28 | 20.9 | 36.0 | 11.0 | 12.8 | 36.0 | 23.7 | 8.0 | 13.7 | 25.6 | 64.8 | 18.1 | 2.5 |
| 29 | 21.1 | 36.0 | 10.9 | 13.2 | 35.9 | 23.9 | 7.9 | 12.0 | 24.4 | 55.8 | 17.6 | 2.5 |
| 30 | 21.0 | 36.0 | 10.3 | 12.6 | 35.8 | 22.8 | 8.0 | 12.0 | 23.7 | 51.3 | 17.0 | 2.1 |
| 31 | 21.3 | 36.0 | 10.2 | 13.0 | 35.9 | 22.2 | 7.9 | 12.0 | 24.2 | 55.7 | 17.4 | 1.6 |
| 32 | 19.9 | 35.9 | 10.1 | 13.2 | 36.0 | 20.9 | 7.8 | 12.0 | 24.0 | 33.0 | 15.9 | 1.5 |
| 33 | 20.4 | 36.0 | 10.0 | 13.0 | 36.0 | 21.2 | 8.0 | 12.0 | 23.2 | 2.5 | 11.9 | 1.1 |
| 34 | 20.1 | 36.0 | 9.6 | 13.6 | 35.9 | 21.0 | 8.0 | 12.0 | 22.7 | 9.5 | 9.7 | 1.0 |
| 35 | 20.9 | 36.0 | 8.6 | 13.0 | 35.8 | 20.9 | 8.0 | 11.9 | 21.8 | 31.4 | 11.7 | 1.4 |
| 36 | 21.0 | 35.5 | 7.7 | 12.9 | 36.0 | 19.8 | 8.0 | 11.8 | 21.2 | 50.7 | 11.7 | 1.1 |
| 37 | 21.1 | 35.8 | 7.2 | 13.1 | 36.0 | 19.1 | 8.0 | 12.0 | 20.6 | 51.4 | 11.2 | 2.4 |
| 38 | 21.4 | 36.0 | 6.5 | 13.5 | 36.0 | 18.2 | 8.0 | 12.0 | 20.1 | 60.9 | 10.6 | 1.9 |
| 39 | 20.4 | 35.9 | 6.0 | 12.0 | 35.5 | 17.3 | 8.0 | 12.0 | 19.9 | 57.7 | 11.7 | 1.9 |
| 40 | 20.5 | 36.0 | 5.8 | 12.5 | 35.9 | 15.8 | 8.0 | 12.0 | 19.5 | 63.1 | 11.2 | 2.0 |
| 41 | 20.2 | 35.6 | 4.9 | 11.8 | 35.9 | 14.9 | 8.0 | 12.0 | 18.9 | 66.8 | 11.1 | 2.0 |
| 42 | 21.0 | 35.9 | 4.1 | 12.3 | 35.8 | 14.3 | 8.0 | 12.0 | 18.7 | 67.3 | 10.5 | 2.4 |
| 43 | 20.1 | 36.0 | 3.7 | 12.5 | 36.0 | 13.6 | 8.0 | 12.0 | 18.0 | 62.3 | 10.1 | 2.5 |
| 44 | 20.2 | 36.0 | 3.6 | 13.5 | 36.0 | 13.5 | 7.9 | 12.0 | 18.2 | 63.5 | 9.3 | 2.1 |
| Average, 44 weeks | 19.3 | 35.6 | 12.7 | 11.8 | 34.4 | 25.8 | 7.9 | 12.0 | 27.9 | 52.5 | 22.8 | 1.8 |

* There were 10 cows in each group in year 1, and 9, 8, 7, and 1, respectively, during year 3. Average for grain consumed toward end of lactation includes all cows in milk but not dry cows in groups 1, 2, and 4, unless a cow received grain while dry within 44-week lactation.

parison of the average grain consumption of group 3 with that of group 2 shows that group 3 did not consume enough grain to compensate for the lower forage intake under *ad lib.* forage feeding in groups 1, 2, and 4.

The average daily grain intakes by weeks for groups 1-4 are shown in figures 1-3 for years 1-3. Clearly the adjustment in the grain feeding table after the first lactation was justified because during year 1 there is not enough difference in grain intake between group 1 (control) and group 2 (liberal grain). During the first year the cows in the control group averaged 12.5 pounds per day, or 3856 pounds for a 44-week lactation, as compared to group 2 with 17.5 pounds per day, or 5403 pounds for the 44 weeks. During year 2, group 1 was nearly the same as in year 1, with an average of 13.1 pounds daily and a total of 4027 pounds. Group 2, with the adjusted liberal grain allowance, averaged 25.4 pounds of grain per day with a total of 7819 pounds for the lactation. Thus, during years 2 and 3, the liberal grain feeding rate for group 2, and for group 4 closely patterned after group 2, was approximately twice the amount of grain fed to group 1 during the 44-week lactation.

Although we used challenge or lead feeding of grain for groups 2 and 4, with a liberal grain allowance of 20 pounds before parturition and a rapid increase immediately afterward, until an *ad lib.* grain level was reached and maintained for 6 weeks, the cows had sluggish appetites at this stage and did not consume grain in line with their requirements during early lactation. Specifically, in group 1, very few cows refused grain during the week before parturition, but half of them did not eat all of the grain offered during the week after parturition. In contrast, more than half of the cows in group 2 refused part of the 20 pounds of grain offered daily during the week before parturition and only 3 cows, during the 3 years of the experiment, ate all of the grain offered during the week after parturition before the expected *ad lib.* feeding level was reached at the daily rate of grain increase listed. Group 4 followed the same pattern, and all of the cows in group 3 on the limited-forage, liberal-grain schedule were on *ad lib.* grain feeding during the week before and the week after parturition when the amounts specified in the plans of the experiment were provided.

Under the *ad lib.* feeding conditions for grain to groups 2, 3, and 4 during the first 6 weeks after parturition, the peak week for grain consumption was beyond the 6-weeks

Table 5. *Average daily feed intakes, by weeks, groups 1 to 4, average of 3 years**

| Week | Feed intake | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group 1 | | | Group 2 | | | Group 3 | | | Group 4 | | |
| | Hay | Silage | Grain | Hay | Silage | Grain | Hay | Silage | Grain | Silage | Grain | S.O.M. |
| | pounds | | | | | | | | | | | |
| −8 | 22.8 | 56.0 | 4.0 | 22.0 | 35.9 | 5.8 | 8.0 | 12.0 | 16.0 | 101.2 | 1.8 | 3.5 |
| −7 | 22.0 | 56.0 | 4.4 | 20.9 | 35.4 | 5.0 | 8.0 | 12.0 | 15.5 | 99.0 | 1.4 | 3.6 |
| −6 | 21.2 | 56.0 | 4.8 | 21.1 | 35.8 | 0.0 | 7.9 | 12.0 | 15.3 | 94.2 | 1.5 | 3.6 |
| −5 | 20.2 | 35.9 | 5.7 | 20.9 | 35.8 | 1.4 | 8.0 | 12.0 | 15.1 | 91.0 | 0.0 | 3.4 |
| −4 | 16.3 | 35.7 | 5.7 | 20.2 | 34.3 | 6.5 | 11.6 | 12.0 | 12.9 | 47.6 | 6.9 | 1.3 |
| −3 | 15.6 | 33.1 | 5.9 | 16.6 | 34.2 | 8.4 | 10.2 | 12.0 | 17.9 | 57.4 | 7.1 | 1.2 |
| −2 | 15.4 | 32.9 | 6.0 | 14.2 | 32.3 | 13.2 | 8.1 | 12.0 | 20.7 | 52.5 | 10.6 | 1.1 |
| −1 | 15.1 | 32.0 | 5.9 | 10.5 | 27.6 | 16.3 | 6.6 | 11.8 | 17.6 | 36.9 | 14.0 | 1.0 |
| 1 | 12.2 | 29.2 | 9.6 | 8.6 | 25.9 | 18.9 | 7.2 | 11.6 | 20.2 | 32.4 | 17.3 | 1.0 |
| 2 | 12.6 | 31.9 | 16.4 | 7.2 | 28.0 | 26.8 | 7.2 | 11.8 | 25.7 | 38.3 | 25.7 | 1.4 |
| 3 | 13.8 | 33.8 | 19.0 | 7.7 | 30.0 | 30.7 | 7.5 | 11.9 | 31.7 | 38.5 | 30.9 | 1.4 |
| 4 | 14.8 | 35.0 | 19.5 | 8.5 | 30.2 | 31.5 | 7.1 | 11.7 | 32.0 | 45.1 | 33.4 | 1.4 |
| 5 | 15.9 | 35.0 | 19.4 | 8.7 | 29.7 | 30.5 | 7.4 | 11.9 | 32.4 | 48.6 | 32.7 | 1.6 |
| 6 | 16.9 | 34.9 | 19.5 | 9.8 | 32.1 | 32.6 | 7.5 | 12.0 | 33.9 | 48.9 | 32.2 | 1.4 |
| 7 | 16.7 | 34.4 | 18.8 | 9.0 | 32.5 | 34.2 | 7.6 | 12.0 | 35.6 | 51.3 | 32.0 | 1.3 |
| 8 | 17.5 | 35.0 | 18.8 | 8.9 | 33.5 | 36.1 | 7.4 | 11.9 | 36.3 | 50.9 | 32.6 | 1.5 |
| 9 | 18.1 | 34.9 | 18.9 | 9.2 | 33.3 | 35.7 | 7.6 | 12.0 | 38.0 | 53.8 | 32.6 | 1.5 |
| 10 | 19.2 | 34.9 | 18.9 | 9.2 | 33.6 | 35.0 | 7.6 | 12.0 | 37.7 | 58.4 | 32.4 | 1.7 |
| 11 | 20.5 | 35.7 | 18.4 | 10.1 | 33.7 | 33.0 | 7.7 | 12.0 | 38.8 | 56.9 | 32.5 | 1.6 |
| 12 | 21.3 | 35.8 | 18.1 | 10.5 | 33.9 | 33.4 | 7.7 | 12.0 | 37.2 | 58.5 | 31.4 | 1.6 |
| 13 | 21.4 | 35.5 | 17.5 | 11.0 | 34.4 | 32.4 | 7.8 | 12.0 | 36.2 | 65.4 | 30.1 | 1.6 |
| 14 | 20.5 | 35.2 | 16.8 | 11.7 | 34.1 | 30.8 | 7.7 | 12.0 | 36.0 | 67.7 | 28.9 | 1.8 |
| 15 | 21.0 | 36.0 | 16.9 | 13.1 | 33.8 | 29.8 | 7.7 | 12.1 | 34.8 | 70.2 | 28.4 | 2.0 |
| 16 | 21.9 | 35.9 | 16.4 | 14.1 | 34.8 | 29.6 | 8.0 | 12.1 | 34.9 | 67.6 | 26.8 | 1.9 |
| 17 | 21.8 | 36.0 | 15.5 | 14.4 | 35.4 | 29.1 | 8.0 | 12.0 | 35.6 | 66.6 | 24.8 | 2.1 |
| 18 | 22.0 | 36.0 | 15.2 | 15.1 | 35.3 | 27.6 | 8.0 | 12.0 | 33.7 | 69.8 | 24.6 | 2.0 |
| 19 | 22.9 | 36.0 | 14.5 | 15.3 | 34.9 | 26.5 | 8.0 | 12.0 | 33.8 | 71.1 | 25.8 | 2.1 |
| 20 | 22.6 | 36.0 | 14.3 | 15.5 | 35.4 | 25.5 | 8.0 | 12.0 | 33.6 | 75.4 | 22.5 | 2.3 |
| 21 | 22.3 | 35.9 | 14.2 | 15.8 | 35.5 | 23.8 | 7.9 | 12.3 | 31.7 | 75.9 | 21.0 | 2.4 |
| 22 | 22.5 | 36.0 | 13.8 | 16.7 | 35.8 | 23.5 | 7.9 | 12.0 | 31.0 | 76.5 | 20.3 | 2.5 |
| 23 | 23.1 | 35.9 | 13.5 | 17.1 | 35.9 | 22.5 | 7.9 | 12.0 | 30.6 | 77.6 | 19.2 | 2.4 |
| 24 | 23.0 | 36.0 | 13.3 | 17.5 | 35.8 | 21.8 | 7.9 | 12.0 | 29.3 | 78.6 | 18.4 | 2.5 |
| 25 | 22.7 | 36.0 | 12.8 | 17.4 | 35.7 | 21.4 | 8.0 | 12.0 | 28.6 | 78.5 | 16.7 | 2.6 |
| 26 | 23.1 | 36.0 | 11.7 | 17.1 | 35.7 | 20.6 | 8.0 | 12.0 | 27.5 | 79.2 | 16.1 | 2.5 |
| 27 | 23.3 | 36.0 | 11.6 | 16.8 | 35.7 | 19.4 | 8.0 | 12.0 | 26.8 | 78.8 | 14.9 | 2.6 |
| 28 | 23.2 | 36.0 | 11.2 | 17.3 | 35.9 | 18.7 | 8.0 | 12.5 | 25.7 | 79.0 | 14.5 | 2.5 |
| 29 | 23.4 | 36.0 | 11.0 | 18.2 | 35.9 | 18.2 | 8.0 | 12.0 | 24.4 | 80.5 | 13.6 | 2.6 |
| 30 | 23.3 | 36.0 | 10.9 | 18.1 | 35.9 | 17.4 | 8.0 | 12.0 | 23.8 | 82.1 | 13.2 | 2.6 |
| 31 | 23.4 | 36.0 | 10.4 | 19.0 | 35.9 | 16.9 | 8.0 | 12.0 | 23.5 | 82.9 | 12.7 | 2.6 |
| 32 | 23.1 | 35.9 | 10.0 | 18.3 | 35.9 | 15.9 | 7.9 | 12.0 | 23.1 | 82.0 | 12.4 | 2.8 |
| 33 | 24.0 | 36.0 | 9.8 | 18.0 | 35.7 | 15.5 | 8.0 | 12.0 | 22.0 | 83.4 | 11.7 | 2.7 |
| 34 | 23.3 | 35.9 | 9.4 | 17.7 | 35.7 | 15.0 | 8.0 | 12.0 | 21.6 | 84.3 | 11.0 | 2.9 |
| 35 | 23.6 | 35.9 | 8.8 | 18.2 | 35.9 | 14.7 | 8.0 | 12.0 | 21.1 | 87.2 | 10.5 | 3.0 |
| 36 | 23.3 | 35.8 | 8.0 | 18.3 | 35.9 | 14.0 | 8.0 | 11.9 | 20.8 | 86.4 | 9.4 | 3.0 |
| 37 | 23.2 | 35.9 | 7.5 | 18.7 | 35.9 | 14.1 | 8.0 | 12.0 | 20.2 | 85.8 | 9.0 | 3.1 |
| 38 | 23.4 | 36.0 | 6.8 | 19.0 | 35.9 | 13.2 | 8.0 | 12.0 | 19.6 | 89.3 | 8.5 | 3.0 |
| 39 | 23.5 | 36.0 | 5.9 | 18.4 | 35.8 | 12.0 | 8.0 | 12.0 | 19.6 | 89.7 | 8.5 | 3.0 |
| 40 | 23.4 | 36.0 | 5.6 | 18.6 | 35.8 | 11.2 | 8.0 | 12.0 | 19.5 | 90.7 | 7.7 | 3.1 |
| 41 | 23.4 | 35.8 | 4.7 | 18.4 | 35.8 | 10.2 | 8.0 | 12.0 | 18.7 | 88.5 | 7.8 | 3.1 |
| 42 | 23.8 | 35.8 | 4.0 | 18.6 | 35.6 | 9.7 | 8.0 | 12.0 | 18.9 | 89.1 | 7.4 | 3.1 |
| 43 | 22.8 | 35.9 | 3.6 | 18.2 | 35.7 | 9.1 | 8.0 | 12.0 | 18.4 | 88.3 | 7.0 | 3.1 |
| 44 | 22.3 | 36.0 | 3.4 | 18.6 | 35.7 | 8.7 | 8.0 | 12.0 | 18.2 | 89.3 | 6.8 | 3.0 |
| Average, 44 weeks | 21.1 | 35.5 | 12.8 | 14.7 | 34.4 | 22.6 | 7.8 | 12.0 | 28.2 | 71.3 | 19.6 | 2.2 |

*Weighted average based on 10 cows in each group during year 1; on 9, 9, 8, and 6, respectively, during year 2; and on 9, 8, 7, and 1, respectively, during year 3. Average is based on total feed consumption by each cow during 44 weeks, in preference to an average of average intake by weeks.

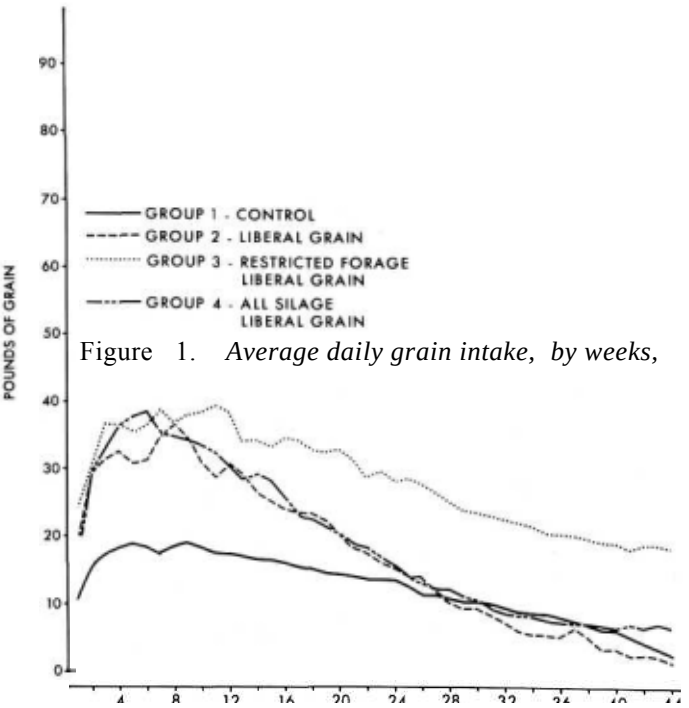


Figure 1. *Average daily grain intake, by weeks, groups 1-4, year 1.*

period; and usually this was over 36 pounds. But few individual cows consumed 36 pounds per day during the first 6 weeks after parturition without going off feed. A practical dairyman could well consider setting the maximum grain allowance at 25 or 30 pounds, depending on conditions during the first 6 weeks of lactation, and try for higher levels later when the cows have a keener appetite for all feeds in the ration. Surprisingly, the cows in group 3 on restricted forage differed very little in average grain consumption from those in groups 2 or 4 during the first 15 weeks of lactation because they lacked the capability to go beyond a certain limit in daily grain consumption at this early stage of lactation.

***Total feed intakes.*** The total feed intake of individual cows during the 44-week lactations for all groups is presented in table 6. The control cows in group 1 showed a considerable range in forage consumption; the average feed intake for 3 years was 6508 pounds of hay, 10,919 pounds of silage, and 3932 pounds of grain. The cows in group 2 on liberal grain feeding varied widely in both hay and grain intakes, with a 3-year average of 4532 pounds of hay, 10,594 pounds of silage, and 6963 pounds of grain. Thus, the extra 3031 pounds of grain intake was associated with a decrease of 1976 pounds of hay intake, as compared to the controls in group 1 when both groups were fed hay according to appetite and were allowed the same amounts of corn silage. Mather *et al.* (1960) reported that forage dry matter decreased by 0.23 pound for each pound of grain consumed. Reid (1956 ) concluded that the intake of forage of above average quality declined from 0.4 to 0.5 pound for each pound of extra concentrate consumed.

The average consumption during 3 years in the restricted forage group 3 was 2409 pounds of hay, 3693 pounds of silage, and 8698 pounds of grain during a 44-week lactation. In this group, 4766 pounds of grain substituted for 4099 pounds of hay plus 7226 pounds of silage. The economics of this substitution can easily be determined when the milk production achieved by each group is evaluated: 16,424 and 16,682 pounds actual production or 15,932 and 16,188 of 4% FCM for groups 1 and 3, respectively (table 16).

Cows in group 4 had an average feed intake of 21,971 pounds of corn silage and 6712 pounds of grain (6048 pounds of grain mixture and 664 of soybean meal) during 44-week lactations for the average of 3 years. Thus, they consumed 2780 pounds of grain above the intake for grain in group 1.

Table 6. *Total feed intakes of individual cows, 44-week lactations, all groups*

| Group | Cow | Year 1 | | | Year 2 | | | Year 3 | | | Average 3 years | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hay | Silage | Grain | Hay | Silage | Grain | Hay | Silage | Grain | Hay | Silage | Grain |
| | no. | pounds | | | | | | | | | | | |
| 1 Control | 233 | 7168 | 10958 | 3451 | 9271 | 10993 | 4300 | 7791 | 10991 | 3584 | 8077 | 10981 | 3778 |
| | 257 | 6834 | 10883 | 3544 | 6190 | 11080 | 3488 | 5731 | 10799 | 2492 | 6252 | 10921 | 3175 |
| | 283 | 4093 | 9921 | 3319 | — | — | — | — | — | — | 4093 | 9921 | 3319 |
| | 319 | 6629 | 10888 | 4318 | 8635 | 11082 | 3861 | 5304 | 11088 | 4343 | 6856 | 11019 | 4174 |
| | 323 | 6407 | 10686 | 4329 | 7385 | 10948 | 5130 | 5857 | 10971 | 4702 | 6550 | 10868 | 4720 |
| | 326 | 6370 | 10574 | 3653 | 6718 | 10891 | 4115 | 5070 | 10650 | 2420 | 6053 | 10705 | 3396 |
| | 336 | 7007 | 11087 | 4160 | 6008 | 10992 | 4085 | 5373 | 11088 | 4524 | 6129 | 11056 | 4256 |
| | 351 | 6414 | 11065 | 3198 | 7262 | 11061 | 2895 | 5755 | 10998 | 4092 | 6477 | 11041 | 3395 |
| | 360 | 5795 | 10963 | 3944 | 6185 | 10882 | 3927 | 6171 | 10967 | 4464 | 6050 | 10937 | 4112 |
| | 366 | 6756 | 11082 | 4642 | 7643 | 11054 | 4442 | 6392 | 11088 | 4679 | 6930 | 11075 | 4588 |
| Average | | 6347 | 10811 | 3856 | 7255 | 10998 | 4027 | 5938 | 10960 | 3922 | 6508 | 10919 | 3932 |
| 2 Liberal grain | 215 | 5820 | 10016 | 4145 | 4036 | 10865 | 8600 | 2889 | 10208 | 7880 | 4248 | 10363 | 6875 |
| | 218 | 3077 | 8698 | 8810 | — | — | — | — | — | — | 3077 | 8698 | 8810 |
| | 241 | 5344 | 9945 | 5600 | 5930 | 10722 | 8018 | 4321 | 10614 | 6765 | 5198 | 10427 | 6794 |
| | 249 | 5410 | 10862 | 4805 | 3306 | 10455 | 6966 | — | — | — | 4358 | 10658 | 5886 |
| | 304 | 6387 | 10652 | 3118 | 6808 | 11049 | 7091 | 3156 | 10551 | 8497 | 5450 | 10751 | 6235 |
| | 312 | 6665 | 10408 | 9689 | 5301 | 10811 | 7922 | 3979 | 9792 | 8845 | 5315 | 10337 | 8819 |
| | 325 | 5066 | 10710 | 4119 | 3767 | 10927 | 6837 | 3538 | 10807 | 6050 | 4124 | 10815 | 5669 |
| | 329 | 5086 | 10567 | 5705 | 3037 | 10987 | 9737 | 4961 | 10821 | 8730 | 4361 | 10792 | 8057 |
| | 337 | 5932 | 10469 | 3102 | 3811 | 11022 | 8577 | 3029 | 11055 | 8148 | 4257 | 10849 | 6609 |
| | 342 | 4021 | 10976 | 4940 | 4509 | 11057 | 6619 | 3175 | 10988 | 8688 | 3902 | 11007 | 6749 |
| Average | | 5281 | 10330 | 5403 | 4501 | 10877 | 7819 | 3631 | 10604 | 7950 | 4532 | 10594 | 6963 |
| 3 Restricted forage, liberal grain | 231 | 2136 | 3681 | 8507 | 2335 | 3712 | 8414 | 2351 | 3695 | 8377 | 2274 | 3696 | 8433 |
| | 239 | 2445 | 3696 | 7310 | 2458 | 3695 | 7274 | 2407 | 3651 | 6650 | 2437 | 3681 | 7078 |
| | 302 | 2455 | 3696 | 9511 | — | — | — | — | — | — | 2455 | 3696 | 9511 |
| | 303 | 2351 | 3696 | 10276 | 2366 | 3696 | 10266 | 2426 | 3751 | 9194 | 2381 | 3714 | 9912 |
| | 308 | 2436 | 3669 | 9657 | 2430 | 3696 | 9104 | 2426 | 3696 | 9198 | 2431 | 3687 | 9320 |
| | 309 | 2378 | 3670 | 9053 | 2464 | 3695 | 8465 | — | — | — | 2421 | 3682 | 8759 |
| | 328 | 2440 | 3692 | 9201 | 2415 | 3669 | 8132 | 2451 | 3696 | 8054 | 2435 | 3686 | 8462 |
| | 335 | 2433 | 3690 | 7730 | 2399 | 3692 | 8904 | 2463 | 3696 | 10054 | 2432 | 3693 | 8896 |
| | 339 | 2448 | 3738 | 8217 | — | — | — | — | — | — | 2448 | 3738 | 8217 |
| | 344 | 2439 | 3684 | 8305 | 2458 | 3696 | 8871 | 2419 | 3681 | 8723 | 2439 | 3687 | 8633 |
| Average | | 2396 | 3691 | 8777 | 2416 | 3694 | 8679 | 2420 | 3695 | 8607 | 2409 | 3693 | 8698 |

| Group | Cow | Year 1 | | | Year 2 | | | Year 3 | | | Average 3 years | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Silage | Grain | S.O.M. | Silage | Grain | S.O.M. | Silage | Grain | S.O.M. | Silage | Grain | S.O.M. |
| | no. | pounds | | | | | | | | | | | |
| 4 All-corn silage, liberal grain | 210 | 19560 | 9438 | 525 | — | — | — | — | — | — | 19560 | 9438 | 525 |
| | 220 | 29325 | 4598 | 930 | 20296 | 6788 | 682 | — | — | — | 24810 | 5693 | 806 |
| | 223 | 20618 | 6023 | 560 | 24325 | 7999 | 750 | — | — | — | 22472 | 7011 | 655 |
| | 246 | 23906 | 3521 | 740 | — | — | — | — | — | — | 23906 | 3521 | 740 |
| | 247 | 26322 | 3406 | 816 | — | — | — | — | — | — | 26322 | 3406 | 816 |
| | 280 | 24797 | 4228 | 760 | 20891 | 8945 | 602 | 16180 | 7016 | 544 | 20623 | 6730 | 635 |
| | 310 | 23764 | 5766 | 746 | 17452 | 4754 | 494 | — | — | — | 20608 | 5260 | 620 |
| | 341 | 24988 | 3514 | 802 | 17293 | 8526 | 470 | — | — | — | 21140 | 6020 | 636 |
| | 343 | 22805 | 5952 | 673 | 17072 | 7469 | 522 | — | — | — | 19938 | 6710 | 598 |
| | 350 | 23916 | 4866 | 672 | — | — | — | — | — | — | 23916 | 4866 | 672 |
| Average | | 24000 | 5131 | 722 | 19555 | 7414 | 587 | 16180 | 7016 | 544 | 21971 | 6048 | 664 |

| | | Hay | Silage | Grain | Hay | Silage | Grain | Hay | Silage | Grain | Hay | Silage | Grain |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 Control, 5 additional young cows | 338 | 6443 | 11070 | 4128 | 6435 | 11039 | 3967 | 6670 | 11051 | 4030 | 6516 | 11053 | 4042 |
| | 370 | 4682 | 10923 | 2800 | 6388 | 11046 | 3386 | 7059 | 11080 | 3870 | 6043 | 11016 | 3352 |
| | 371 | 6222 | 10455 | 3165 | 7913 | 11062 | 3580 | 7022 | 11015 | 3404 | 7052 | 10844 | 3383 |
| | 380 | 5548 | 10857 | 3505 | 8317 | 11088 | 3947 | 7344 | 11083 | 2919 | 7070 | 11009 | 3457 |
| | 385 | 4554 | 11086 | 2755 | 6182 | 11088 | 3704 | 5233 | 11036 | 3834 | 5323 | 11070 | 3431 |
| 5-cow average | | 5490 | 10878 | 3271 | 7047 | 11065 | 3717 | 6666 | 11053 | 3611 | 6401 | 10999 | 3533 |
| 15-cow average* | | 6061 | 10833 | 3661 | 7181 | 11022 | 3916 | 6198 | 10993 | 3811 | 6470 | 10947 | 3793 |
| 3 Restricted forage, liberal grain, 5 additional young cows | 362 | 2407 | 3688 | 9550 | 2459 | 3687 | 9725 | 2426 | 3679 | 8327 | 2431 | 3685 | 9201 |
| | 375 | 2430 | 3680 | 9629 | 2449 | 3695 | 7477 | 2452 | 3692 | 9852 | 2444 | 3689 | 8986 |
| | 376 | 2254 | 3586 | 6656 | 2460 | 3696 | 6720 | 2410 | 3636 | 6450 | 2375 | 3639 | 6609 |
| | 377 | 2156 | 3691 | 7970 | 2239 | 3612 | 8474 | 2437 | 3694 | 8994 | 2277 | 3666 | 8479 |
| | 381 | 2410 | 3658 | 7178 | 2400 | 3683 | 8545 | 2422 | 3688 | 7743 | 2411 | 3676 | 7822 |
| 5-cow average | | 2331 | 3661 | 8197 | 2401 | 3675 | 8188 | 2429 | 3678 | 8273 | 2387 | 3671 | 8219 |
| 15-cow average* | | 2375 | 3681 | 8583 | 2410 | 3686 | 8490 | 2424 | 3688 | 8468 | 2401 | 3685 | 8518 |

*There were 15 cows in groups 1 and 3 during year 1, 14 in group 1 for years 2 and 3, and 13 and 12 in group 3 for years 2 and 3, respectively. The 3-year averages for groups are weighted.

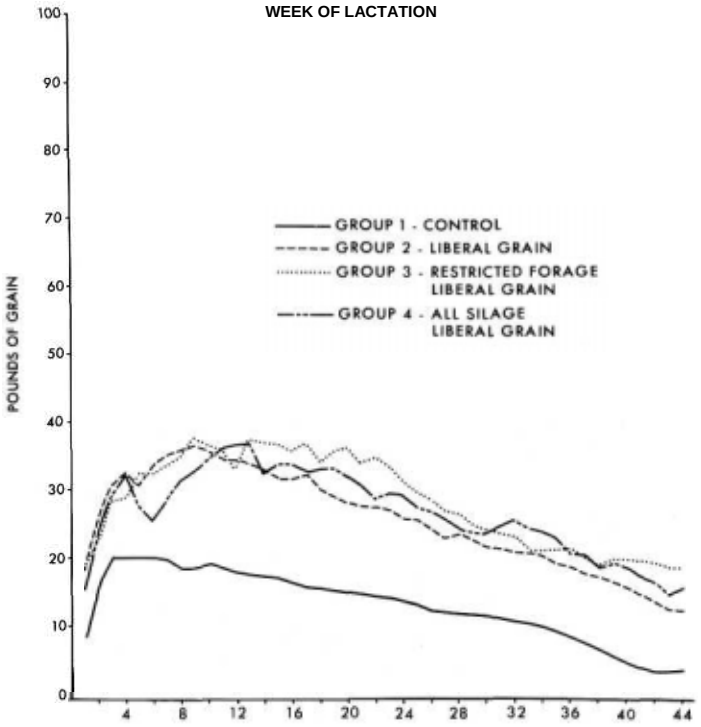


Figure 2. *Average daily grain intake, by weeks, groups 1-4, year 2.*

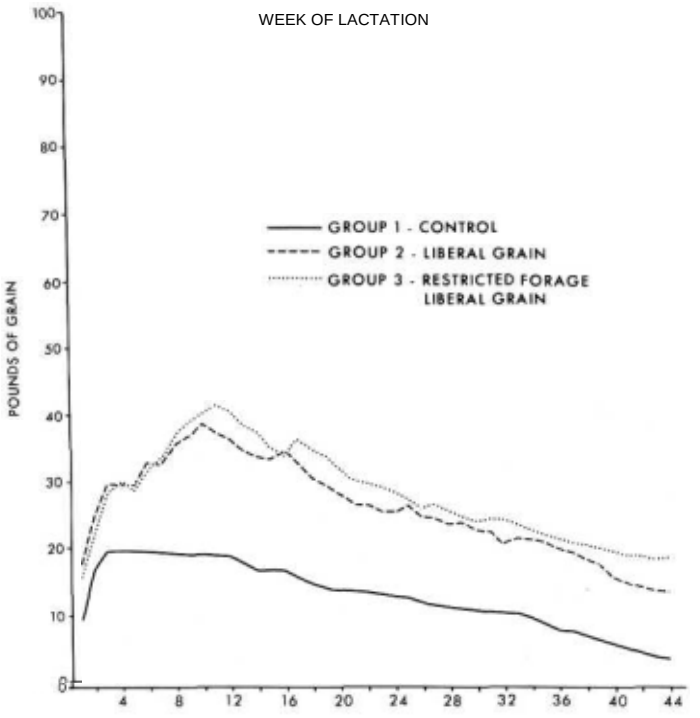


Figure 3. *Average daily grain intake, by weeks, groups 1-3, year 3.*

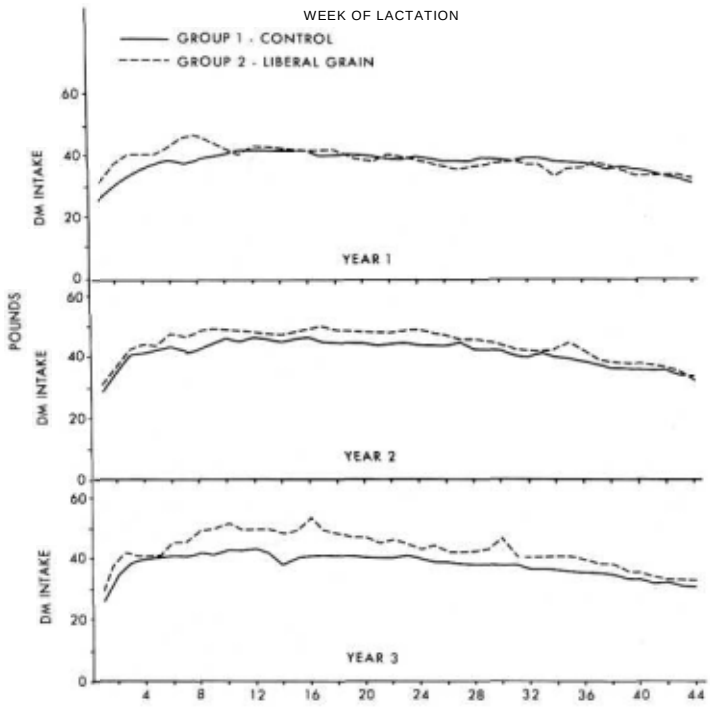


Figure 4. *Average daily dry-matter intake, by weeks, groups 1 and 2.*

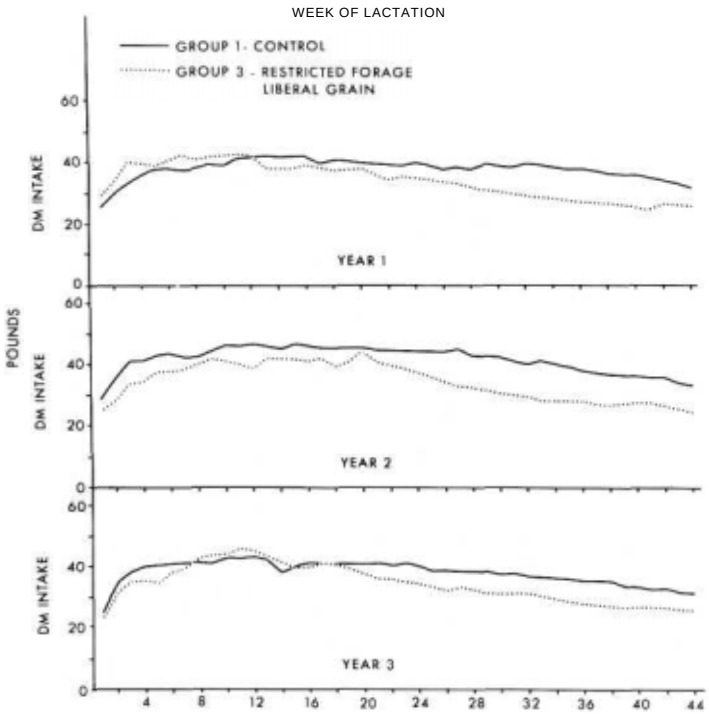


Figure 5. *Average daily dry-matter intake, by weeks, groups 1 and 3.*

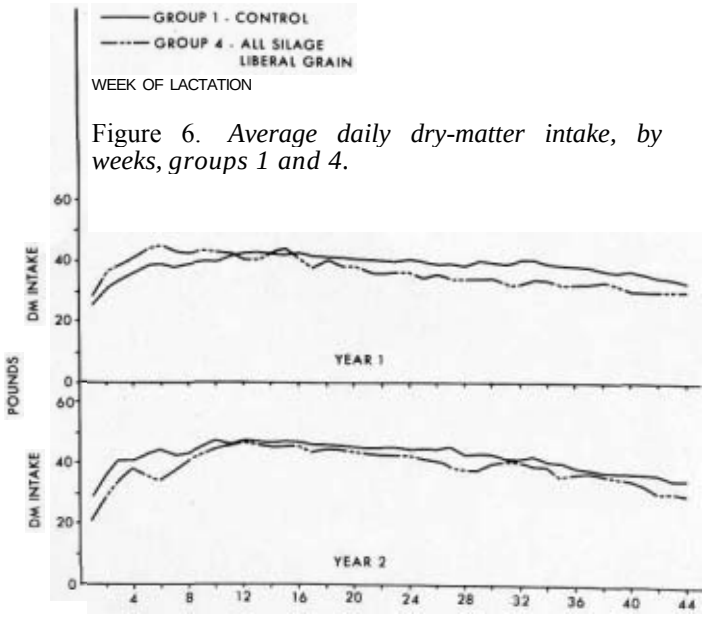


Figure 6. *Average daily dry-matter intake, by weeks, groups 1 and 4.*

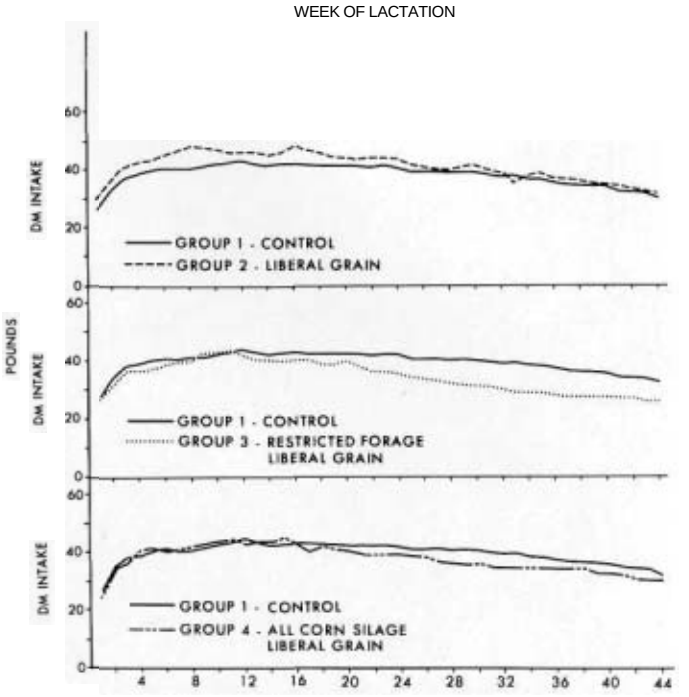


Figure 7. *Average daily total dry-matter intake, by weeks, average of 3 years, groups 1-4.*

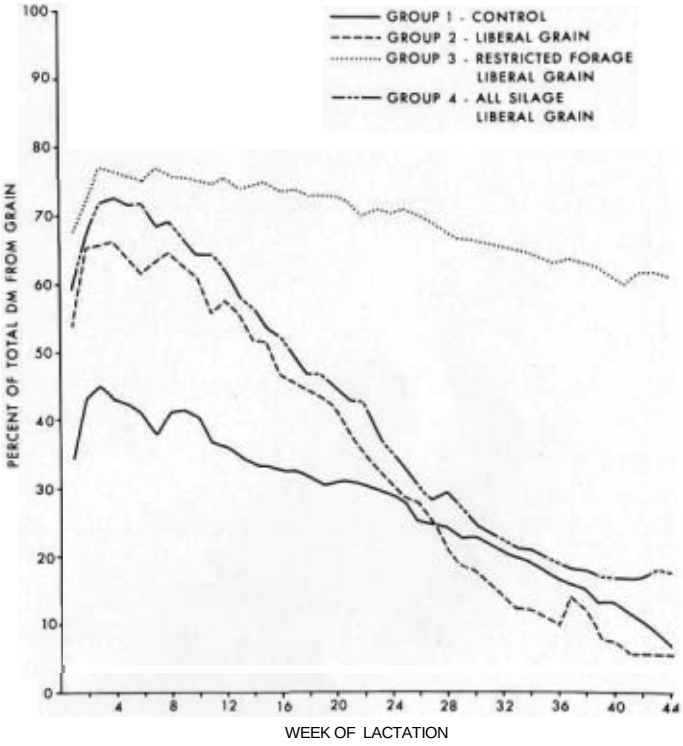


Figure 8. *Average percentage of total dry matter from grain, by weeks, year 1, groups 1-4.*

The levels of grain intake for the various groups can be brought into proper perspective for evaluation by comparing them to the approximate average of 4500 pounds of grain consumed per year by Holstein cows on DHIC test in the United States during this interval. Another valid comparison, especially for the control cows, is the 4558 pounds of grain allowed during a 308-day lactation to cows on forage-comparison experiments at Cornell for 15 years. Under this procedure the experimental cows were held at a maximum of 20 pounds per day for 60 days after freshening and then decreased at the predetermined level of 0.3 pound per day once each week.

***Dry-matter intake.*** The average daily dry-matter intake by weeks for groups 1 to 4 is shown in table 7 and in figures 4-7. When control group 1 is compared with liberal-grain group 2 (figure 4) it is observed that dry-matter intakes were about the same during year 1, but were higher for group 2 in years 2 and 3 after the rate of grain feeding was adjusted upward. The daily dry-matter intake (34.6) of group 3 on restricted forage was less than for the control (39.7) during all 3 years, as shown in figure 5. The cows in group 4 on all-corn silage and liberal grain consumed slightly less dry matter than did the control cows, as expected. In making the calculation on protein needed, an arbitrary estimate of 85 percent of dry-matter intake in treatment 4 as compared with treatment 2 was made by dividing the value of protein needed in corn silage and hay substitution by 0.85. This information in table 7 shows that the results are consistent among years and that the average per day of 39.7 and 37.4 pounds for groups 1 and 4, respectively, for the 3 years differs by 2.3 pounds in dry-matter intake per day in favor of the control group. The cows in group 2 on liberal grain with 42.3 pounds of dry-matter intake daily were the highest in this respect.

Table 7. *Average daily dry-matter intake, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | | Average 3 years | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | pounds | | | | | | | | | | | | | | | |
| 1 | 26.2 | 31.3 | 30.2 | 28.0 | 28.9 | 31.5 | 25.4 | 20.3 | 26.0 | 29.8 | 23.6 | 24.9 | 27.0 | 30.9 | 26.8 | 25.1 |
| 2 | 30.9 | 38.1 | 34.4 | 36.8 | 35.7 | 36.8 | 28.2 | 27.8 | 34.8 | 36.4 | 31.1 | 34.0 | 33.7 | 37.2 | 31.5 | 33.5 |
| 3 | 33.7 | 40.3 | 40.6 | 39.2 | 41.7 | 42.8 | 34.0 | 34.2 | 38.6 | 41.9 | 34.8 | 39.0 | 37.8 | 41.6 | 36.9 | 37.4 |
| 4 | 36.6 | 41.4 | 39.9 | 41.7 | 41.7 | 46.5 | 34.6 | 38.4 | 40.1 | 40.8 | 35.3 | 45.6 | 39.4 | 42.9 | 36.9 | 40.8 |
| 5 | 38.4 | 40.6 | 39.0 | 44.1 | 43.0 | 45.6 | 37.7 | 35.3 | 40.8 | 40.8 | 34.8 | 47.0 | 40.6 | 42.3 | 37.4 | 41.2 |
| 6 | 39.2 | 43.2 | 40.8 | 44.8 | 44.1 | 48.5 | 37.7 | 34.8 | 41.0 | 45.9 | 38.1 | 46.5 | 41.4 | 45.8 | 39.1 | 41.4 |
| 7 | 38.1 | 46.5 | 42.8 | 43.2 | 42.8 | 47.6 | 38.8 | 37.3 | 41.2 | 45.4 | 39.5 | 46.5 | 40.6 | 46.5 | 40.6 | 41.3 |
| 8 | 39.0 | 47.6 | 41.2 | 42.3 | 43.0 | 48.7 | 39.9 | 41.2 | 41.9 | 49.2 | 42.1 | 42.1 | 41.2 | 48.4 | 41.0 | 41.9 |
| 9 | 39.9 | 45.4 | 42.5 | 42.8 | 44.5 | 50.5 | 42.1 | 42.3 | 41.7 | 49.8 | 43.6 | 45.2 | 42.0 | 48.4 | 42.7 | 42.8 |
| 10 | 39.7 | 43.0 | 42.5 | 43.0 | 46.5 | 50.0 | 41.2 | 44.3 | 43.2 | 51.4 | 43.4 | 44.8 | 43.0 | 47.8 | 42.3 | 43.6 |
| 11 | 42.1 | 41.7 | 43.2 | 41.9 | 45.9 | 49.2 | 41.0 | 45.6 | 42.8 | 50.0 | 46.1 | 46.3 | 43.5 | 46.7 | 43.3 | 43.5 |
| 12 | 42.3 | 43.9 | 42.8 | 40.6 | 47.2 | 48.9 | 38.8 | 46.7 | 43.6 | 50.3 | 45.0 | 38.8 | 44.3 | 47.5 | 42.1 | 42.6 |
| 13 | 42.8 | 43.6 | 38.8 | 40.6 | 46.5 | 48.5 | 42.3 | 49.2 | 42.3 | 50.3 | 43.2 | 41.2 | 43.8 | 47.2 | 41.2 | 43.7 |
| 14 | 42.3 | 42.5 | 38.8 | 42.5 | 45.6 | 48.3 | 42.1 | 45.9 | 38.6 | 48.9 | 42.5 | 43.6 | 42.2 | 46.3 | 40.9 | 43.8 |
| 15 | 42.3 | 42.1 | 38.4 | 44.1 | 46.5 | 48.9 | 42.1 | 45.4 | 40.6 | 49.8 | 40.1 | 40.6 | 43.1 | 46.6 | 40.1 | 44.4 |
| 16 | 43.2 | 42.3 | 39.7 | 40.8 | 46.7 | 50.3 | 41.2 | 45.4 | 41.2 | 54.9 | 40.1 | 43.6 | 43.7 | 48.7 | 40.3 | 42.6 |
| 17 | 41.0 | 43.0 | 39.2 | 38.1 | 46.1 | 50.7 | 42.3 | 43.9 | 41.7 | 49.8 | 41.7 | 43.9 | 42.9 | 47.6 | 40.9 | 40.5 |
| 18 | 41.4 | 43.2 | 38.1 | 40.1 | 45.9 | 49.4 | 39.7 | 44.3 | 41.2 | 48.5 | 40.6 | 43.4 | 42.8 | 46.8 | 39.3 | 41.8 |
| 19 | 41.4 | 41.4 | 37.9 | 38.6 | 45.9 | 48.9 | 41.2 | 44.1 | 41.7 | 47.8 | 39.7 | 41.4 | 42.9 | 45.8 | 39.5 | 40.7 |
| 20 | 40.8 | 39.7 | 38.1 | 38.6 | 45.9 | 48.7 | 44.8 | 43.4 | 41.0 | 47.6 | 38.1 | 42.3 | 42.5 | 45.0 | 40.2 | 40.5 |
| 21 | 40.3 | 39.5 | 36.8 | 37.3 | 44.8 | 48.7 | 41.2 | 42.8 | 41.2 | 45.4 | 36.4 | 41.4 | 42.0 | 44.3 | 38.1 | 39.5 |
| 22 | 39.9 | 40.6 | 34.8 | 36.8 | 45.2 | 48.5 | 40.3 | 42.8 | 40.8 | 46.3 | 36.4 | 41.2 | 41.9 | 44.9 | 37.0 | 39.2 |
| 23 | 39.7 | 40.1 | 35.7 | 36.4 | 45.4 | 49.4 | 39.0 | 43.9 | 41.7 | 45.2 | 35.3 | 41.0 | 42.2 | 44.7 | 36.6 | 39.3 |
| 24 | 40.8 | 39.7 | 34.8 | 36.2 | 44.5 | 49.8 | 37.7 | 44.3 | 40.8 | 43.6 | 34.6 | 41.7 | 42.0 | 44.2 | 35.7 | 39.4 |
| 25 | 39.7 | 38.8 | 35.1 | 35.1 | 44.3 | 48.5 | 36.2 | 42.1 | 39.5 | 44.3 | 33.7 | 41.2 | 41.1 | 43.7 | 35.1 | 37.9 |
| 26 | 39.0 | 37.9 | 34.4 | 35.7 | 44.1 | 48.3 | 35.1 | 41.4 | 39.5 | 42.5 | 32.6 | 40.1 | 40.8 | 42.7 | 34.1 | 38.0 |
| 27 | 39.5 | 37.0 | 33.7 | 34.4 | 45.9 | 46.3 | 33.5 | 40.1 | 38.8 | 42.3 | 33.5 | 39.7 | 41.3 | 41.7 | 33.6 | 36.7 |
| 28 | 38.8 | 36.8 | 32.4 | 34.6 | 43.2 | 46.3 | 33.1 | 38.8 | 38.8 | 42.3 | 33.1 | 35.7 | 40.2 | 41.6 | 32.8 | 36.1 |
| 29 | 39.9 | 37.7 | 31.3 | 34.0 | 43.0 | 45.9 | 32.0 | 38.1 | 38.8 | 43.9 | 31.5 | 31.7 | 40.5 | 42.3 | 31.6 | 35.3 |
| 30 | 39.7 | 38.6 | 31.3 | 34.2 | 42.8 | 44.3 | 31.1 | 37.9 | 38.1 | 47.2 | 31.1 | 29.8 | 40.2 | 43.0 | 31.2 | 35.2 |
| 31 | 39.2 | 39.5 | 30.4 | 32.4 | 41.7 | 43.9 | 30.6 | 39.9 | 38.4 | 41.7 | 31.5 | 30.9 | 39.7 | 41.6 | 30.8 | 35.0 |
| 32 | 39.9 | 37.7 | 29.8 | 32.4 | 41.0 | 43.0 | 30.6 | 40.8 | 37.3 | 40.8 | 31.1 | 23.6 | 39.4 | 40.4 | 30.4 | 34.8 |
| 33 | 39.9 | 36.6 | 29.5 | 33.3 | 42.1 | 41.9 | 28.4 | 39.9 | 37.3 | 40.6 | 30.4 | 11.7 | 39.8 | 39.6 | 29.4 | 34.4 |
| 34 | 39.2 | 34.8 | 29.1 | 33.3 | 40.6 | 43.0 | 28.4 | 39.2 | 36.8 | 41.0 | 30.0 | 12.1 | 38.9 | 39.4 | 29.1 | 34.1 |
| 35 | 38.6 | 36.4 | 28.4 | 32.6 | 39.9 | 45.2 | 28.4 | 38.6 | 36.8 | 40.8 | 29.3 | 20.7 | 38.4 | 40.6 | 28.7 | 34.0 |
| 36 | 38.4 | 36.4 | 28.0 | 32.6 | 38.4 | 42.1 | 28.7 | 35.3 | 35.9 | 39.7 | 28.7 | 26.2 | 37.6 | 39.3 | 28.4 | 33.2 |
| 37 | 37.7 | 37.7 | 27.6 | 32.4 | 37.7 | 39.9 | 27.6 | 35.7 | 35.7 | 39.0 | 28.4 | 27.3 | 37.1 | 38.8 | 27.8 | 33.3 |
| 38 | 37.0 | 37.5 | 27.3 | 32.8 | 36.8 | 39.5 | 26.9 | 35.7 | 35.5 | 38.6 | 28.0 | 29.1 | 36.5 | 38.5 | 27.4 | 33.6 |
| 39 | 36.6 | 35.7 | 26.9 | 31.7 | 37.0 | 39.2 | 27.8 | 34.8 | 34.2 | 36.6 | 27.8 | 29.1 | 36.0 | 37.1 | 27.4 | 32.6 |
| 40 | 36.4 | 35.1 | 26.2 | 30.6 | 36.4 | 38.4 | 27.6 | 34.4 | 33.7 | 35.7 | 27.3 | 30.4 | 35.5 | 36.4 | 27.0 | 31.9 |
| 41 | 35.3 | 34.4 | 25.8 | 30.4 | 35.9 | 37.7 | 27.3 | 32.8 | 32.8 | 34.4 | 27.1 | 31.3 | 34.7 | 35.5 | 26.6 | 31.3 |
| 42 | 34.0 | 34.2 | 26.7 | 30.2 | 36.2 | 36.6 | 26.9 | 30.2 | 33.1 | 34.0 | 26.9 | 31.3 | 34.4 | 34.9 | 26.8 | 30.3 |
| 43 | 33.3 | 33.1 | 26.5 | 30.0 | 34.6 | 35.5 | 26.2 | 30.2 | 32.0 | 33.5 | 26.2 | 29.5 | 33.3 | 34.0 | 26.3 | 30.0 |
| 44 | 32.4 | 33.1 | 26.0 | 29.3 | 34.0 | 33.3 | 26.0 | 29.5 | 32.0 | 33.1 | 26.2 | 29.1 | 32.8 | 33.2 | 26.1 | 29.4 |
| Average, 44 weeks | 38.6 | 39.3 | 34.5 | 36.6 | 42.0 | 44.9 | 34.7 | 39.1 | 38.5 | 43.2 | 34.6 | 36.1 | 39.7 | 42.3 | 34.6 | 37.4 |

*There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3.

***Percentage of total dry matter from grain.*** The summary figures on percentage of total dry matter supplied by grain are presented in table 8 and in figures 8-10 for groups 1-4 years 1-3. A comparison of figures 8, 9, and 10 again reflects the adjustment to more grain feeding for years 2 and 3.

*Average* ***daily crude-protein intake.*** The average daily crude-protein intake, by weeks, during a 44-week lactation for groups 1-4, years 1-3 is listed in table 9. The protein content of the ration as recommended by the nutritionist associated with the experiment was considered ample to meet the requirements. Goppock *et al.* (1968) pointed out that the ability of the cow to mobilize tissue protein for the synthesis of milk indicates that this capacity is quite small in relation to the ability to mobilize energy. Thus, the concentration of protein in the diet should be increased to meet requirements before this becomes a limiting factor of high-producing cows.

Reid *et al.* (1966) calculated that high-producing cows may lose as much as 0.8 pound of body protein per day during early lactation, and that therefore a high-producing cow can produce milk without restriction for only a short period of low nitrogen intake while a low-producing cow can tolerate a low intake of protein for a long time.

*Average* ***daily TDN consumed and required during 44 weeks of lactation.*** The average daily TDN consumed, by weeks, for groups 1 to 4 during a 44-week lactation is presented in table 10. Estimated TDN intake was based on the digestibility and composition determinations made each year on the feeds used for this experiment.

The average daily TDN required, by weeks, for groups 1 and 4 during a 44-week lactation, plus the 3-year averages, are presented in table 11. The average difference of 2.2, 0.9, 4.0, and 1.5 pounds per day between TDN required and TDN intake can be accounted for by gain in weight during lactation beyond the 44 weeks and/or dur-

Table 8. *Average percent of total dry matter from grain, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | 34.9 | 53.4 | 67.8 | 59.6 | 25.6 | 48.9 | 61.9 | 64.7 | 30.4 | 51.3 | 56.7 | 54.1 |
| 2 | 43.3 | 65.1 | 71.5 | 67.5 | 40.0 | 59.9 | 65.0 | 69.4 | 41.8 | 59.8 | 66.1 | 58.8 |
| 3 | 45.0 | 65.8 | 76.8 | 72.0 | 42.0 | 61.4 | 68.8 | 75.0 | 44.4 | 62.2 | 70.5 | 64.9 |
| 4 | 43.0 | 66.7 | 76.2 | 72.3 | 42.2 | 59.2 | 70.5 | 71.8 | 42.3 | 62.6 | 71.7 | 70.1 |
| 5 | 42.4 | 64.3 | 75.4 | 71.4 | 41.0 | 58.3 | 73.5 | 68.4 | 41.2 | 62.2 | 68.0 | 70.4 |
| 6 | 40.9 | 61.5 | 75.0 | 71.5 | 39.8 | 60.6 | 73.1 | 64.5 | 41.1 | 62.0 | 71.6 | 73.9 |
| 7 | 37.8 | 63.3 | 76.8 | 68.2 | 40.3 | 62.5 | 72.7 | 67.4 | 40.3 | 61.7 | 72.9 | 78.2 |
| 8 | 41.3 | 64.7 | 75.8 | 69.3 | 36.7 | 63.2 | 74.1 | 66.2 | 39.3 | 62.7 | 75.7 | 81.3 |
| 9 | 41.5 | 62.6 | 75.6 | 67.0 | 36.7 | 62.0 | 76.0 | 66.1 | 39.3 | 63.6 | 75.9 | 80.5 |
| 10 | 40.2 | 61.1 | 75.0 | 64.1 | 35.7 | 61.8 | 75.0 | 65.0 | 38.3 | 64.9 | 75.1 | 75.9 |
| 11 | 36.5 | 55.7 | 74.6 | 64.2 | 35.1 | 60.1 | 74.4 | 66.3 | 37.8 | 64.2 | 76.3 | 80.6 |
| 12 | 36.0 | 57.8 | 75.6 | 62.1 | 32.8 | 60.1 | 72.7 | 66.3 | 37.2 | 62.1 | 76.1 | 78.7 |
| 13 | 34.5 | 55.9 | 73.8 | 58.1 | 32.9 | 59.2 | 75.3 | 63.9 | 36.2 | 60.0 | 75.7 | 70.1 |
| 14 | 33.6 | 51.9 | 74.2 | 56.6 | 33.1 | 58.0 | 75.1 | 59.9 | 36.5 | 59.5 | 75.2 | 67.5 |
| 15 | 33.2 | 51.1 | 74.9 | 55.5 | 32.2 | 55.0 | 75.2 | 63.5 | 36.0 | 58.4 | 74.0 | 68.9 |
| 16 | 32.5 | 46.7 | 73.4 | 52.2 | 30.6 | 54.2 | 74.7 | 64.3 | 34.2 | 59.1 | 73.4 | 61.4 |
| 17 | 32.4 | 45.5 | 73.4 | 49.1 | 29.8 | 54.5 | 75.3 | 64.3 | 31.3 | 55.9 | 74.4 | 60.1 |
| 18 | 31.1 | 44.5 | 72.7 | 46.8 | 30.2 | 52.5 | 73.6 | 64.1 | 30.1 | 53.7 | 73.6 | 60.6 |
| 19 | 30.4 | 43.2 | 72.7 | 46.7 | 28.6 | 51.2 | 74.8 | 65.3 | 28.4 | 52.4 | 73.0 | 56.7 |
| 20 | 30.8 | 41.6 | 72.7 | 44.1 | 28.1 | 50.0 | 75.2 | 63.8 | 28.2 | 50.6 | 72.0 | 55.9 |
| 21 | 30.8 | 37.4 | 71.8 | 42.4 | 28.6 | 49.2 | 73.5 | 61.9 | 28.3 | 49.9 | 70.9 | 55.9 |
| 22 | 30.0 | 35.4 | 69.9 | 42.7 | 27.4 | 48.7 | 74.2 | 60.0 | 28.6 | 48.9 | 70.8 | 55.0 |
| 23 | 29.6 | 32.7 | 70.7 | 37.8 | 26.9 | 48.7 | 73.5 | 58.1 | 26.4 | 48.0 | 70.5 | 49.1 |
| 24 | 28.8 | 30.2 | 70.0 | 35.2 | 26.1 | 48.3 | 72.3 | 57.3 | 26.5 | 47.2 | 69.9 | 48.6 |
| 25 | 27.9 | 28.5 | 70.7 | 32.2 | 25.8 | 45.1 | 71.4 | 56.3 | 26.3 | 50.4 | 68.8 | 48.7 |
| 26 | 25.0 | 27.6 | 70.1 | 29.8 | 24.0 | 43.5 | 70.5 | 56.3 | 25.2 | 50.1 | 67.7 | 48.8 |
| 27 | 24.9 | 25.0 | 69.2 | 28.2 | 23.3 | 42.7 | 69.3 | 55.2 | 25.3 | 49.2 | 68.3 | 47.9 |
| 28 | 24.1 | 21.6 | 67.8 | 29.1 | 23.5 | 43.4 | 68.9 | 54.1 | 24.3 | 47.9 | 66.5 | 49.6 |
| 29 | 22.5 | 18.3 | 66.7 | 26.6 | 23.5 | 42.6 | 67.8 | 54.4 | 24.0 | 47.7 | 66.4 | 54.2 |
| 30 | 22.8 | 17.2 | 66.2 | 24.6 | 23.9 | 42.4 | 66.8 | 54.1 | 22.9 | 46.8 | 65.7 | 55.1 |
| 31 | 21.9 | 15.3 | 65.7 | 23.6 | 22.5 | 42.2 | 66.0 | 53.4 | 22.6 | 45.7 | 66.3 | 52.8 |
| 32 | 20.6 | 13.8 | 65.5 | 22.2 | 21.6 | 41.9 | 65.9 | 54.4 | 23.0 | 45.8 | 66.4 | 63.4 |
| 33 | 19.5 | 11.8 | 64.9 | 20.7 | 21.3 | 42.6 | 63.0 | 52.9 | 22.7 | 44.8 | 65.4 | 94.8 |
| 34 | 19.0 | 11.7 | 64.4 | 20.5 | 21.4 | 41.7 | 63.5 | 52.4 | 22.0 | 44.1 | 64.8 | 76.7 |
| 35 | 17.6 | 10.5 | 63.2 | 19.2 | 19.4 | 41.3 | 64.1 | 51.7 | 19.8 | 44.3 | 63.9 | 54.7 |
| 36 | 16.2 | 9.5 | 62.8 | 18.6 | 18.7 | 41.5 | 64.1 | 50.6 | 18.2 | 43.2 | 63.5 | 42.3 |
| 37 | 15.7 | 13.1 | 63.1 | 17.7 | 17.5 | 38.5 | 62.6 | 48.3 | 17.1 | 42.1 | 62.6 | 43.6 |
| 38 | 14.9 | 11.8 | 62.9 | 17.8 | 16.1 | 37.4 | 61.3 | 44.9 | 15.6 | 40.6 | 62.0 | 37.5 |
| 39 | 12.9 | 7.2 | 62.2 | 16.8 | 13.4 | 36.5 | 62.5 | 40.9 | 15.0 | 40.8 | 61.9 | 40.6 |
| 40 | 13.0 | 7.0 | 60.7 | 16.5 | 11.5 | 35.6 | 62.5 | 40.5 | 14.8 | 38.0 | 61.0 | 37.9 |
| 41 | 11.3 | 5.8 | 59.5 | 16.4 | 9.7 | 32.7 | 61.8 | 39.2 | 13.2 | 37.4 | 60.4 | 36.3 |
| 42 | 10.1 | 5.4 | 61.4 | 16.4 | 8.2 | 30.9 | 61.6 | 35.1 | 11.0 | 35.9 | 60.0 | 35.8 |
| 43 | 8.8 | 5.5 | 61.1 | 17.7 | 7.8 | 29.7 | 60.9 | 30.1 | 10.3 | 33.6 | 59.1 | 37.0 |
| 44 | 7.0 | 5.3 | 60.4 | 17.1 | 9.2 | 26.6 | 60.5 | 26.3 | 10.0 | 29.6 | 59.6 | 34.5 |
| Average, 44 weeks | 27.6 | 34.8 | 69.4 | 41.1 | 26.5 | 48.3 | 69.2 | 56.5 | 27.9 | 50.9 | 68.4 | 58.3 |

*There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3.

Table 9. *Average daily crude protein intake, by weeks, starting with 10 cows in each group in year 1**

| Week | Crude protein intake | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 1 | | | | Year 2 | | | | Year 3 | | | |
| | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | 4.0 | 5.3 | 5.7 | 4.8 | 4.0 | 5.1 | 4.4 | 3.7 | 3.7 | 4.8 | 4.2 | 4.4 |
| 2 | 4.8 | 6.8 | 6.6 | 6.6 | 5.5 | 6.2 | 4.8 | 5.1 | 5.5 | 6.2 | 5.7 | 6.0 |
| 3 | 5.5 | 7.3 | 7.9 | 7.3 | 6.4 | 7.3 | 6.0 | 6.2 | 6.0 | 7.1 | 6.4 | 7.1 |
| 4 | 5.7 | 7.5 | 7.9 | 7.7 | 6.4 | 7.7 | 6.2 | 6.6 | 6.2 | 7.1 | 6.6 | 8.4 |
| 5 | 6.2 | 7.3 | 7.7 | 8.2 | 6.6 | 7.5 | 6.8 | 6.0 | 6.4 | 7.1 | 6.4 | 8.6 |
| 6 | 6.2 | 7.7 | 7.9 | 8.4 | 6.8 | 8.2 | 6.8 | 5.7 | 6.4 | 7.9 | 7.1 | 8.8 |
| 7 | 6.0 | 8.4 | 8.4 | 7.9 | 6.6 | 8.2 | 7.1 | 6.4 | 6.4 | 7.7 | 7.3 | 9.0 |
| 8 | 6.2 | 8.6 | 8.2 | 7.9 | 6.4 | 8.4 | 7.3 | 7.1 | 6.4 | 8.4 | 7.9 | 8.4 |
| 9 | 6.4 | 8.1 | 8.4 | 7.9 | 6.8 | 8.6 | 7.7 | 7.3 | 6.4 | 8.6 | 8.2 | 8.8 |
| 10 | 6.2 | 7.7 | 8.4 | 7.9 | 7.1 | 8.4 | 7.5 | 7.7 | 6.6 | 8.8 | 7.9 | 8.4 |
| 11 | 6.6 | 7.3 | 8.4 | 7.7 | 7.1 | 8.4 | 7.5 | 7.9 | 6.4 | 8.6 | 8.6 | 9.0 |
| 12 | 6.6 | 7.7 | 8.4 | 7.3 | 7.1 | 8.2 | 7.1 | 8.2 | 6.6 | 8.6 | 8.4 | 7.3 |
| 13 | 6.6 | 7.5 | 7.5 | 7.1 | 7.1 | 8.2 | 7.7 | 8.4 | 6.4 | 8.4 | 7.9 | 7.3 |
| 14 | 6.4 | 7.3 | 7.5 | 7.3 | 6.8 | 8.2 | 7.7 | 7.9 | 5.7 | 8.2 | 7.7 | 7.7 |
| 15 | 6.4 | 7.1 | 7.3 | 7.5 | 7.1 | 8.2 | 7.7 | 7.9 | 6.0 | 8.4 | 7.3 | 7.3 |
| 16 | 6.6 | 7.1 | 7.5 | 6.8 | 7.1 | 8.4 | 7.7 | 7.9 | 6.0 | 9.3 | 7.3 | 7.5 |
| 17 | 6.2 | 7.1 | 7.3 | 6.4 | 6.8 | 8.4 | 7.7 | 7.7 | 6.2 | 8.2 | 7.5 | 7.5 |
| 18 | 6.2 | 7.1 | 7.1 | 6.6 | 6.8 | 7.9 | 7.3 | 7.7 | 6.0 | 7.9 | 7.3 | 7.5 |
| 19 | 6.2 | 6.6 | 7.1 | 6.4 | 6.6 | 7.9 | 7.5 | 7.7 | 6.0 | 7.7 | 7.1 | 7.1 |
| 20 | 6.2 | 6.4 | 7.1 | 6.2 | 6.6 | 7.9 | 8.2 | 7.5 | 6.0 | 7.7 | 6.8 | 7.1 |
| 21 | 6.0 | 6.2 | 6.8 | 6.0 | 6.6 | 7.7 | 7.5 | 7.5 | 6.0 | 7.5 | 6.4 | 7.1 |
| 22 | 6.0 | 6.2 | 6.4 | 6.0 | 6.6 | 7.7 | 7.5 | 7.5 | 5.7 | 7.5 | 6.4 | 7.1 |
| 23 | 5.7 | 6.0 | 6.6 | 5.7 | 6.6 | 7.9 | 7.1 | 7.3 | 6.0 | 7.1 | 6.2 | 6.6 |
| 24 | 6.0 | 6.0 | 6.4 | 5.5 | 6.4 | 7.9 | 6.8 | 7.5 | 5.7 | 6.8 | 6.0 | 6.8 |
| 25 | 5.7 | 5.7 | 6.6 | 5.3 | 6.4 | 7.7 | 6.6 | 7.1 | 5.5 | 7.1 | 5.7 | 6.6 |
| 26 | 5.5 | 5.5 | 6.4 | 5.3 | 6.4 | 7.5 | 6.4 | 7.1 | 5.5 | 6.8 | 5.5 | 6.6 |
| 27 | 5.7 | 5.3 | 6.2 | 5.1 | 6.6 | 7.3 | 6.2 | 6.8 | 5.3 | 6.8 | 5.7 | 6.4 |
| 28 | 5.5 | 5.1 | 6.0 | 5.1 | 6.2 | 7.3 | 6.0 | 6.4 | 5.3 | 6.6 | 5.5 | 6.0 |
| 29 | 5.5 | 5.3 | 5.7 | 4.8 | 6.2 | 7.1 | 5.7 | 6.4 | 5.3 | 6.8 | 5.3 | 5.5 |
| 30 | 5.5 | 5.3 | 5.5 | 4.8 | 6.2 | 6.8 | 5.5 | 6.4 | 5.1 | 7.3 | 5.3 | 5.3 |
| 31 | 5.5 | 5.3 | 5.5 | 4.6 | 6.0 | 6.8 | 5.5 | 6.6 | 5.3 | 6.4 | 5.3 | 5.1 |
| 32 | 5.5 | 5.1 | 5.3 | 4.6 | 5.7 | 6.6 | 5.5 | 6.8 | 5.1 | 6.2 | 5.3 | 4.4 |
| 33 | 5.5 | 4.8 | 5.3 | 4.8 | 6.0 | 6.4 | 5.1 | 6.6 | 5.1 | 6.2 | 5.1 | 2.6 |
| 34 | 5.5 | 4.6 | 5.3 | 4.8 | 5.7 | 6.6 | 5.1 | 6.6 | 4.8 | 6.4 | 5.1 | 2.4 |
| 35 | 5.3 | 4.8 | 5.1 | 4.6 | 5.5 | 7.1 | 5.1 | 6.6 | 4.8 | 6.2 | 4.8 | 3.5 |
| 36 | 5.3 | 4.8 | 4.8 | 4.6 | 5.3 | 6.4 | 5.1 | 6.0 | 4.6 | 6.0 | 4.8 | 4.0 |
| 37 | 5.1 | 5.1 | 4.8 | 4.6 | 5.3 | 6.0 | 4.8 | 6.0 | 4.6 | 5.7 | 4.6 | 4.4 |
| 38 | 5.1 | 5.1 | 4.8 | 4.6 | 5.1 | 6.0 | 4.6 | 5.7 | 4.6 | 5.7 | 4.6 | 4.4 |
| 39 | 4.8 | 4.6 | 4.8 | 4.4 | 5.1 | 6.0 | 4.8 | 5.5 | 4.4 | 5.5 | 4.6 | 4.4 |
| 40 | 4.8 | 4.4 | 4.6 | 4.4 | 4.8 | 5.7 | 4.8 | 5.5 | 4.2 | 5.1 | 4.4 | 4.6 |
| 41 | 4.6 | 4.4 | 4.4 | 4.4 | 4.6 | 5.5 | 4.8 | 5.3 | 4.2 | 4.8 | 4.4 | 4.6 |
| 42 | 4.4 | 4.4 | 4.6 | 4.2 | 4.6 | 5.3 | 4.8 | 4.6 | 4.2 | 4.8 | 4.4 | 4.6 |
| 43 | 4.4 | 4.2 | 4.6 | 4.4 | 4.4 | 5.1 | 4.6 | 4.6 | 4.0 | 4.6 | 4.2 | 4.4 |
| 44 | 4.2 | 4.2 | 4.4 | 4.2 | 4.4 | 4.9 | 4.6 | 4.4 | 4.0 | 4.4 | 4.2 | 4.2 |
| Average, 44 weeks | 5.6 | 6.1 | 6.4 | 5.9 | 6.1 | 7.2 | 6.3 | 6.6 | 5.5 | 6.9 | 6.1 | 6.2 |

*There were 9, 9, 8, and 6 cows, respectively, in each group during year 2; and 9, 8, 7, and 1, respectively, during year 3.

ing the dry period with plenty of margin for weight of the calf and weight losses during calving.

Figures 11—15 illustrate graphically the above results for years 1-3. All graphs for different years and different groups follow basically the same pattern between TDN consumed and required. The spread between these two was wide until the 12th to 16th weeks, when it approached a balance; they then remained nearly identical until the 36th week when the required amount became less than that consumed, except for group 3 where the two were very close. Group 3 had good gains during the dry period, because the cows received 15 pounds of grain as forage replacement; thus all groups were nearly the same weight at the next calving. The fact that group 3 had the greatest spread between TDN intake and TDN required early in lactation reflects a definite ceiling on grain intake and the advantage of offering high-quality forage *ad lib.* early in lactation. This was indicated also by group 2 (liberal grain with *ad lib.* forage) because the cows in this group had the least spread between the TDN required and consumed during early lactation. Also, group 2 had the smallest average difference (0.9 pound) per day between TDN required and consumed over the 44-week lactation and group 3 on restricted forage and liberal grain with 15 pounds of grain per day for forage replacement had the greatest average daily difference (4.0 pounds) between TDN required and consumed.

Everyone concerned with the problem appreciates the advantages of high energy intake early in lactation so production will not be restricted by lack of dietary energy. To date, the attempt to feed high-producing cows adequate energy at peak production has not been successful. Maximum energy yield occurs much earlier in lactation than maximum TDN intake. Based on an experiment in which cows were lead-fed and fed liberally, Reid (1961) reported these as the 3rd and 8th week, respectively. Jumah *et al.* (1965) found this to be the 5th week for maximum energy yield and the 3rd month postpartum for the highest nutrient intake. Coppock *et al.* (1966) reported that maximum forage intake was achieved after the 9th week of lactation.

Cows cannot consume enough nutrients during early lactation but can mobilize body tissues to compensate for this. Flatt (1966), from research with cows in metabolism stalls, concluded that the extremely high producer early in lactation may get only a fraction of the required nu-

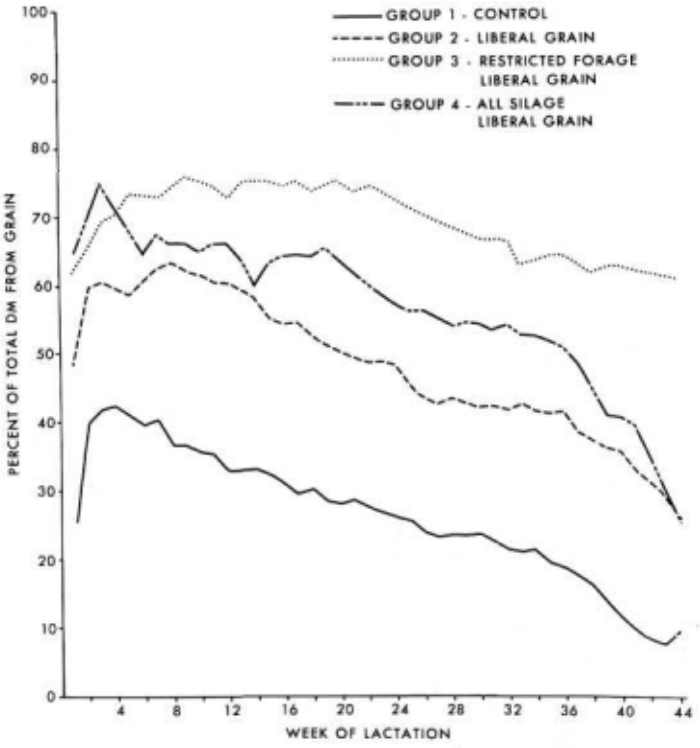


Figure 9. *Average percentage of total dry matter from grain, by weeks, year 2, groups 1-4.*

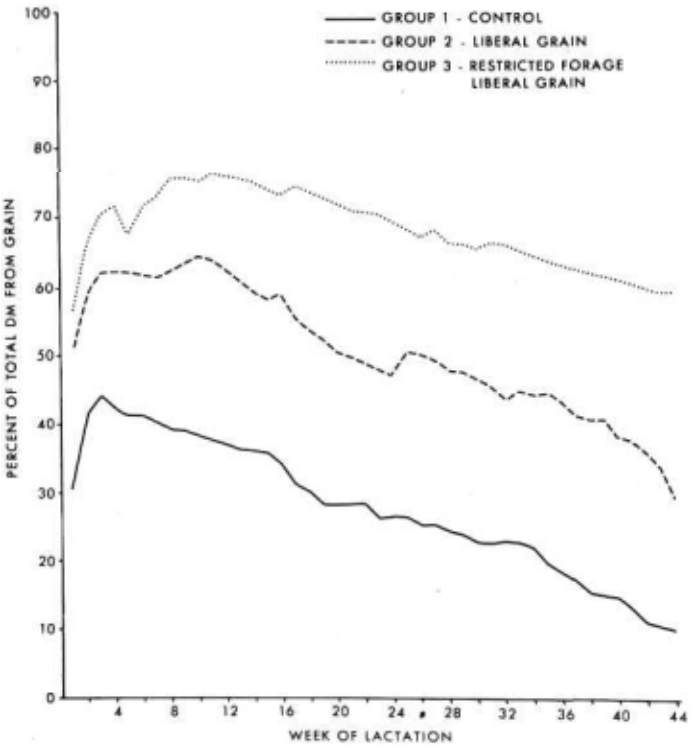


Figure 10. *Average percentage of total dry matter from grain, by weeks, year 3, groups 1-3.*

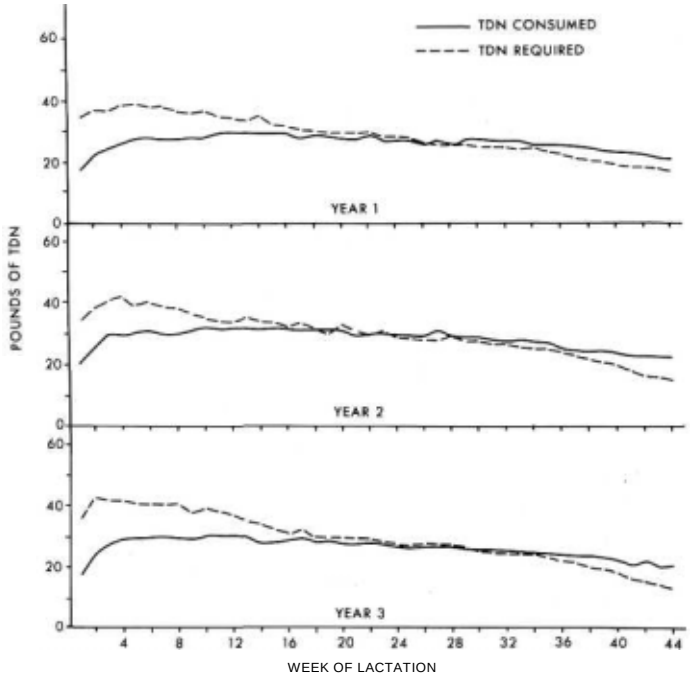


Figure 11. *Average daily TDN consumed and TDN required, by weeks group 1.*

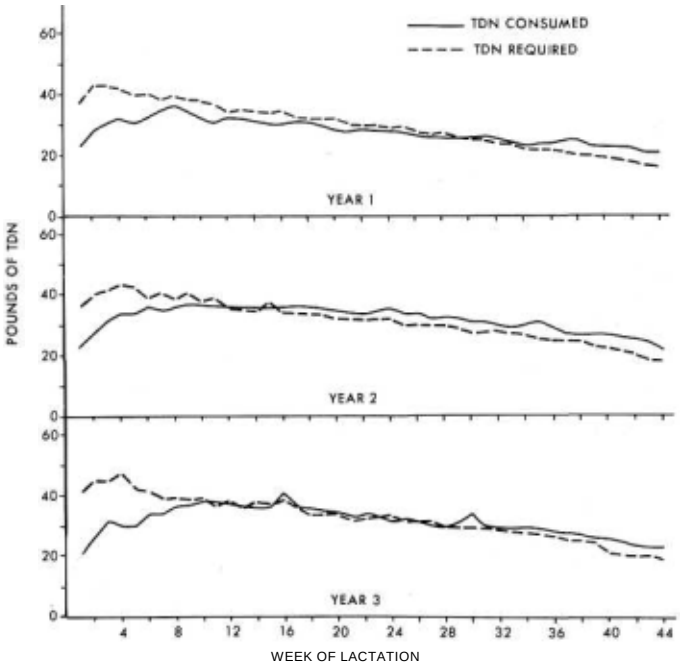


Figure 12. *Average daily TDN consumed and TDN required, by weeks, group 2.*

trients from the feed fed and may supply a considerable part from body tissue, which is predominantly fat.

To bring energy intake and requirement into balance for high-producing cows, Brown *et al.* (1962), Olson *et al.* (1966), Swanson *et al.* (1967), and others fed concentrates *ad lib.* during early lactation, but usually the cows

Table 10. *Average daily TDN consumed, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | | Average 3 years | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | pounds | | | | | | | | | | | | | | | |
| 1 | 18.3 | 22.7 | 22.5 | 21.4 | 19.8 | 22.9 | 18.5 | 15.9 | 18.1 | 21.6 | 17.2 | 19.2 | 18.7 | 22.4 | 19.7 | 19.3 |
| 2 | 22.0 | 28.2 | 25.6 | 28.4 | 25.4 | 27.3 | 20.9 | 21.6 | 24.7 | 26.9 | 22.9 | 26.2 | 24.0 | 27.5 | 23.3 | 25.9 |
| 3 | 24.0 | 30.2 | 30.4 | 30.6 | 29.3 | 31.7 | 25.4 | 26.7 | 27.6 | 31.1 | 26.0 | 30.2 | 26.9 | 31.0 | 27.6 | 29.2 |
| 4 | 26.0 | 31.1 | 30.0 | 32.4 | 29.3 | 34.4 | 25.6 | 29.7 | 28.7 | 30.4 | 26.5 | 35.5 | 27.9 | 32.0 | 27.6 | 31.6 |
| 5 | 27.3 | 30.2 | 29.3 | 34.4 | 30.2 | 33.5 | 28.0 | 27.3 | 28.9 | 30.4 | 25.8 | 36.6 | 28.7 | 31.4 | 27.9 | 32.0 |
| 6 | 27.8 | 32.0 | 30.4 | 34.8 | 30.9 | 35.7 | 28.0 | 26.9 | 29.1 | 34.2 | 28.4 | 36.4 | 29.2 | 33.9 | 29.1 | 32.1 |
| 7 | 26.9 | 34.6 | 32.2 | 33.5 | 30.0 | 35.3 | 28.9 | 28.9 | 29.3 | 34.0 | 29.3 | 36.4 | 28.7 | 34.7 | 30.3 | 32.0 |
| 8 | 27.6 | 35.7 | 30.9 | 33.1 | 30.0 | 36.2 | 29.8 | 32.0 | 29.5 | 36.6 | 31.5 | 33.1 | 29.0 | 36.1 | 30.7 | 32.7 |
| 9 | 28.2 | 34.0 | 31.7 | 33.3 | 30.9 | 37.3 | 31.5 | 32.8 | 29.3 | 37.0 | 32.8 | 35.5 | 29.4 | 36.0 | 31.9 | 33.3 |
| 10 | 27.8 | 32.0 | 32.0 | 33.3 | 32.2 | 37.0 | 30.9 | 34.6 | 30.2 | 38.4 | 32.6 | 35.1 | 30.0 | 35.6 | 31.8 | 33.9 |
| 11 | 29.3 | 30.6 | 32.4 | 32.4 | 31.7 | 36.4 | 30.6 | 35.5 | 30.0 | 37.3 | 34.6 | 36.4 | 30.3 | 34.5 | 32.4 | 33.7 |
| 12 | 29.3 | 32.4 | 32.0 | 31.5 | 32.4 | 36.2 | 28.9 | 36.4 | 30.4 | 37.3 | 33.7 | 30.4 | 30.6 | 35.1 | 31.5 | 33.2 |
| 13 | 29.5 | 32.0 | 28.9 | 31.5 | 31.7 | 35.7 | 31.7 | 38.1 | 29.5 | 37.0 | 32.4 | 32.2 | 30.2 | 34.7 | 30.8 | 33.9 |
| 14 | 29.3 | 30.9 | 29.1 | 32.8 | 31.3 | 35.5 | 31.5 | 35.5 | 27.1 | 36.2 | 31.7 | 34.0 | 29.2 | 34.0 | 30.6 | 33.8 |
| 15 | 29.3 | 30.4 | 28.4 | 34.0 | 32.0 | 35.7 | 31.5 | 35.3 | 28.4 | 36.6 | 30.0 | 31.7 | 29.9 | 34.0 | 29.8 | 34.3 |
| 16 | 29.8 | 30.2 | 29.5 | 31.5 | 32.0 | 36.6 | 30.9 | 35.3 | 28.7 | 40.6 | 29.8 | 33.7 | 30.2 | 35.4 | 30.0 | 33.0 |
| 17 | 28.2 | 30.9 | 29.3 | 29.3 | 31.3 | 36.8 | 31.7 | 34.0 | 28.9 | 36.4 | 31.3 | 34.0 | 29.4 | 34.5 | 30.6 | 31.2 |
| 18 | 28.7 | 30.6 | 28.4 | 30.9 | 31.3 | 35.7 | 29.5 | 34.4 | 28.4 | 35.3 | 30.4 | 33.7 | 29.4 | 33.7 | 29.3 | 32.3 |
| 19 | 28.4 | 29.3 | 28.2 | 29.5 | 31.1 | 35.3 | 30.9 | 34.2 | 28.7 | 34.8 | 29.5 | 32.0 | 29.4 | 32.9 | 29.4 | 31.3 |
| 20 | 28.0 | 28.2 | 28.4 | 29.5 | 31.1 | 35.1 | 33.3 | 33.7 | 28.2 | 34.4 | 28.4 | 32.6 | 29.1 | 32.3 | 30.0 | 31.2 |
| 21 | 27.8 | 27.8 | 27.3 | 28.4 | 30.4 | 34.8 | 30.6 | 33.1 | 28.2 | 32.8 | 27.1 | 32.0 | 28.8 | 31.6 | 28.3 | 30.3 |
| 22 | 29.5 | 28.4 | 25.8 | 28.2 | 30.6 | 34.6 | 30.0 | 33.1 | 28.0 | 33.3 | 27.1 | 31.7 | 29.4 | 31.9 | 27.5 | 30.1 |
| 23 | 27.1 | 27.8 | 26.5 | 27.8 | 30.6 | 35.3 | 29.1 | 33.7 | 28.4 | 32.6 | 26.2 | 31.3 | 28.6 | 31.7 | 27.2 | 30.1 |
| 24 | 27.8 | 27.3 | 25.8 | 27.6 | 30.0 | 35.5 | 28.0 | 34.2 | 27.8 | 31.3 | 25.8 | 32.0 | 28.5 | 31.2 | 26.5 | 30.2 |
| 25 | 27.1 | 26.7 | 26.0 | 26.7 | 29.8 | 34.4 | 26.7 | 32.4 | 27.1 | 32.2 | 24.9 | 31.5 | 28.0 | 30.9 | 25.9 | 29.0 |
| 26 | 26.5 | 26.0 | 25.6 | 27.1 | 29.5 | 34.0 | 26.0 | 32.0 | 26.9 | 30.9 | 24.3 | 30.9 | 27.6 | 30.1 | 25.4 | 29.1 |
| 27 | 26.7 | 25.4 | 24.9 | 26.0 | 31.1 | 32.6 | 24.9 | 30.9 | 26.5 | 30.6 | 24.7 | 30.4 | 28.0 | 29.3 | 24.8 | 28.0 |
| 28 | 26.2 | 24.9 | 24.0 | 26.2 | 28.9 | 32.8 | 24.5 | 30.0 | 26.5 | 30.6 | 24.5 | 27.6 | 27.2 | 29.2 | 24.3 | 27.6 |
| 29 | 26.7 | 25.4 | 23.1 | 25.8 | 28.9 | 32.4 | 23.4 | 29.3 | 26.5 | 31.5 | 23.1 | 24.5 | 27.3 | 29.5 | 23.2 | 27.0 |
| 30 | 26.7 | 25.8 | 22.9 | 25.8 | 28.9 | 31.3 | 22.9 | 29.3 | 26.0 | 34.2 | 22.9 | 22.9 | 27.2 | 30.1 | 22.9 | 26.9 |
| 31 | 26.5 | 26.2 | 22.3 | 24.5 | 28.0 | 31.1 | 22.5 | 30.6 | 26.0 | 30.0 | 23.1 | 23.8 | 26.8 | 29.0 | 22.6 | 26.6 |
| 32 | 26.7 | 25.1 | 21.8 | 24.3 | 27.6 | 30.4 | 22.5 | 31.5 | 25.4 | 29.3 | 22.9 | 18.3 | 26.6 | 28.1 | 22.3 | 26.5 |
| 33 | 26.5 | 24.3 | 21.6 | 25.1 | 28.2 | 29.5 | 20.9 | 30.6 | 25.4 | 29.1 | 22.5 | 9.3 | 26.7 | 27.5 | 21.6 | 26.1 |
| 34 | 26.0 | 23.1 | 21.4 | 25.1 | 27.1 | 30.4 | 20.7 | 30.2 | 24.9 | 29.5 | 22.0 | 9.5 | 26.0 | 27.4 | 21.3 | 26.0 |
| 35 | 25.6 | 24.0 | 20.7 | 24.5 | 26.7 | 32.0 | 20.7 | 29.8 | 24.9 | 29.1 | 21.4 | 15.9 | 25.7 | 28.2 | 20.9 | 25.9 |
| 36 | 25.4 | 24.0 | 20.5 | 24.5 | 25.6 | 29.8 | 20.9 | 27.1 | 24.3 | 28.4 | 20.9 | 20.1 | 25.1 | 27.2 | 20.7 | 25.2 |
| 37 | 24.9 | 24.9 | 20.3 | 24.3 | 25.1 | 28.2 | 20.3 | 27.6 | 24.0 | 28.0 | 20.7 | 20.9 | 24.7 | 26.9 | 20.4 | 25.3 |
| 38 | 24.5 | 24.7 | 20.1 | 24.7 | 24.5 | 27.6 | 19.4 | 27.3 | 23.8 | 27.6 | 20.5 | 22.3 | 24.3 | 26.5 | 20.0 | 25.5 |
| 39 | 24.0 | 23.1 | 19.6 | 23.8 | 24.5 | 27.3 | 20.3 | 26.5 | 22.9 | 26.2 | 20.3 | 22.3 | 23.8 | 25.4 | 20.0 | 24.7 |
| 40 | 23.8 | 22.7 | 19.2 | 22.9 | 24.0 | 26.9 | 20.1 | 26.2 | 22.7 | 25.4 | 19.8 | 23.1 | 23.5 | 24.9 | 19.7 | 24.1 |
| 41 | 23.1 | 22.3 | 18.7 | 22.7 | 23.4 | 26.2 | 19.8 | 24.9 | 21.8 | 24.5 | 19.6 | 23.8 | 22.8 | 24.3 | 19.3 | 23.5 |
| 42 | 22.3 | 22.3 | 19.4 | 22.7 | 23.6 | 25.4 | 19.6 | 22.9 | 22.0 | 24.0 | 19.4 | 23.8 | 22.6 | 23.8 | 19.5 | 22.8 |
| 43 | 21.8 | 21.4 | 19.2 | 22.5 | 22.5 | 24.5 | 19.2 | 22.9 | 21.2 | 23.8 | 19.0 | 22.5 | 21.8 | 23.1 | 19.1 | 22.6 |
| 44 | 21.2 | 21.2 | 19.0 | 22.0 | 22.3 | 22.9 | 19.0 | 22.3 | 21.2 | 23.1 | 19.2 | 22.0 | 21.6 | 22.3 | 19.1 | 22.1 |
| Average, 44 weeks | 26.4 | 27.5 | 25.6 | 28.0 | 28.5 | 32.3 | 25.7 | 30.2 | 26.5 | 31.5 | 25.6 | 27.9 | 27.1 | 30.3 | 25.6 | 28.8 |

*There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3.

were unable to consume enough grain to accomplish this during early lactation. Frequently forage dry matter intake is depressed and then the milk fat percentage may be depressed. Reid (1956) and Mather *et al.* (1960) established that the liberal allowance of concentrates will depress forage intake and frequently this is in the range of a quarter to a half of the weight of the extra concentrate consumed.

Most energy intakes tend to lag behind peak energy yields in milk during early lactation regardless of the application of modern feeding procedures and use of the best rations known. Most conditions favor high-quality forage as the most economical source of nutrients and research results suggest that high-quality forage should be fed *ad lib.* The objective is to feed grain for maximum energy intake to get maximum production to a point of maximum net profit early in lactation, and later reduce it for best results. Hoglund (1963) (1964) outlined factors associated with the most profitable levels of grain feeding as measured by returns above cost of feed. Usually the most profitable rate of grain feeding is 1100 to 1600 pounds higher for the high-response cow as compared to cows with a low response.

Broster (1970) emphasized the importance of observing production over the entire lactation to measure the cumulative effect of plane of nutrition. He reported a residual effect from additional feeding during early lactation. An immediate response of 200 kilograms in milk production was obtained from additional feeding during weeks 1 to 9 or during weeks 10 to 18, but the total response in production was 33 percent greater (600 kilograms) when the additional feed was allowed during both periods. Cows not liberally fed during early lactation (weeks 1 to 9) did not show the residual effect from additional feeding during weeks 10 to 18 and repeated later. The normal swing in partition toward liveweight gain and away

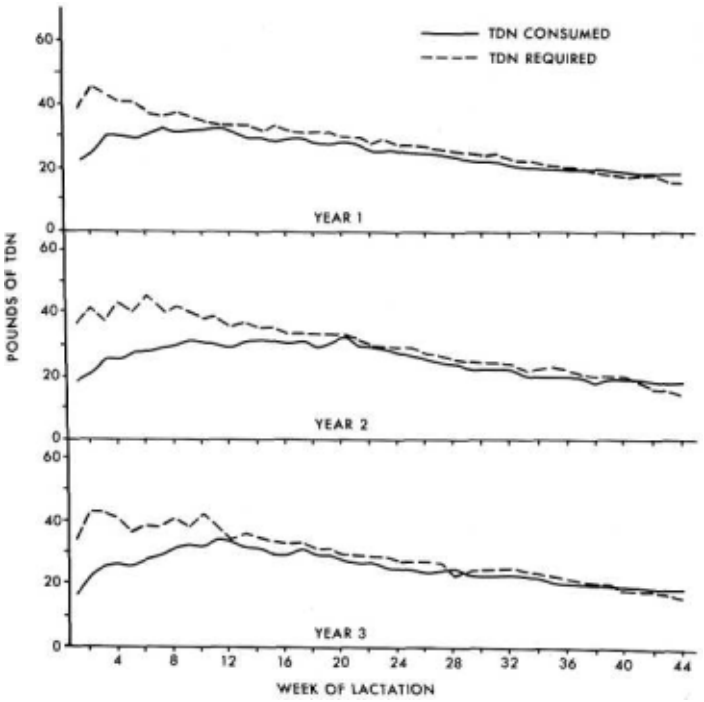


Figure 13. *Average daily TDN consumed and TDN required, by weeks, group 3.*

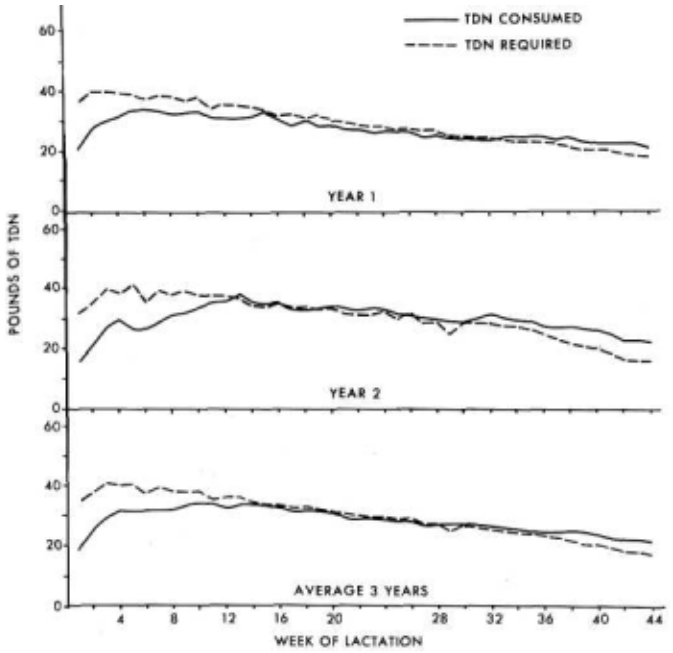


Figure 14. *Average daily TDN consumed and TDN required, by weeks, group 4.*

from milk production was delayed by generous feeding during early lactation.

***Percent of total TDN from grain.*** The average percentages of total TDN from grain, by weeks, for a 44-week lactation are given in table 12 and figures 16-18.

The highest percentage of total TDN from grain was reached during weeks 3, 4, and 3, respectively, for group **1**

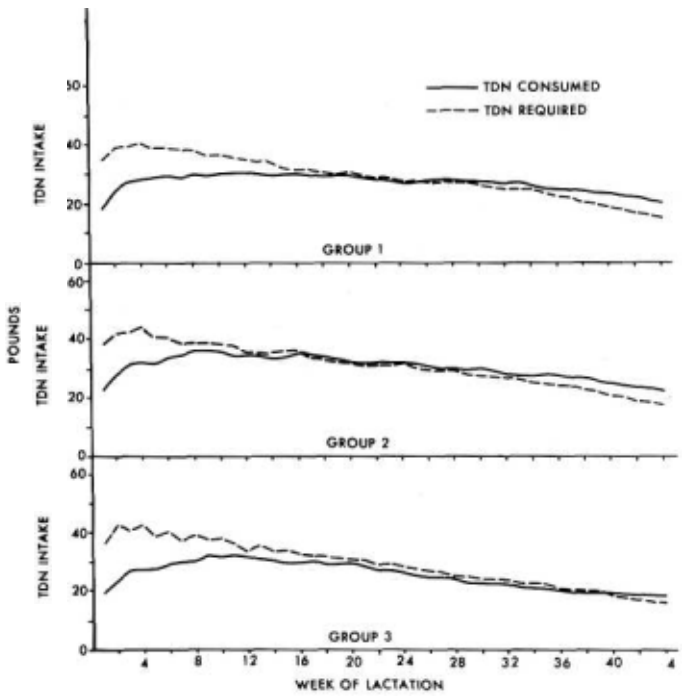


Figure 15. *Average daily TDN consumed and TDN required, by weeks, 3-year average, groups 1-3.*

during years 1-3; during postpartum weeks 4, 8, and 10, respectively, for group 2; during weeks 3, 9, and 11, respectively, for group 3; and during weeks 4, 3, and 8, respectively, for group 4.

Kesler and Spahr (1964) reported that maximum TDN intake occurs when about 50 percent of the ration consists of concentrates. This did not apply to the averages for various weeks but did apply to the average percentage of total TDN from grain on the basis of the entire 44-week lactation in this experiment.

Conrad *et al.* (1966) reported that the relative amount of digestible dry matter consumed decreased as the proportion of grain in the ration increased above 50 percent of the dry weight of the ration. Kesler and Spahr (1964) reported that most of their experimental cows reached their maximum intake of productive energy when concentrates made up 50 to 60 percent of the ration. They stated that increasing the proportion of concentrates above 60 percent may result in a slight reduction in intake. The data reported herein do not follow this generalization except for the cows on restricted forage.

## Milk Production

***Daily milk yield.*** The average daily milk production by weeks, for groups 1-4 is summarized in table 13, which shows a consistent level of production for the 3 years.

This is apparent also in the graphs where milk produc-

Table 11. *Average daily TDN required, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | | Average 3 years | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | pounds | | | | | | | | | | | | | | | |
| 1 | 34.0 | 36.8 | 38.4 | 37.3 | 34.4 | 35.9 | 36.8 | 32.2 | 35.7 | 41.0 | 33.7 | 33.5 | 34.7 | 37.7 | 36.6 | 35.3 |
| 2 | 36.6 | 42.5 | 45.2 | 40.3 | 38.6 | 39.7 | 41.7 | 35.3 | 42.3 | 44.3 | 43.0 | 40.3 | 39.1 | 42.1 | 43.5 | 38.5 |
| 3 | 36.2 | 42.3 | 42.3 | 40.8 | 41.2 | 41.2 | 37.7 | 40.8 | 41.2 | 44.5 | 42.8 | 43.9 | 39.4 | 42.6 | 41.0 | 41.0 |
| 4 | 37.7 | 41.7 | 41.2 | 40.6 | 42.3 | 43.9 | 44.1 | 39.2 | 41.2 | 47.2 | 41.0 | 46.1 | 40.3 | 44.1 | 42.1 | 40.4 |
| 5 | 38.1 | 39.5 | 40.6 | 40.1 | 39.2 | 42.3 | 39.9 | 41.9 | 40.6 | 42.1 | 37.0 | 48.3 | 39.3 | 41.2 | 39.4 | 41.2 |
| 6 | 37.5 | 39.7 | 37.3 | 38.1 | 40.1 | 39.2 | 46.1 | 36.2 | 40.1 | 41.7 | 37.9 | 43.7 | 39.2 | 40.1 | 40.3 | 37.8 |
| 7 | 37.7 | 37.7 | 36.6 | 39.5 | 38.8 | 40.8 | 40.3 | 40.3 | 40.1 | 39.0 | 38.6 | 37.9 | 38.8 | 39.1 | 38.3 | 39.7 |
| 8 | 36.8 | 39.5 | 37.5 | 39.0 | 37.9 | 39.0 | 41.9 | 38.6 | 40.6 | 39.2 | 40.6 | 37.3 | 38.4 | 39.2 | 39.8 | 38.8 |
| 9 | 35.7 | 37.7 | 35.7 | 37.5 | 36.6 | 41.0 | 40.8 | 39.7 | 37.5 | 38.8 | 38.1 | 36.1 | 36.6 | 39.1 | 38.0 | 38.2 |
| 10 | 36.4 | 37.7 | 34.8 | 38.8 | 34.8 | 37.9 | 38.6 | 38.6 | 39.2 | 39.2 | 42.3 | 36.8 | 36.8 | 38.2 | 38.1 | 38.6 |
| 11 | 35.1 | 37.0 | 33.7 | 35.1 | 34.2 | 39.0 | 39.0 | 38.4 | 38.1 | 36.8 | 38.4 | 31.7 | 35.8 | 37.6 | 36.7 | 36.1 |
| 12 | 34.4 | 33.7 | 33.3 | 36.6 | 34.0 | 35.9 | 36.4 | 37.7 | 37.3 | 38.4 | 35.3 | 32.4 | 35.2 | 35.8 | 34.9 | 36.7 |
| 13 | 33.1 | 34.6 | 33.7 | 36.6 | 35.3 | 35.5 | 37.5 | 37.5 | 35.1 | 35.7 | 35.9 | 33.5 | 34.4 | 35.2 | 35.5 | 36.7 |
| 14 | 35.1 | 34.0 | 32.2 | 35.3 | 33.7 | 34.8 | 35.5 | 35.3 | 33.7 | 37.9 | 35.1 | 30.4 | 34.2 | 35.4 | 34.1 | 35.0 |
| 15 | 32.2 | 33.3 | 33.5 | 34.8 | 33.3 | 37.7 | 35.9 | 35.1 | 32.4 | 37.3 | 34.2 | 26.9 | 32.6 | 36.0 | 34.5 | 34.4 |
| 16 | 31.3 | 34.2 | 32.2 | 32.6 | 32.6 | 34.8 | 34.2 | 35.7 | 30.9 | 38.6 | 33.1 | 29.5 | 31.6 | 35.7 | 33.1 | 33.5 |
| 17 | 30.6 | 32.6 | 31.1 | 33.1 | 33.3 | 34.4 | 34.2 | 34.6 | 32.2 | 35.5 | 33.7 | 25.1 | 32.0 | 34.1 | 32.8 | 33.2 |
| 18 | 30.4 | 32.0 | 31.5 | 32.6 | 32.0 | 34.0 | 34.4 | 35.1 | 29.8 | 33.3 | 32.0 | 28.2 | 30.7 | 33.1 | 32.6 | 33.2 |
| 19 | 30.2 | 31.5 | 31.3 | 33.1 | 30.6 | 33.3 | 33.7 | 33.7 | 30.0 | 33.7 | 31.3 | 26.2 | 30.3 | 32.8 | 32.1 | 32.9 |
| 20 | 30.2 | 31.3 | 30.2 | 31.1 | 33.1 | 32.6 | 33.5 | 34.2 | 29.5 | 33.7 | 29.8 | 26.9 | 30.9 | 32.4 | 31.1 | 31.9 |
| 21 | 29.3 | 30.0 | 30.2 | 30.9 | 30.9 | 32.2 | 32.6 | 32.4 | 29.3 | 32.0 | 29.8 | 26.5 | 29.8 | 31.3 | 30.9 | 31.2 |
| 22 | 28.9 | 29.1 | 28.4 | 30.2 | 29.8 | 32.0 | 30.2 | 32.0 | 28.9 | 32.4 | 29.1 | 26.5 | 29.2 | 31.0 | 29.2 | 30.6 |
| 23 | 28.2 | 29.1 | 29.8 | 29.1 | 30.9 | 31.5 | 29.5 | 32.2 | 28.4 | 32.8 | 28.9 | 27.1 | 29.1 | 31.0 | 29.5 | 30.1 |
| 24 | 27.8 | 28.4 | 28.2 | 28.9 | 28.9 | 32.6 | 29.8 | 33.3 | 28.0 | 33.3 | 28.2 | 26.5 | 28.2 | 31.3 | 28.7 | 30.3 |
| 25 | 28.0 | 28.7 | 28.2 | 28.2 | 28.7 | 30.6 | 28.9 | 30.9 | 27.8 | 31.7 | 28.2 | 25.6 | 28.2 | 30.2 | 28.4 | 29.0 |
| 26 | 26.9 | 27.3 | 27.3 | 28.4 | 28.0 | 30.6 | 28.0 | 32.8 | 27.1 | 31.5 | 27.3 | 26.0 | 27.3 | 29.6 | 27.5 | 29.8 |
| 27 | 26.2 | 26.5 | 26.5 | 27.8 | 27.8 | 30.4 | 27.3 | 28.9 | 27.1 | 31.5 | 27.1 | 25.1 | 27.0 | 29.3 | 26.9 | 28.0 |
| 28 | 26.2 | 27.3 | 26.0 | 27.8 | 28.9 | 30.4 | 26.0 | 29.1 | 26.9 | 30.6 | 23.4 | 24.7 | 27.3 | 29.3 | 25.3 | 28.1 |
| 29 | 26.2 | 25.6 | 25.1 | 26.0 | 27.8 | 29.1 | 26.0 | 25.6 | 26.7 | 30.2 | 24.9 | 24.7 | 26.9 | 28.1 | 25.3 | 25.8 |
| 30 | 25.6 | 25.8 | 24.2 | 26.0 | 27.8 | 28.0 | 25.1 | 29.1 | 26.2 | 29.3 | 25.4 | 24.3 | 26.5 | 27.6 | 24.8 | 27.0 |
| 31 | 24.9 | 24.7 | 24.5 | 25.1 | 26.7 | 28.0 | 25.1 | 28.9 | 25.8 | 29.5 | 25.4 | 23.4 | 25.8 | 27.2 | 24.9 | 26.3 |
| 32 | 24.9 | 23.8 | 23.4 | 25.1 | 26.7 | 28.2 | 24.3 | 28.7 | 25.6 | 28.9 | 25.6 | 21.6 | 25.7 | 26.8 | 24.3 | 26.2 |
| 33 | 24.0 | 24.0 | 22.7 | 24.7 | 26.2 | 27.3 | 22.0 | 28.2 | 25.4 | 28.7 | 24.5 | 19.2 | 25.2 | 26.5 | 23.0 | 25.6 |
| 34 | 24.7 | 22.5 | 22.0 | 23.6 | 25.4 | 26.7 | 23.8 | 28.0 | 24.5 | 28.4 | 23.8 | 19.8 | 24.9 | 25.6 | 23.1 | 24.9 |
| 35 | 23.4 | 22.3 | 21.6 | 23.6 | 25.4 | 26.2 | 23.4 | 26.9 | 23.6 | 27.3 | 23.4 | 19.2 | 24.1 | 25.1 | 22.7 | 24.5 |
| 36 | 22.5 | 22.0 | 21.2 | 23.1 | 24.3 | 25.4 | 22.3 | 25.1 | 22.3 | 26.7 | 22.0 | 19.0 | 23.0 | 24.5 | 21.8 | 23.6 |
| 37 | 21.6 | 21.6 | 20.7 | 22.5 | 23.1 | 25.4 | 21.6 | 23.6 | 22.0 | 26.0 | 21.8 | 18.5 | 22.2 | 24.2 | 21.3 | 22.7 |
| 38 | 20.9 | 20.3 | 19.8 | 22.0 | 22.0 | 24.5 | 20.9 | 22.0 | 20.7 | 25.4 | 21.2 | 20.3 | 21.2 | 23.2 | 20.5 | 21.9 |
| 39 | 20.7 | 20.1 | 19.4 | 21.4 | 21.2 | 23.4 | 20.7 | 21.2 | 19.8 | 24.5 | 20.3 | 19.8 | 20.6 | 22.5 | 20.1 | 21.2 |
| 40 | 19.6 | 19.6 | 18.3 | 20.9 | 20.1 | 22.7 | 20.5 | 20.7 | 18.7 | 21.4 | 19.4 | 19.8 | 19.5 | 21.2 | 19.3 | 20.8 |
| 41 | 19.2 | 18.5 | 18.7 | 20.5 | 18.1 | 21.8 | 19.2 | 19.0 | 16.8 | 20.9 | 18.7 | 19.4 | 18.1 | 20.3 | 18.9 | 19.9 |
| 42 | 19.0 | 17.9 | 17.9 | 19.6 | 17.0 | 20.7 | 17.2 | 17.2 | 16.1 | 20.3 | 18.1 | 19.2 | 17.4 | 19.5 | 17.7 | 18.7 |
| 43 | 17.9 | 17.0 | 16.8 | 19.4 | 16.5 | 19.0 | 16.8 | 16.1 | 15.2 | 20.5 | 17.6 | 18.3 | 16.6 | 18.7 | 17.0 | 18.2 |
| 44 | 17.2 | 16.1 | 16.1 | 18.7 | 15.4 | 18.5 | 15.4 | 16.1 | 13.4 | 19.4 | 17.2 | 17.0 | 15.4 | 17.9 | 16.2 | 17.7 |
| Average, 44 weeks | 28.7 | 29.5 | 28.8 | 30.1 | 30.1 | 31.8 | 30.4 | 31.1 | 29.4 | 32.8 | 29.7 | 27.9 | 29.3 | 31.2 | 29.6 | 30.3 |

*There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3.

tion was plotted over a 44-week period. Group 1 (figure 19) gave a uniform response for the 3 years. Group 2 (figure 20) responded to increased grain feeding during mid and late lactation in years 2 and 3. The results of group 3 (figure 21) are consistent but tempered somewhat by the ceiling on total amount of grain consumed during the first half of lactation. This is evident when group 3 is compared with group 4. The production of group 4 varied the most, showing the influence of erratic grain and silage consumption and the loss of 4 cows in year 2, and of 5 in year 3, from this group. Group 1 had a 3-year average daily production of 53.3, with 52.7, 54.1, and 53.3 pounds of milk for years 1-3, respectively, which indicates that the quality of hay and silage was relatively uniform from year to year under the harvesting procedure described in the experimental plans. Further, it indicates excellent and uniform management procedures throughout the 3 lactations.

Group 2 consistently produced more milk than the controls, but in year 1 this excess averaged only 1.2 pounds per day. After the adjustment for increased grain to a level of approximately twice that of group 1, the average production of the cows in group 2 exceeded the control group by 3.7 and 6.1 pounds per day for years 2 and 3, respectively. The average production of 56.8 pounds per day for group 2 over the 3-year period surpassed the average of 53.3 pounds for group 1 by 3.5 pounds per day. The economics of this can be calculated by evaluating the increased production with the increased grain and decreased hay consumption, as compared for these 2 groups under *Total Feed Intakes.*

The milk production for group 3 closely resembles that of the control. The cows in group 4 averaged 56.1 pounds of milk per day — an average advantage over the control of 2.8 pounds for the 3 years.

***Average 4% fat-corrected milk production.*** The information on the average daily 4% FCM (.4M + 15F) production, by weeks, throughout a 44-week lactation is sum-

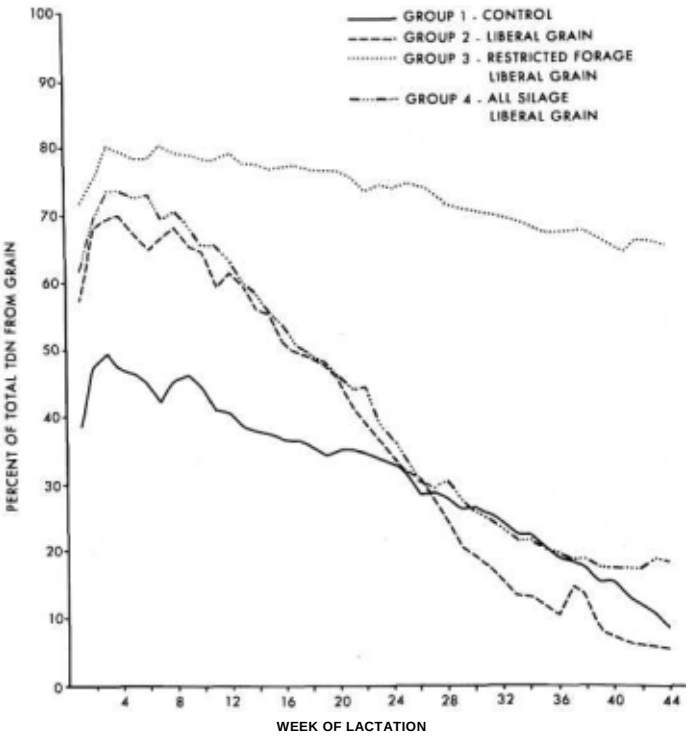


Figure 16. *Average percentage of total TDN from grain, year 1.*

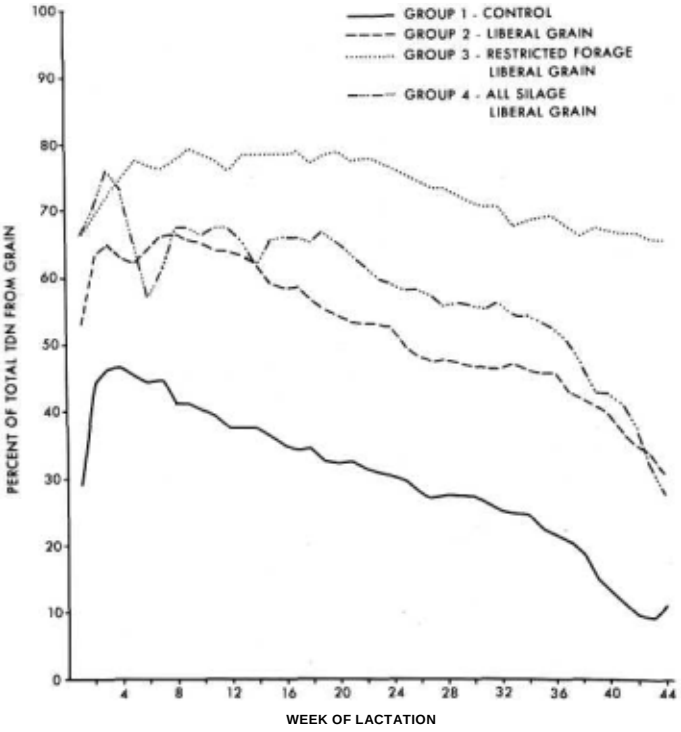


Figure 17. *Average percentage of total TDN from grain, year 2.*

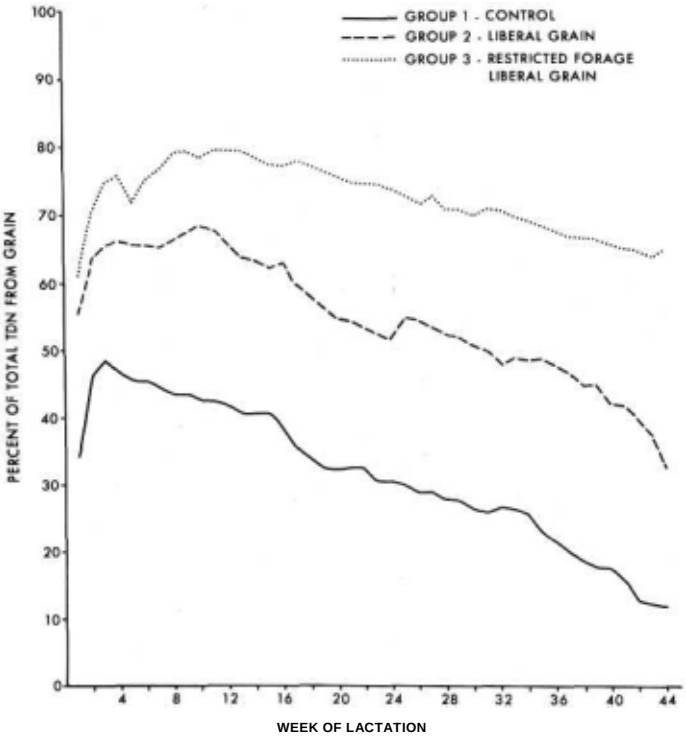


Figure 18. *Average percentage of total TDN from grain, year 3.*

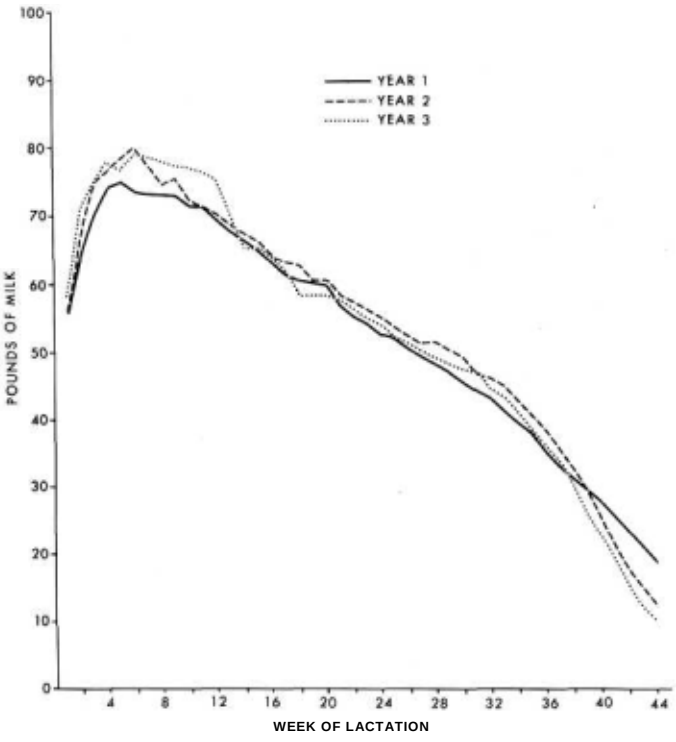


Figure 19. *Actual milk production, control group 1.*

marized in table 14. Group 2 had an average advantage of 4.6 pounds per day over the control group for the 3-year average 4% FCM production. Group 4 averaged 2.8 pounds, and group 3, 0.9 pound, per day more than the cows in group 1. The results are shown graphically in figures 23-25. The fat-corrected milk production was used

Table 12. *Average percent of total TDN from grain, by weeks**

| Week | Year 1 Group 1 | Year 1 Group 2 | Year 1 Group 3 | Year 1 Group 4 | Year 2 Group 1 | Year 2 Group 2 | Year 2 Group 3 | Year 2 Group 4 | Year 3 Group 1 | Year 3 Group 2 | Year 3 Group 3 | Year 3 Group 4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 38.9 | 57.5 | 71.9 | 61.9 | 29.0 | 53.0 | 66.3 | 66.3 | 34.2 | 55.5 | 61.3 | 55.9 |
| 2 | 47.4 | 68.6 | 75.3 | 69.3 | 44.3 | 63.4 | 69.0 | 70.9 | 46.0 | 63.4 | 70.3 | 60.6 |
| 3 | 49.1 | 69.1 | 80.1 | 73.6 | 46.4 | 65.0 | 72.7 | 76.3 | 48.5 | 65.8 | 74.4 | 66.5 |
| 4 | 47.1 | 70.0 | 79.5 | 73.8 | 46.7 | 63.0 | 74.4 | 73.2 | 46.6 | 66.1 | 75.4 | 71.6 |
| 5 | 46.6 | 67.8 | 78.7 | 72.9 | 45.6 | 62.2 | 77.2 | 65.2 | 45.6 | 65.8 | 71.8 | 71.9 |
| 6 | 45.2 | 65.2 | 78.4 | 73.0 | 44.5 | 64.5 | 76.8 | 57.5 | 45.3 | 65.7 | 75.3 | 75.3 |
| 7 | 42.1 | 66.8 | 80.1 | 69.7 | 44.9 | 66.1 | 76.4 | 61.4 | 44.6 | 65.1 | 76.5 | 79.5 |
| 8 | 45.7 | 68.0 | 79.2 | 70.9 | 41.2 | 66.9 | 77.7 | 67.8 | 43.6 | 66.2 | 79.0 | 82.4 |
| 9 | 46.0 | 65.9 | 79.0 | 68.6 | 41.3 | 65.8 | 79.3 | 67.7 | 43.6 | 67.2 | 79.2 | 81.6 |
| 10 | 44.7 | 64.5 | 78.4 | 65.8 | 40.3 | 65.5 | 78.5 | 66.6 | 42.8 | 68.4 | 78.5 | 77.3 |
| 11 | 41.0 | 59.5 | 78.0 | 65.8 | 39.7 | 64.0 | 77.9 | 67.9 | 42.2 | 67.6 | 79.5 | 81.7 |
| 12 | 40.6 | 61.6 | 79.0 | 63.8 | 37.4 | 64.0 | 76.4 | 67.9 | 41.6 | 65.7 | 79.4 | 79.9 |
| 13 | 38.9 | 59.7 | 77.5 | 59.8 | 37.4 | 63.1 | 78.8 | 65.6 | 40.6 | 65.7 | 79.1 | 71.6 |
| 14 | 38.0 | 56.0 | 77.8 | 58.3 | 37.6 | 62.0 | 78.6 | 61.7 | 40.5 | 63.2 | 78.6 | 69.1 |
| 15 | 37.6 | 55.2 | 76.7 | 55.3 | 36.7 | 59.2 | 78.7 | 65.2 | 40.1 | 62.3 | 77.5 | 70.5 |
| 16 | 36.8 | 50.9 | 77.1 | 53.9 | 35.0 | 58.5 | 78.2 | 66.0 | 38.2 | 62.9 | 77.0 | 63.2 |
| 17 | 36.6 | 49.7 | 77.2 | 50.9 | 34.1 | 58.7 | 78.8 | 66.0 | 35.3 | 59.9 | 77.9 | 61.9 |
| 18 | 35.5 | 48.6 | 76.4 | 48.6 | 34.5 | 56.8 | 77.3 | 65.8 | 34.0 | 57.9 | 77.1 | 62.3 |
| 19 | 34.6 | 47.3 | 76.5 | 48.4 | 32.8 | 55.6 | 78.3 | 67.0 | 32.3 | 56.5 | 76.6 | 58.5 |
| 20 | 35.0 | 45.5 | 76.5 | 45.8 | 32.3 | 54.4 | 78.7 | 65.5 | 32.0 | 54.9 | 75.7 | 55.7 |
| 21 | 35.0 | 41.1 | 75.6 | 44.2 | 32.8 | 53.6 | 77.1 | 63.7 | 32.1 | 54.1 | 74.7 | 55.7 |
| 22 | 34.1 | 39.1 | 73.9 | 44.4 | 31.6 | 53.1 | 77.8 | 61.7 | 32.3 | 53.2 | 74.6 | 54.9 |
| 23 | 33.8 | 36.4 | 74.6 | 39.4 | 31.0 | 53.2 | 77.2 | 59.9 | 30.1 | 52.2 | 74.3 | 51.0 |
| 24 | 33.0 | 35.7 | 74.0 | 36.7 | 30.2 | 52.6 | 76.1 | 59.1 | 30.2 | 51.3 | 73.8 | 50.4 |
| 25 | 31.9 | 31.8 | 74.7 | 33.7 | 29.9 | 49.5 | 75.3 | 58.1 | 29.9 | 54.6 | 72.8 | 50.5 |
| 26 | 28.7 | 30.8 | 74.1 | 31.1 | 27.9 | 48.0 | 74.5 | 58.1 | 28.8 | 54.1 | 71.8 | 50.6 |
| 27 | 28.8 | 27.8 | 73.3 | 29.6 | 27.0 | 47.1 | 73.4 | 57.0 | 28.8 | 53.3 | 72.3 | 49.8 |
| 28 | 27.8 | 24.3 | 71.9 | 30.4 | 27.3 | 47.8 | 73.1 | 55.9 | 27.8 | 52.0 | 70.6 | 51.5 |
| 29 | 26.1 | 20.6 | 70.9 | 27.9 | 27.3 | 47.0 | 72.0 | 56.2 | 27.4 | 51.9 | 70.6 | 56.1 |
| 30 | 26.4 | 19.4 | 70.5 | 25.9 | 27.6 | 46.8 | 71.0 | 55.9 | 26.2 | 50.8 | 69.9 | 57.0 |
| 31 | 25.4 | 17.3 | 70.0 | 24.8 | 26.1 | 46.6 | 70.5 | 55.2 | 25.9 | 49.8 | 70.5 | 54.7 |
| 32 | 24.1 | 15.5 | 69.8 | 23.4 | 25.0 | 46.3 | 70.2 | 56.2 | 26.3 | 47.8 | 70.6 | 65.1 |
| 33 | 22.7 | 13.3 | 69.3 | 21.8 | 24.8 | 47.0 | 67.4 | 54.7 | 26.0 | 48.9 | 69.6 | 95.2 |
| 34 | 22.1 | 13.1 | 68.8 | 21.7 | 24.9 | 46.0 | 68.0 | 54.2 | 25.2 | 48.2 | 69.1 | 78.1 |
| 35 | 20.6 | 11.9 | 67.6 | 20.3 | 22.7 | 45.7 | 68.5 | 53.6 | 22.8 | 48.5 | 68.3 | 56.5 |
| 36 | 19.0 | 10.8 | 67.3 | 19.7 | 21.8 | 45.8 | 68.6 | 52.4 | 21.0 | 47.3 | 67.8 | 44.2 |
| 37 | 18.4 | 14.8 | 67.6 | 18.7 | 20.4 | 42.8 | 67.2 | 50.1 | 19.8 | 46.2 | 66.9 | 45.5 |
| 38 | 17.5 | 15.4 | 67.5 | 18.8 | 18.9 | 41.7 | 65.8 | 46.7 | 18.2 | 44.7 | 66.4 | 39.3 |
| 39 | 15.2 | 8.2 | 66.8 | 17.8 | 15.7 | 40.7 | 67.0 | 42.5 | 17.4 | 44.7 | 66.5 | 42.4 |
| 40 | 15.3 | 7.8 | 65.3 | 17.5 | 13.5 | 39.8 | 66.8 | 42.1 | 17.2 | 41.9 | 65.4 | 39.6 |
| 41 | 13.4 | 6.4 | 64.1 | 17.4 | 11.4 | 36.8 | 66.4 | 40.8 | 15.4 | 41.1 | 64.9 | 38.1 |
| 42 | 12.0 | 6.0 | 66.0 | 17.5 | 9.8 | 34.7 | 66.2 | 36.7 | 12.8 | 39.7 | 64.5 | 37.6 |
| 43 | 10.4 | 6.0 | 65.7 | 18.7 | 9.3 | 33.6 | 65.5 | 31.6 | 12.0 | 37.3 | 63.7 | 38.8 |
| 44 | 8.4 | 5.7 | 65.1 | 18.1 | 11.0 | 30.1 | 65.1 | 27.6 | 11.6 | 32.8 | 64.1 | 36.3 |
| Average, 44 weeks | 31.3 | 37.6 | 73.4 | 42.5 | 30.2 | 52.4 | 73.2 | 58.2 | 31.4 | 54.8 | 72.4 | 59.9 |

*There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3.

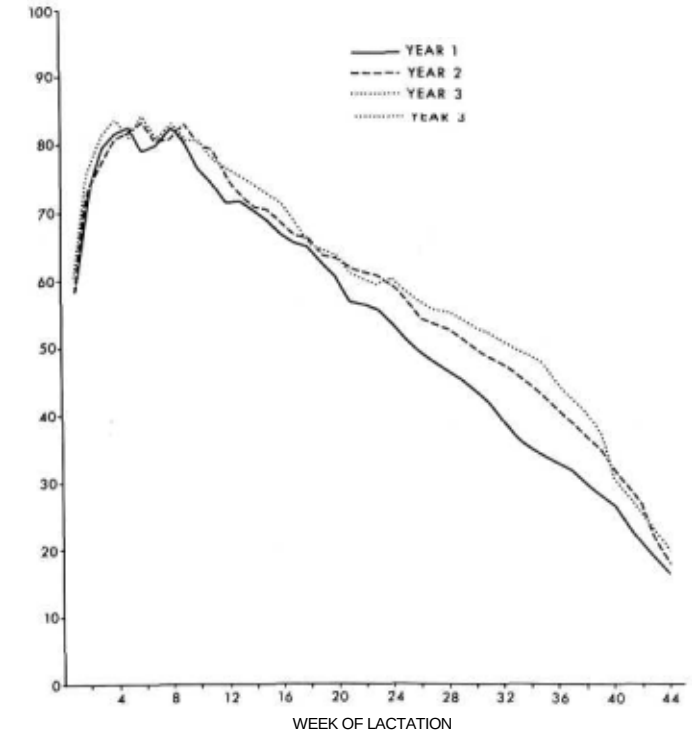


Figure 20. *Actual milk production, group 2 (liberal grain).*

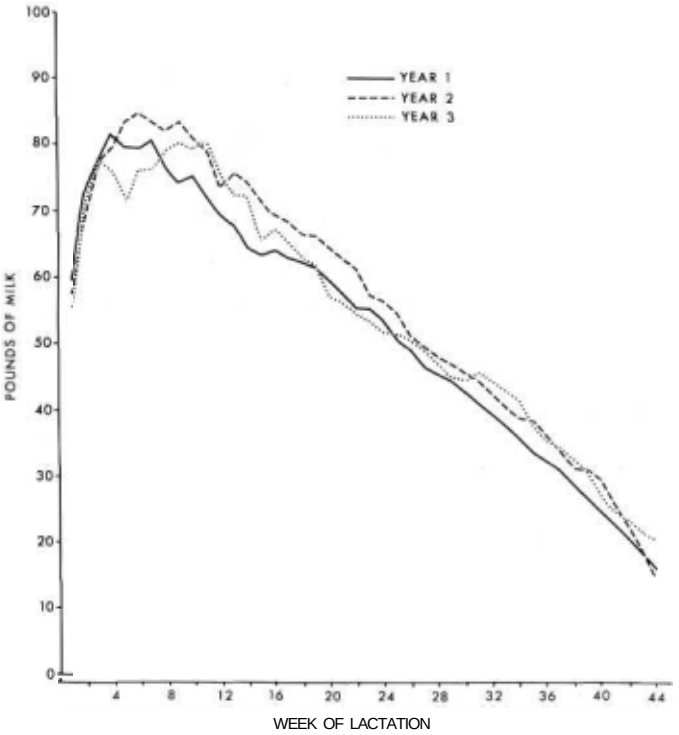


Figure 21. *Actual milk production, group 3 (restricted forage, liberal grain).*

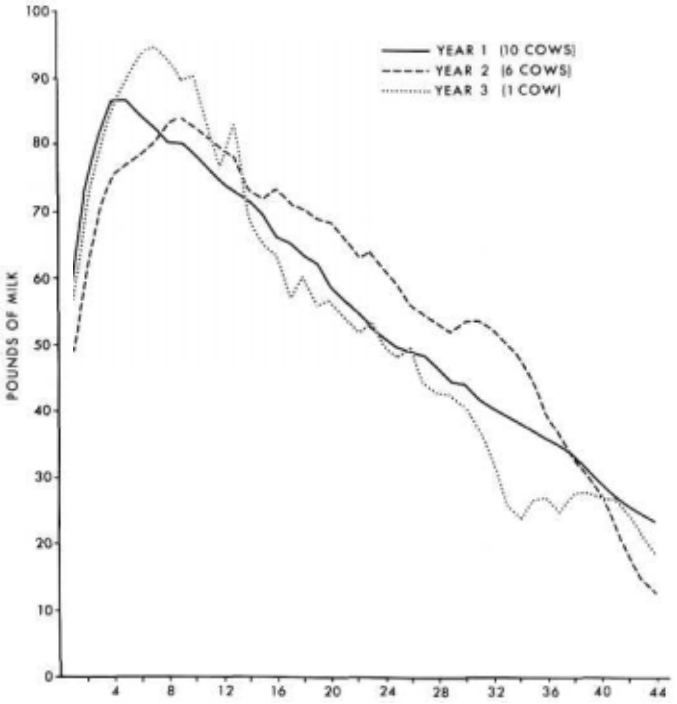


Figure 22. *Actual milk production, group 4 (all-corn silage, liberal grain).*

in preference to solids-corrected milk because there was no serious milk-fat depression.

Table 13. *Average daily milk production, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | | Average 3 years | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | pounds | | | | | | | | | | | | | | | |
| 1 | 55.3 | 58.5 | 59.6 | 57.6 | 56.7 | 58.8 | 57.7 | 49.1 | 58.1 | 61.8 | 55.7 | 56.5 | 56.6 | 59.6 | 57.9 | 54.5 |
| 2 | 64.8 | 72.8 | 72.2 | 73.7 | 68.0 | 72.7 | 68.4 | 60.8 | 70.8 | 75.7 | 71.6 | 71.7 | 67.8 | 73.6 | 70.8 | 69.0 |
| 3 | 70.6 | 79.4 | 77.4 | 82.0 | 75.1 | 78.0 | 77.2 | 70.4 | 75.0 | 81.4 | 77.5 | 79.7 | 73.5 | 79.5 | 77.4 | 77.8 |
| 4 | 74.3 | 81.6 | 81.5 | 86.7 | 77.4 | 81.3 | 79.2 | 75.3 | 77.6 | 83.5 | 76.0 | 86.5 | 76.4 | 82.1 | 79.2 | 82.7 |
| 5 | 75.2 | 82.5 | 79.7 | 86.7 | 78.3 | 81.8 | 83.6 | 77.3 | 76.6 | 81.6 | 71.3 | 89.8 | 76.6 | 82.0 | 78.6 | 83.6 |
| 6 | 73.8 | 79.0 | 79.6 | 84.4 | 80.0 | 83.5 | 84.7 | 78.4 | 79.1 | 83.9 | 76.3 | 93.6 | 77.5 | 82.0 | 80.3 | 82.8 |
| 7 | 73.0 | 79.9 | 80.6 | 83.0 | 77.1 | 81.1 | 83.4 | 80.1 | 78.8 | 81.5 | 76.6 | 94.6 | 76.2 | 80.8 | 80.4 | 82.7 |
| 8 | 73.1 | 82.5 | 76.6 | 80.3 | 74.5 | 81.8 | 82.2 | 83.7 | 78.4 | 82.6 | 79.3 | 93.4 | 75.3 | 82.3 | 79.1 | 82.3 |
| 9 | 73.1 | 80.0 | 74.2 | 80.2 | 75.1 | 83.0 | 83.4 | 84.1 | 77.4 | 80.6 | 80.3 | 89.7 | 75.1 | 81.2 | 78.9 | 82.1 |
| 10 | 71.4 | 76.3 | 75.1 | 78.9 | 72.6 | 80.3 | 81.0 | 82.7 | 77.2 | 80.4 | 79.4 | 90.2 | 73.6 | 78.8 | 78.2 | 80.9 |
| 11 | 71.5 | 74.5 | 72.5 | 76.3 | 71.1 | 79.7 | 79.0 | 81.3 | 76.5 | 78.1 | 80.3 | 82.3 | 73.0 | 77.3 | 76.8 | 78.4 |
| 12 | 69.6 | 71.4 | 69.9 | 74.3 | 70.1 | 75.2 | 73.7 | 79.1 | 75.4 | 76.7 | 75.8 | 76.8 | 71.6 | 74.2 | 72.8 | 76.1 |
| 13 | 67.8 | 71.6 | 68.0 | 72.7 | 69.0 | 72.6 | 75.5 | 78.2 | 69.8 | 75.1 | 72.0 | 83.0 | 68.8 | 73.0 | 71.5 | 75.2 |
| 14 | 66.8 | 70.2 | 64.5 | 71.3 | 67.7 | 70.5 | 74.4 | 73.1 | 65.2 | 74.4 | 72.1 | 69.0 | 66.6 | 71.5 | 69.8 | 71.8 |
| 15 | 65.3 | 69.0 | 63.4 | 69.5 | 66.9 | 70.3 | 71.2 | 70.9 | 65.5 | 72.3 | 65.4 | 64.6 | 65.9 | 70.4 | 66.5 | 69.7 |
| 16 | 63.8 | 67.0 | 64.4 | 66.1 | 64.1 | 68.8 | 69.7 | 73.2 | 63.7 | 71.2 | 67.4 | 63.7 | 63.9 | 68.8 | 66.9 | 68.5 |
| 17 | 61.2 | 65.7 | 63.0 | 65.6 | 63.6 | 66.6 | 68.8 | 71.0 | 61.8 | 68.5 | 65.5 | 56.8 | 62.2 | 66.8 | 65.6 | 67.0 |
| 18 | 60.6 | 65.5 | 62.6 | 63.7 | 63.3 | 66.2 | 66.7 | 70.1 | 58.3 | 65.6 | 62.9 | 61.1 | 60.7 | 65.8 | 64.0 | 65.8 |
| 19 | 60.2 | 62.7 | 61.6 | 62.2 | 61.4 | 63.8 | 66.4 | 69.0 | 58.3 | 64.3 | 61.7 | 56.3 | 60.0 | 63.5 | 63.2 | 64.3 |
| 20 | 60.1 | 60.5 | 59.9 | 58.4 | 60.9 | 63.3 | 64.4 | 68.4 | 58.6 | 63.4 | 57.0 | 56.5 | 59.9 | 62.3 | 60.5 | 61.8 |
| 21 | 57.0 | 56.8 | 57.3 | 56.9 | 58.2 | 61.9 | 63.0 | 66.2 | 57.9 | 61.0 | 56.6 | 54.0 | 57.7 | 59.7 | 58.9 | 60.0 |
| 22 | 55.2 | 56.2 | 55.3 | 54.8 | 57.6 | 61.0 | 61.3 | 63.0 | 56.3 | 60.2 | 54.4 | 52.1 | 56.3 | 59.0 | 57.0 | 57.5 |
| 23 | 54.7 | 55.7 | 55.4 | 52.8 | 56.4 | 60.7 | 57.3 | 64.0 | 54.9 | 59.4 | 53.4 | 53.1 | 55.3 | 58.5 | 55.4 | 56.8 |
| 24 | 52.7 | 53.5 | 53.2 | 51.2 | 55.3 | 59.1 | 56.4 | 61.6 | 54.0 | 60.0 | 51.7 | 50.4 | 54.0 | 57.3 | 53.8 | 54.8 |
| 25 | 52.4 | 51.2 | 50.7 | 49.8 | 53.6 | 57.0 | 54.5 | 59.2 | 52.0 | 58.4 | 51.4 | 48.2 | 52.7 | 55.3 | 52.1 | 53.0 |
| 26 | 50.7 | 49.3 | 49.3 | 49.0 | 52.6 | 54.0 | 52.1 | 56.0 | 51.0 | 56.7 | 50.4 | 49.1 | 51.4 | 53.1 | 50.5 | 51.5 |
| 27 | 49.0 | 47.9 | 46.2 | 48.6 | 51.2 | 53.4 | 49.8 | 54.2 | 50.0 | 55.6 | 49.2 | 44.3 | 50.0 | 52.0 | 48.2 | 50.3 |
| 28 | 48.0 | 46.5 | 45.2 | 46.5 | 51.8 | 52.6 | 47.9 | 53.2 | 49.1 | 55.4 | 47.1 | 42.7 | 49.6 | 51.2 | 46.6 | 48.6 |
| 29 | 47.3 | 45.2 | 44.4 | 44.3 | 50.1 | 51.2 | 47.0 | 52.8 | 48.3 | 54.3 | 44.8 | 42.1 | 48.5 | 49.9 | 45.3 | 47.2 |
| 30 | 45.6 | 43.7 | 42.8 | 44.1 | 49.4 | 49.7 | 45.2 | 53.1 | 47.2 | 52.7 | 44.1 | 40.6 | 47.3 | 48.4 | 43.9 | 47.1 |
| 31 | 44.3 | 42.0 | 40.9 | 41.9 | 46.9 | 48.5 | 44.6 | 53.4 | 46.9 | 52.0 | 45.6 | 37.4 | 46.0 | 47.1 | 43.4 | 45.7 |
| 32 | 43.3 | 39.3 | 39.2 | 40.8 | 46.4 | 47.6 | 42.4 | 52.7 | 44.8 | 50.7 | 44.4 | 32.1 | 44.8 | 45.4 | 41.7 | 44.5 |
| 33 | 41.2 | 36.5 | 37.6 | 39.7 | 45.0 | 45.8 | 40.0 | 51.0 | 43.6 | 49.7 | 42.9 | 26.2 | 43.2 | 43.5 | 39.9 | 42.9 |
| 34 | 39.2 | 34.8 | 35.6 | 38.4 | 42.7 | 44.1 | 38.7 | 48.9 | 41.1 | 48.9 | 40.6 | 24.0 | 40.9 | 42.1 | 38.0 | 41.3 |
| 35 | 38.1 | 33.9 | 33.6 | 37.6 | 41.4 | 42.6 | 38.1 | 44.9 | 38.3 | 47.2 | 38.2 | 26.8 | 39.2 | 40.7 | 36.3 | 39.5 |
| 36 | 35.4 | 32.6 | 32.3 | 35.9 | 38.2 | 40.5 | 35.7 | 39.7 | 35.9 | 44.4 | 35.4 | 27.0 | 36.5 | 38.7 | 34.3 | 36.7 |
| 37 | 33.1 | 31.9 | 31.0 | 35.0 | 35.5 | 38.8 | 33.8 | 36.7 | 33.3 | 42.1 | 34.1 | 24.8 | 33.9 | 37.2 | 32.8 | 35.0 |
| 38 | 31.2 | 29.6 | 28.4 | 33.6 | 32.8 | 36.4 | 31.2 | 32.8 | 30.0 | 40.6 | 32.5 | 27.8 | 31.3 | 35.1 | 30.4 | 33.0 |
| 39 | 29.6 | 28.0 | 26.4 | 31.3 | 29.3 | 35.0 | 30.9 | 30.2 | 26.3 | 37.1 | 30.3 | 27.9 | 28.4 | 33.0 | 28.9 | 30.7 |
| 40 | 28.0 | 26.3 | 24.2 | 29.7 | 25.9 | 31.9 | 29.1 | 27.4 | 23.2 | 30.8 | 26.6 | 27.2 | 25.8 | 29.5 | 26.4 | 28.7 |
| 41 | 25.6 | 23.5 | 22.6 | 27.1 | 21.9 | 29.2 | 25.3 | 22.6 | 19.4 | 27.9 | 24.9 | 27.0 | 22.4 | 26.7 | 24.1 | 25.5 |
| 42 | 23.4 | 20.8 | 20.7 | 25.6 | 18.0 | 26.6 | 22.1 | 17.8 | 15.5 | 25.3 | 23.0 | 24.6 | 19.1 | 24.1 | 21.8 | 22.8 |
| 43 | 21.6 | 18.6 | 18.3 | 24.6 | 15.4 | 21.4 | 18.2 | 14.8 | 12.4 | 22.3 | 21.2 | 21.4 | 16.6 | 20.6 | 19.2 | 21.0 |
| 44 | 19.0 | 16.2 | 15.7 | 23.2 | 12.6 | 17.6 | 14.4 | 12.7 | 10.2 | 19.9 | 20.1 | 18.1 | 14.1 | 17.8 | 16.5 | 19.2 |
| Average, 44 weeks | 52.7 | 53.9 | 52.5 | 55.4 | 54.1 | 57.8 | 56.1 | 57.8 | 53.3 | 59.4 | 54.3 | 53.8 | 53.3 | 56.8 | 54.2 | 56.1 |

*There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3. The average for 3 years is weighted. The average milk production, for each year, by weeks, includes all cows whether milking or dry during the first 44 weeks of lactation.

***Peak production.*** The average actual milk and 4% FCM produced during the peak week of production and the stage, by weeks, during which the highest production was achieved during the lactation are presented in table 15. In general, the weeks of peak production for both actual milk and 4% FGM were quite uniform among the different groups and fairly uniform for the individual cows for the 3 years, but the variations from cow to cow were large. The peak production for a week in actual milk and 4% FGM was higher in all groups on liberal grain during all 3 years when compared to the control, with one exception: group 4 in year 2 for 4% FCM production. During the 3 years, none of the cows in the control group reached an actual production of 100 pounds per day and 6 surpassed this mark for 4% FGM during the peak week. In group 2, 6 cows surpassed the 100-pound level for actual production and 13 cows surpassed this level on 4% FCM. In group 3 there were 5 cows above this level in actual production and 11 above it for 4% FCM. In group 4, one cow exceeded the 100-pound level for actual average production per day for a week and 2 individual cows exceeded this level on 4% FGM for the daily average production during the peak week.

***Total lactation production.*** The production of milk, milk fat, and 4% fat-corrected milk during a 44-week lactation of individual cows in all groups is given in table 16. The 3-year actual average milk production for the 44 weeks of lactation for groups 1 to 4, respectively, was 16,424, 17,508, 16,682, and 17,293 pounds. It should be recognized that group 2 averaged 17,813 and 18,307 pounds for years 2 and 3, respectively, after the level of grain feeding was adjusted to a more liberal allowance during mid- and late lactation.

The economic advantage or disadvantage of each system

Table 14. *Average daily 4% fat-corrected milk production, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | | Average 3 years | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | pounds | | | | | | | | | | | | | | | |
| 1 | 63.9 | 70.5 | 73.9 | 71.6 | 64.8 | 68.8 | 69.9 | 59.7 | 67.5 | 79.6 | 62.4 | 62.4 | 65.3 | 72.6 | 69.4 | 66.9 |
| 2 | 70.8 | 83.3 | 88.8 | 79.4 | 75.0 | 77.4 | 80.9 | 67.9 | 82.7 | 87.7 | 84.0 | 79.1 | 76.0 | 82.6 | 84.9 | 75.3 |
| 3 | 70.1 | 83.1 | 82.9 | 80.2 | 81.1 | 80.9 | 72.1 | 80.5 | 80.5 | 88.2 | 84.0 | 86.9 | 77.0 | 83.9 | 79.8 | 80.7 |
| 4 | 73.6 | 81.8 | 80.9 | 80.0 | 83.3 | 86.0 | 87.1 | 76.9 | 80.5 | 93.3 | 79.1 | 91.7 | 78.9 | 86.6 | 82.4 | 79.6 |
| 5 | 75.0 | 77.2 | 80.0 | 78.9 | 76.7 | 82.7 | 77.8 | 82.5 | 79.4 | 83.1 | 71.2 | 96.6 | 77.0 | 80.8 | 76.8 | 81.2 |
| 6 | 73.4 | 77.8 | 72.8 | 74.5 | 79.1 | 76.3 | 89.7 | 68.6 | 78.5 | 82.5 | 73.2 | 86.6 | 76.9 | 78.7 | 78.3 | 73.1 |
| 7 | 73.9 | 73.4 | 70.8 | 77.4 | 76.1 | 79.6 | 79.4 | 79.6 | 78.3 | 75.8 | 73.9 | 73.4 | 76.0 | 76.2 | 74.4 | 77.9 |
| 8 | 71.6 | 73.9 | 73.4 | 76.5 | 73.9 | 76.1 | 82.9 | 75.6 | 79.6 | 76.5 | 78.7 | 72.3 | 74.9 | 75.4 | 77.9 | 75.9 |
| 9 | 69.2 | 73.2 | 69.0 | 72.8 | 70.8 | 80.7 | 80.2 | 78.0 | 72.5 | 75.6 | 73.9 | 69.4 | 70.8 | 76.4 | 74.0 | 74.4 |
| 10 | 70.5 | 72.5 | 67.0 | 75.2 | 66.6 | 73.9 | 75.4 | 75.6 | 76.3 | 76.1 | 82.5 | 71.2 | 71.1 | 74.0 | 74.0 | 75.1 |
| 11 | 67.5 | 71.9 | 64.4 | 67.0 | 64.8 | 76.1 | 76.3 | 75.4 | 73.9 | 70.8 | 74.1 | 58.9 | 68.7 | 73.0 | 70.9 | 69.5 |
| 12 | 66.1 | 64.2 | 63.1 | 70.8 | 64.4 | 69.0 | 70.3 | 73.4 | 71.6 | 74.3 | 66.8 | 60.6 | 67.3 | 68.8 | 66.4 | 71.1 |
| 13 | 62.6 | 66.4 | 63.9 | 70.8 | 67.2 | 67.9 | 73.0 | 72.8 | 66.1 | 68.1 | 68.8 | 63.1 | 65.2 | 67.4 | 68.2 | 71.0 |
| 14 | 67.5 | 64.6 | 60.4 | 67.7 | 63.5 | 66.1 | 68.3 | 67.7 | 63.1 | 73.0 | 66.6 | 55.6 | 64.8 | 67.6 | 64.7 | 67.0 |
| 15 | 60.4 | 63.3 | 64.2 | 66.6 | 62.6 | 73.0 | 69.0 | 67.2 | 59.7 | 71.6 | 64.4 | 46.1 | 60.9 | 69.0 | 65.8 | 65.6 |
| 16 | 58.4 | 65.3 | 60.8 | 61.5 | 60.8 | 66.6 | 65.0 | 68.8 | 56.2 | 73.6 | 61.9 | 53.1 | 58.5 | 68.2 | 62.5 | 63.6 |
| 17 | 56.9 | 61.3 | 58.0 | 61.9 | 62.2 | 65.5 | 65.0 | 65.9 | 59.5 | 66.8 | 63.5 | 41.4 | 59.4 | 64.3 | 61.8 | 62.1 |
| 18 | 56.2 | 59.5 | 59.1 | 61.1 | 56.7 | 64.4 | 65.5 | 67.0 | 53.6 | 62.2 | 59.1 | 49.2 | 55.5 | 61.9 | 61.1 | 62.5 |
| 19 | 55.8 | 58.4 | 58.6 | 62.2 | 56.0 | 62.6 | 63.9 | 63.9 | 54.0 | 62.8 | 57.8 | 43.6 | 55.3 | 61.1 | 60.1 | 61.7 |
| 20 | 55.6 | 58.0 | 55.8 | 57.3 | 58.6 | 60.8 | 63.7 | 64.6 | 53.4 | 62.6 | 54.2 | 44.8 | 55.9 | 60.3 | 57.9 | 59.1 |
| 21 | 53.6 | 54.7 | 55.8 | 56.7 | 56.0 | 59.5 | 61.1 | 60.8 | 52.5 | 58.6 | 54.0 | 44.3 | 54.0 | 57.5 | 57.0 | 57.4 |
| 22 | 52.5 | 52.9 | 51.6 | 54.9 | 53.4 | 58.9 | 55.6 | 59.5 | 51.1 | 59.3 | 52.5 | 44.3 | 52.3 | 56.8 | 53.1 | 55.9 |
| 23 | 50.7 | 52.7 | 54.2 | 52.2 | 56.4 | 57.5 | 53.4 | 60.0 | 50.3 | 60.4 | 51.8 | 45.9 | 52.4 | 56.6 | 53.3 | 54.6 |
| 24 | 49.6 | 51.1 | 50.7 | 51.6 | 51.1 | 60.6 | 54.0 | 62.8 | 48.5 | 61.3 | 50.0 | 43.6 | 49.7 | 57.3 | 51.6 | 55.1 |
| 25 | 49.8 | 51.6 | 50.5 | 49.6 | 50.5 | 55.6 | 51.8 | 56.9 | 48.1 | 57.3 | 49.8 | 41.0 | 49.5 | 54.6 | 50.7 | 51.7 |
| 26 | 47.4 | 48.3 | 48.3 | 50.3 | 48.9 | 55.6 | 50.0 | 61.1 | 46.5 | 56.9 | 47.2 | 42.5 | 47.6 | 53.3 | 48.5 | 53.7 |
| 27 | 45.4 | 46.1 | 46.1 | 48.9 | 48.3 | 54.9 | 48.3 | 52.0 | 46.3 | 56.7 | 46.7 | 39.7 | 46.6 | 52.2 | 47.0 | 49.5 |
| 28 | 45.4 | 48.3 | 44.8 | 48.5 | 50.9 | 54.7 | 44.8 | 52.5 | 45.6 | 54.9 | 36.6 | 38.8 | 47.2 | 52.4 | 42.5 | 49.3 |
| 29 | 45.4 | 43.4 | 42.3 | 44.3 | 48.5 | 51.1 | 44.8 | 42.5 | 45.2 | 53.6 | 40.8 | 39.0 | 46.3 | 49.0 | 42.7 | 43.4 |
| 30 | 43.6 | 43.9 | 41.0 | 44.3 | 48.3 | 48.7 | 42.3 | 52.0 | 43.6 | 51.1 | 41.9 | 37.5 | 45.1 | 47.6 | 41.7 | 46.6 |
| 31 | 41.7 | 41.2 | 40.3 | 41.7 | 45.4 | 48.7 | 42.1 | 51.6 | 42.5 | 51.8 | 41.7 | 35.3 | 43.1 | 46.8 | 41.3 | 44.8 |
| 32 | 41.7 | 38.8 | 37.5 | 41.9 | 45.4 | 48.7 | 39.9 | 50.9 | 41.9 | 50.0 | 42.5 | 30.2 | 43.0 | 45.4 | 39.7 | 44.4 |
| 33 | 39.0 | 39.2 | 35.5 | 41.0 | 44.3 | 46.7 | 33.5 | 49.2 | 41.2 | 49.6 | 39.9 | 25.1 | 41.4 | 44.8 | 36.1 | 43.0 |
| 34 | 40.6 | 35.5 | 33.5 | 37.9 | 41.4 | 45.0 | 38.1 | 48.7 | 39.0 | 48.9 | 37.9 | 27.3 | 40.3 | 42.6 | 36.2 | 41.1 |
| 35 | 37.3 | 34.8 | 32.6 | 37.5 | 41.2 | 43.9 | 37.0 | 45.9 | 36.6 | 45.9 | 36.8 | 25.1 | 38.3 | 41.1 | 35.2 | 39.7 |
| 36 | 34.4 | 34.0 | 31.3 | 36.6 | 38.6 | 41.2 | 34.0 | 41.0 | 33.1 | 44.1 | 33.1 | 24.2 | 35.3 | 39.4 | 32.7 | 37.4 |
| 37 | 32.0 | 33.1 | 30.2 | 34.8 | 35.3 | 41.2 | 32.4 | 36.6 | 31.7 | 42.3 | 32.2 | 22.5 | 33.0 | 38.5 | 31.5 | 34.7 |
| 38 | 30.0 | 29.5 | 27.1 | 33.3 | 32.6 | 38.8 | 30.2 | 32.2 | 28.2 | 40.6 | 30.2 | 27.3 | 30.3 | 35.9 | 29.0 | 32.6 |
| 39 | 29.8 | 28.4 | 25.8 | 31.3 | 30.0 | 35.3 | 29.5 | 29.8 | 25.1 | 37.9 | 27.8 | 25.8 | 28.4 | 33.5 | 27.5 | 30.4 |
| 40 | 26.2 | 27.3 | 23.6 | 30.0 | 26.7 | 33.7 | 28.4 | 28.0 | 22.7 | 29.5 | 24.7 | 26.0 | 25.2 | 30.1 | 25.4 | 29.1 |
| 41 | 25.4 | 24.0 | 23.6 | 28.0 | 21.2 | 30.9 | 24.7 | 23.4 | 16.8 | 28.4 | 22.9 | 24.7 | 21.3 | 27.6 | 23.8 | 26.2 |
| 42 | 24.2 | 22.3 | 20.9 | 26.0 | 17.9 | 28.0 | 19.2 | 18.3 | 14.8 | 26.2 | 21.2 | 23.6 | 19.2 | 25.4 | 20.4 | 23.1 |
| 43 | 20.9 | 19.4 | 17.9 | 24.9 | 15.9 | 22.7 | 18.1 | 15.0 | 11.9 | 23.1 | 19.8 | 21.4 | 16.4 | 21.6 | 18.5 | 21.2 |
| 44 | 18.7 | 16.8 | 15.4 | 23.1 | 13.0 | 21.2 | 15.7 | 14.3 | 9.7 | 20.3 | 18.1 | 17.6 | 14.0 | 19.3 | 15.6 | 19.7 |
| Average, 44 weeks | 51.0 | 52.6 | 51.1 | 54.1 | 52.9 | 57.6 | 54.6 | 56.3 | 51.4 | 59.4 | 52.3 | 47.2 | 51.7 | 56.3 | 52.6 | 54.5 |

*There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3. The 3-year averages are weighted.

of feeding can be determined by a comparison of extra milk produced and feed consumed, as listed under *Total Feed Intakes*. For such a comparison it should be noted that the actual milk production of group 2 exceeded that of the control group by 1084 pounds. This was accomplished with 3031 pounds of extra grain intake and 1976 pounds less hay. Group 3 surpassed the controls by 258 pounds and group 4 had an average production advantage of 869 pounds, but the low survival rate cannot be overlooked when economic factors are evaluated. For group 3 the feeding of an extra 4766 pounds of grain substituted for 4099 pounds of hay plus 7226 pounds of silage resulted in an increase of only 258 pounds of milk during a 44-week lactation. The cows in group 4 consumed 21,971 pounds of corn silage and 6712 pounds of grain (6048 of grain mixture and 664 of soybean meal). The advantage of 869 pounds in milk production in 44 weeks must be reconciled by comparing the group 1 3-year-average feed intake of 6508 pounds of hay, 10,919 pounds of silage, and 3932 pounds of grain with 21,971 pounds of silage, 6048 pounds of grain, and 664 pounds soybean meal for group 4. The grain intake of group 4 exceeded the intake of group 1 by 2780 pounds per 44 weeks of lactation for the average of 3 years. Preferably actual calculations should be made individually by applying prevailing milk and feed prices, but it is obvious that the margins are small for groups 2 and 4, and group 3 is at a distinct disadvantage because at prevailing prices the cost of the extra grain does not balance against the value of extra milk produced and the value of the hay and silage for which the grain substituted. Whether cows fed high levels of grain produce more milk or gain body weight, including fattening, depends to a large extent on the genetic make-up of the individual cow and on the rate of concentrate feeding. This is discussed under *Body weight gains*. Reports by Balch *et al.* (1961), Huffman (1961), Brown *et al.* (1962), Kesler and

Table 15. *Peak week for actual and 4% fat-corrected milk production for individual cows*

*There were 15 cows in groups 1 and 3 during year 1; 14 in group 1 for years 2 and 3; and 13 and 12 in group 3 for years 2 and 3, respectively.

| Group | Cow | Peak production: Actual milk, Year 1 | Peak production: Actual milk, Year 2 | Peak production: Actual milk, Year 3 | Peak production: 4% FCM, Year 1 | Peak production: 4% FCM, Year 2 | Peak production: 4% FCM, Year 3 | Average daily for peak week: Actual milk, Year 1 | Average daily for peak week: Actual milk, Year 2 | Average daily for peak week: Actual milk, Year 3 | Average daily for peak week: 4% FCM, Year 1 | Average daily for peak week: 4% FCM, Year 2 | Average daily for peak week: 4% FCM, Year 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | no. | week | | | | | | pounds | | | | | |
| 1 Control | 233 | 4 | 6 | 6 | 2 | 3 | 2 | 89.9 | 89.7 | 79.6 | 101.9 | 93.7 | 93.5 |
| | 257 | 7 | 6 | 9 | 7 | 7 | 5 | 69.0 | 72.1 | 53.1 | 85.6 | 76.7 | 54.7 |
| | 283 | 8 | – | – | 7 | – | – | 67.7 | – | – | 74.7 | – | – |
| | 319 | 9 | 6 | 4 | 9 | 4 | 2 | 77.2 | 89.5 | 86.4 | 83.1 | 104.9 | 97.4 |
| | 323 | 13 | 9 | 12 | 13 | 4 | 14 | 81.8 | 89.1 | 82.7 | 85.1 | 111.1 | 79.8 |
| | 326 | 7 | 5 | 5 | 8 | 3 | 11 | 74.1 | 75.2 | 76.5 | 86.0 | 87.7 | 91.7 |
| | 556 | 3 | 5 | 5 | 4 | 6 | 7 | 90.6 | 83.8 | 89.5 | 79.8 | 92.4 | 107.8 |
| | 551 | 3 | 5 | 6 | 5 | 3 | 12 | 71.9 | 77.2 | 86.0 | 74.5 | 90.8 | 95.5 |
| | 360 | 5 | 4 | 4 | 1 | 2 | 4 | 80.5 | 79.4 | 85.3 | 80.2 | 84.7 | 102.1 |
| | 566 | 5 | 6 | 7 | 7 | 8 | 2 | 87.3 | 82.5 | 95.0 | 84.0 | 95.3 | 110.9 |
| Average | | 6.4 | 5.8 | 6.4 | 6.3 | 4.4 | 6.6 | 79.0 | 82.1 | 81.6 | 83.5 | 92.8 | 92.6 |
| 2 Liberal Grain | 215 | 5 | 6 | 6 | 4 | 8 | 11 | 92.6 | 102.3 | 102.3 | 86.9 | 91.5 | 96.1 |
| | 218 | 8 | – | – | 4 | – | – | 104.5 | – | – | 106.3 | – | – |
| | 241 | 3 | 5 | 3 | 6 | 4 | 5 | 87.7 | 75.4 | 76.5 | 108.7 | 66.1 | 85.8 |
| | 249 | 4 | 8 | – | 3 | 8 | – | 93.3 | 80.7 | – | 94.8 | 75.8 | – |
| | 304 | 3 | 6 | 4 | 2 | 5 | 4 | 78.0 | 72.8 | 92.4 | 82.0 | 72.5 | 100.1 |
| | 312 | 11 | 5 | 12 | 10 | 7 | 12 | 108.9 | 101.6 | 97.2 | 119.9 | 128.1 | 92.8 |
| | 325 | 5 | 4 | 4 | 4 | 3 | 4 | 92.8 | 104.9 | 91.7 | 105.6 | 97.2 | 117.9 |
| | 329 | 10 | 11 | 3 | 5 | 4 | 4 | 84.9 | 92.4 | 85.1 | 108.0 | 110.0 | 103.8 |
| | 337 | 4 | 7 | 6 | 1 | 4 | 4 | 76.1 | 90.4 | 88.0 | 75.0 | 118.2 | 88.2 |
| | 342 | 5 | 6 | 10 | 2 | 8 | 16 | 77.4 | 76.7 | 88.2 | 104.3 | 81.1 | 118.6 |
| Average | | 5.8 | 6.4 | 6.0 | 3.9 | 5.7 | 7.2 | 89.6 | 88.6 | 89.9 | 99.2 | 93.3 | 100.4 |
| 3 Restricted forage, liberal grain | 231 | 4 | 3 | 7 | 2 | 3 | 7 | 98.8 | 87.1 | 86.2 | 145.1 | 90.8 | 75.8 |
| | 239 | 4 | 5 | 20 | 2 | 3 | 3 | 73.0 | 69.0 | 51.1 | 76.3 | 72.1 | 47.6 |
| | 302 | 3 | – | – | 2 | – | – | 98.5 | – | – | 107.4 | – | – |
| | 305 | 6 | 10 | 11 | 4 | 6 | 4 | 101.0 | 104.9 | 89.1 | 103.6 | 144.8 | 96.1 |
| | 308 | 5 | 5 | 5 | 2 | 3 | 3 | 100.7 | 97.2 | 88.0 | 91.9 | 86.0 | 82.5 |
| | 309 | 6 | 9 | – | 5 | 7 | – | 81.5 | 81.1 | – | 93.0 | 88.8 | – |
| | 328 | 3 | 6 | 14 | 3 | 4 | 2 | 88.2 | 87.5 | 80.0 | 109.3 | 105.6 | 102.5 |
| | 335 | 4 | 8 | 8 | 3 | 4 | 7 | 75.6 | 89.9 | 102.1 | 88.8 | 100.3 | 119.9 |
| | 339 | 4 | – | – | 3 | – | – | 86.0 | – | – | 90.4 | – | – |
| | 344 | 10 | 5 | 6 | 8 | 2 | 8 | 69.4 | 97.2 | 101.6 | 76.7 | 123.0 | 131.4 |
| Average | | 4.9 | 6.4 | 10.1 | 3.4 | 4.0 | 4.9 | 87.0 | 89.2 | 85.4 | 98.0 | 101.4 | 93.7 |
| 4 All-corn silage, liberal rain | 210 | 3 | – | – | 2 | – | – | 98.8 | – | – | 106.7 | – | – |
| | 220 | 5 | 8 | – | 6 | 6 | – | 87.5 | 81.3 | – | 82.9 | 81.8 | – |
| | 223 | 6 | 9 | – | 10 | 12 | – | 89.1 | 86.2 | – | 117.9 | 93.7 | – |
| | 246 | 4 | – | – | 9 | – | – | 79.8 | – | – | 91.7 | – | – |
| | 247 | 4 | – | – | 3 | – | – | 93.9 | – | – | 99.4 | – | – |
| | 280 | 6 | 10 | 7 | 4 | 7 | 5 | 99.0 | 103.0 | 94.6 | 82.7 | 95.0 | 96.6 |
| | 310 | 5 | 8 | – | 12 | 5 | – | 89.7 | 82.9 | – | 92.6 | 83.8 | – |
| | 341 | 5 | 7 | – | 5 | 1 | – | 76.5 | 95.9 | – | 85.8 | 90.2 | – |
| | 343 | 7 | 15 | – | 12 | 15 | – | 87.1 | 80.0 | – | 89.9 | 95.9 | – |
| | 350 | 5 | – | – | 6 | – | – | 93.9 | – | – | 82.2 | – | – |
| Average | | 5.0 | 9.2 | 7.0 | 6.9 | 7.3 | 5.0 | 89.5 | 88.2 | 94.6 | 93.2 | 90.1 | 96.6 |
| 1 Control 5 additional young cows | 338 | 5 | 6 | 6 | 2 | 6 | 7 | 81.6 | 86.9 | 86.9 | 95.5 | 97.2 | 87.7 |
| | 370 | 4 | 7 | 5 | 5 | 7 | 9 | 56.0 | 67.9 | 71.2 | 54.0 | 69.4 | 81.1 |
| | 371 | 6 | 8 | 5 | 8 | 8 | 11 | 59.5 | 80.2 | 62.4 | 61.1 | 94.6 | 57.1 |
| | 380 | 6 | 4 | 5 | 5 | 5 | 6 | 62.8 | 71.0 | 56.9 | 63.3 | 85.5 | 58.0 |
| | 385 | 4 | 5 | 5 | 5 | 5 | 5 | 55.8 | 74.1 | 80.7 | 54.9 | 79.6 | 90.2 |
| 5-cow average | | 5.0 | 6.0 | 5.2 | 5.0 | 5.8 | 7.2 | 63.1 | 76.0 | 71.6 | 65.8 | 85.5 | 74.8 |
| 15-cow average* | | 5.9 | 5.9 | 6.0 | 5.9 | 4.9 | 6.8 | 73.7 | 79.9 | 78.0 | 77.4 | 90.1 | 86.2 |
| 3 Restricted forage, liberal grain 5 additional young cows | 362 | 4 | 10 | 2 | 5 | 4 | 2 | 90.2 | 93.0 | 88.8 | 92.6 | 102.3 | 102.1 |
| | 375 | 12 | 8 | 7 | 5 | 7 | 10 | 77.8 | 60.4 | 87.7 | 84.9 | 66.8 | 95.7 |
| | 376 | 8 | 5 | 6 | 9 | 1 | 6 | 47.6 | 64.4 | 61.9 | 41.2 | 79.4 | 57.3 |
| | 377 | 6 | 6 | 7 | 4 | 5 | 6 | 55.4 | 92.2 | 90.8 | 59.5 | 114.6 | 106.9 |
| | 381 | 9 | 4 | 6 | 8 | 2 | 2 | 59.3 | 89.1 | 84.0 | 58.6 | 98.8 | 85.5 |
| 5-cow average | | 7.8 | 6.6 | 5.6 | 6.2 | 3.4 | 5.2 | 65.7 | 79.8 | 82.6 | 67.4 | 92.4 | 89.5 |
| 15-cow average* | | 5.9 | 6.5 | 8.2 | 4.3 | 3.8 | 5.0 | 79.9 | 85.6 | 84.3 | 87.8 | 97.9 | 91.9 |

Spahr (1964), and Lassiter (1964) emphasize that cows with the proper genetic capability will respond to liberal concentrate feeding with increased milk production. The increase is attributed to greater intake of energy.

Charron (1961) reported that 91 percent of the cows responded to more grain and that the grain intake of some was as much as 44 pounds. Boyd *et al.* (1962) found no advantage in feeding grain *ad lib.* to cows of low production potential. Bloom *et al.* (1957) attached considerable

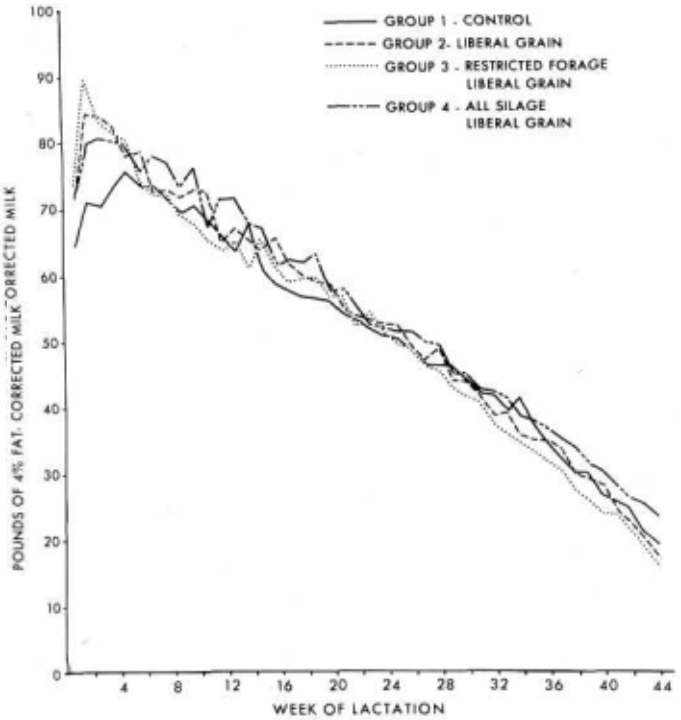


Figure 23. *Average daily 4 percent fat-corrected milk production, by weeks, year 1.*

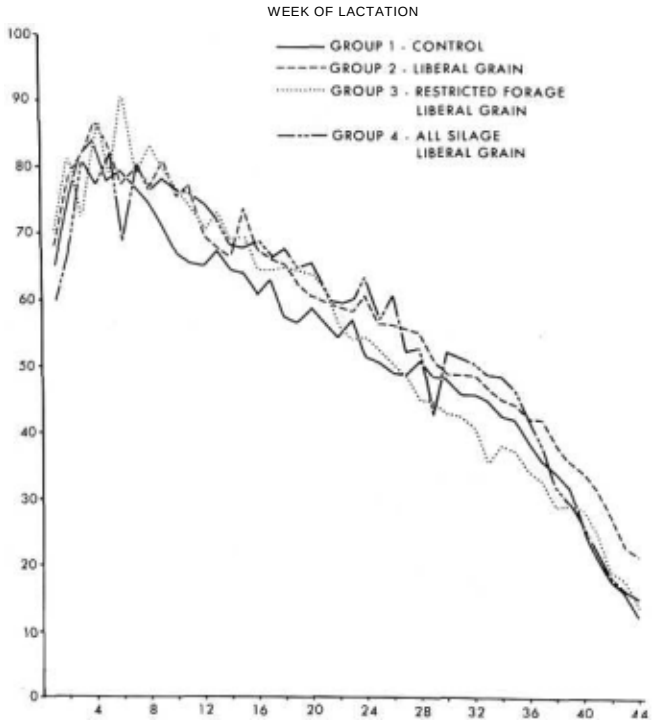


Figure 24. *Average daily 4 percent fat-corrected milk production,, by weeks, year 2.*

importance to ability (potential) and individuality of animals in the response achieved from liberal grain feeding. Thus, the practice of nearly *ad lib.* grain feeding usually

Table 16. *Production of milk, milk fat, and 4% fat-corrected milk for individual cows during 44-week lacatations*

| Group | Cow | Actual milk | | | | Milk fat | | | | 4% fat-corrected milk | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Year | | | Avg. | Year | | | Avg. | Year | | | Avg. |
| | | 1 | 2 | 3 | | 1 | 2 | 3 | | 1 | 2 | 3 | |
| | no. | pounds | | | | | | | | | | | |
| | 233 | 13938 | 17429 | 13727 | 15031 | 631 | 719 | 584 | 645 | 15000 | 17784 | 14246 | 15677 |
| | 257 | 14957 | 14208 | 11417 | 13527 | 631 | 584 | 470 | 562 | 15441 | 14409 | 11638 | 13829 |
| | 283 | 14413 | – | – | 14413 | 558 | – | – | 558 | 14164 | – | – | 14164 |
| | 319 | 17700 | 15859 | 17987 | 17182 | 631 | 591 | 624 | 615 | 16548 | 15176 | 16574 | 16099 |
| 1 | 323 | 18277 | 21188 | 19169 | 19545 | 666 | 816 | 692 | 725 | 17295 | 20648 | 18014 | 18652 |
| Control | 326 | 15431 | 16686 | 9676 | 13931 | 653 | 672 | 408 | 578 | 15924 | 16750 | 10009 | 14228 |
| | 336 | 17727 | 16869 | 19126 | 17907 | 617 | 617 | 666 | 633 | 16365 | 16058 | 17668 | 16697 |
| | 351 | 14104 | 13056 | 17681 | 14947 | 496 | 454 | 666 | 539 | 13038 | 12013 | 17063 | 14038 |
| | 360 | 16662 | 16545 | 18775 | 17327 | 624 | 659 | 719 | 667 | 16019 | 16486 | 18265 | 16923 |
| | 366 | 18990 | 18170 | 20100 | 19087 | 653 | 659 | 725 | 679 | 17383 | 17185 | 18931 | 17833 |
| Average | | 16220 | 16668 | 16406 | 16424 | 616 | 641 | 617 | 624 | 15718 | 16279 | 15823 | 15932 |
| | 215 | 15685 | 19872 | 18789 | 18115 | 509 | 734 | 686 | 643 | 13893 | 18911 | 17791 | 16865 |
| | 218 | 20704 | – | – | 20704 | 780 | – | – | 780 | 19963 | – | – | 19963 |
| | 241 | 17919 | 17361 | 15575 | 16953 | 679 | 666 | 639 | 661 | 17335 | 16920 | 15787 | 16681 |
| | 249 | 15331 | 16052 | – | 15692 | 571 | 591 | – | 581 | 14647 | 15298 | – | 14972 |
| 2 | 304 | 14089 | 15841 | 19984 | 16638 | 461 | 591 | 692 | 581 | 12568 | 15229 | 18340 | 15379 |
| Liberal grain | 312 | 22803 | 19130 | 20543 | 20825 | 985 | 862 | 822 | 890 | 23840 | 20567 | 20507 | 21638 |
| | 325 | 15102 | 16690 | 15154 | 15649 | 536 | 529 | 571 | 545 | 14090 | 14654 | 14605 | 14450 |
| | 329 | 16478 | 20590 | 17417 | 18162 | 767 | 937 | 787 | 830 | 18069 | 22244 | 18735 | 19683 |
| | 337 | 13323 | 18972 | 18229 | 16841 | 509 | 787 | 754 | 683 | 12921 | 19378 | 18565 | 16955 |
| | 342 | 14519 | 15811 | 20768 | 17033 | 597 | 686 | 917 | 733 | 14824 | 16603 | 22041 | 17823 |
| Average | | 16595 | 17813 | 18307 | 17508 | 639 | 709 | 734 | 690 | 16215 | 17756 | 18296 | 17345 |
| | 231 | 17136 | 15978 | 15478 | 16197 | 679 | 591 | 549 | 606 | 17050 | 15271 | 14403 | 15575 |
| | 239 | 15214 | 16247 | 12849 | 14770 | 564 | 604 | 421 | 530 | 14537 | 15379 | 11429 | 13782 |
| | 302 | 16404 | – | – | 16404 | 705 | – | – | 705 | 17158 | – | – | 17158 |
| 3 | 303 | 18480 | 19515 | 18333 | 18776 | 734 | 754 | 780 | 756 | 18353 | 19101 | 18862 | 18772 |
| Restricted forage, liberal grain | 308 | 17911 | 18809 | 18911 | 18544 | 617 | 624 | 639 | 627 | 16466 | 16914 | 17145 | 16842 |
| | 309 | 16226 | 16674 | – | 16450 | 659 | 699 | – | 679 | 16411 | 17145 | – | 16778 |
| | 328 | 18816 | 16205 | 15836 | 16952 | 679 | 679 | 666 | 675 | 17674 | 16479 | 16263 | 16805 |
| | 335 | 14043 | 17917 | 19679 | 17213 | 470 | 666 | 679 | 605 | 12676 | 17105 | 18062 | 15948 |
| | 339 | 14195 | – | – | 14195 | 522 | – | – | 522 | 13554 | – | – | 13554 |
| | 344 | 13351 | 16957 | 15893 | 15400 | 549 | 692 | 679 | 640 | 13554 | 17158 | 16561 | 15758 |
| Average | | 16178 | 17288 | 16711 | 16682 | 618 | 664 | 630 | 636 | 15743 | 16819 | 16104 | 16188 |
| | 210 | 21983 | – | – | 21983 | 829 | – | – | 829 | 21186 | – | – | 21186 |
| | 220 | 14615 | 15977 | – | 15296 | 584 | 653 | – | 618 | 14599 | 16146 | – | 15372 |
| | 223 | 18708 | 18406 | – | 18557 | 747 | 754 | – | 750 | 18686 | 18666 | – | 18676 |
| 4 | 246 | 12800 | – | – | 12800 | 578 | – | – | 578 | 13763 | – | – | 13763 |
| All-corn silage, liberal grain | 247 | 15954 | – | – | 15954 | 571 | – | – | 571 | 14932 | – | – | 14932 |
| | 280 | 16300 | 20872 | 16556 | 17909 | 536 | 705 | 529 | 590 | 14517 | 18937 | 14550 | 16001 |
| | 310 | 19410 | 13147 | – | 16278 | 754 | 522 | – | 638 | 19074 | 13119 | – | 16096 |
| | 341 | 15001 | 20561 | – | 17781 | 558 | 659 | – | 608 | 14321 | 17932 | – | 16126 |
| | 343 | 19075 | 17929 | – | 18502 | 836 | 816 | – | 826 | 20168 | 19209 | – | 19688 |
| | 350 | 16687 | – | – | 16687 | 591 | – | – | 591 | 15536 | – | – | 15536 |
| Average | | 17053 | 17815 | 16556 | 17293 | 658 | 685 | 529 | 660 | 16678 | 17335 | 14550 | 16785 |
| 1 | 338 | 16078 | 16016 | 16919 | 16338 | 712 | 705 | 705 | 707 | 17083 | 17024 | 17363 | 17157 |
| Control | 370 | 12281 | 13890 | 15353 | 13841 | 503 | 564 | 646 | 571 | 12399 | 14034 | 15774 | 14069 |
| 5 additional | 371 | 13240 | 14095 | 13502 | 13612 | 483 | 529 | 454 | 489 | 12513 | 13567 | 12262 | 12781 |
| young | 380 | 14140 | 16017 | 10738 | 13632 | 558 | 624 | 441 | 541 | 13968 | 15754 | 10897 | 13540 |
| cows | 385 | 12128 | 15360 | 16205 | 14564 | 476 | 624 | 653 | 584 | 12004 | 15556 | 16235 | 14598 |
| 5-cow average | | 13573 | 15076 | 14543 | 14397 | 546 | 609 | 580 | 578 | 13593 | 15187 | 14506 | 14429 |
| 15-cow average* | | 15338 | 16099 | 15741 | 15717 | 593 | 630 | 604 | 608 | 15010 | 15889 | 15353 | 15408 |
| 3 | 362 | 16179 | 18762 | 17478 | 17473 | 509 | 747 | 653 | 636 | 14076 | 18699 | 16737 | 16504 |
| Restricted | 375 | 19151 | 13703 | 19703 | 17519 | 692 | 516 | 734 | 647 | 18089 | 13172 | 18843 | 16701 |
| forage, | 376 | 9984 | 9300 | 9490 | 9591 | 326 | 353 | 306 | 328 | 8889 | 9030 | 8351 | 8757 |
| liberal grain | 377 | 12814 | 14088 | 15459 | 14120 | 503 | 604 | 646 | 584 | 12630 | 14713 | 15875 | 14406 |
| 5 additional young cows | 381 | 13818 | 18049 | 14269 | 15379 | 542 | 611 | 489 | 547 | 13668 | 16351 | 13016 | 14345 |
| 5-cow average | | 14389 | 14780 | 15280 | 14816 | 514 | 566 | 566 | 548 | 15470 | 14393 | 14564 | 14142 |
| 15-cow average* | | 15582 | 16323 | 16115 | 15983 | 583 | 626 | 603 | 603 | 14986 | 15886 | 15462 | 15421 |

*There were 15 cows in groups 1 and 3 during year 1; 14 in group 1 for years 2 and 3; and 13 and 12 in group 3 for years 2 and 3, respectively. The 3-year averages for groups are weighted.

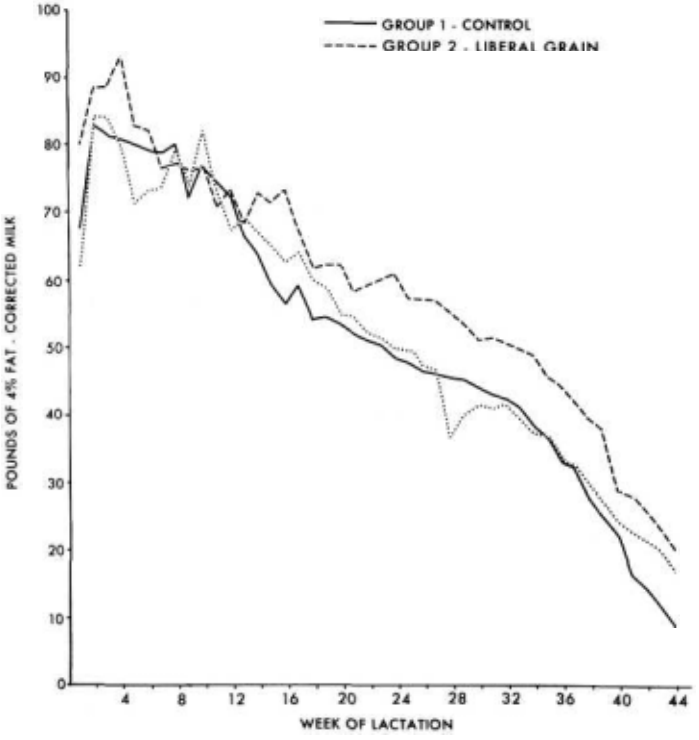


Figure 25. *Average daily 4 percent fat-corrected milk production, by weeks, year 3.*

can be justified only where attention is given to individual-cow production response.

## Milk Composition

*Percentage of milk fat, protein, and solids-not-fat.* The average percentage of milk fat, protein, and solids-not-fat was determined from a composite sample for each cow taken on 2 consecutive days each week. In table 17, results for milk fat are given, by weeks, for each group during years 1 to 3. Table 18 gives similar information for milk protein content, and table 19 for solids-not-fat.

Although group 3 had an average low test for several weeks during year 1, there were no differences at the end of the year (table 17). The 3.2 percent for group 4 represents only one cow with a characteristically low fat test. There are many individual differences in physiological response among cows, and apparently this one responded with depressed fat content in her milk because she was low on forage consumption (all-corn silage). No explanation is available for the uniformly lower averages in table 19 for all groups during year 3.

With the uniformity between groups in the averages for milk fat, protein, and solids-not-fat, it is easy to conclude that the rations had no effect on milk composition. The cows on liberal grain, allowed 8 pounds of hay and 12 pounds of silage per day, consumed enough forage to avoid a depression of milk fat.

Van Soest (1963) discussed in detail the mechanisms involved in fat reduction in milk and the physiological difference between the use of concentrates for fattening rations and those for lactation. Rook (1961), Boyd and Mathew (1962), Kesler and Spahr (1964), Swanson *et al.* (1967), Olson *et al* (1966) and McCaffree and Merrill (1968a) reported a milk fat depression from a high level of concentrate feeding, but Brown *et al.* (1962), Hooven and Plowman (1963), and Gardner (1969) reported that they found no change in milk composition from liberal grain rations. Elliot (1962) reported that fat-depressing rations do not depress protein or solids-not-fat, and occasionally may increase the content of these constituents.

Table 17. *Average percentage of milk fat, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4† |
| 1 | 5.0 | 5.4 | 5.0 | 5.6 | 5.0 | 5.1 | 5.4 | 5.4 | 5.1 | 5.9 | 4.9 | 4.7 |
| 2 | 4.6 | 5.0 | 5.6 | 4.5 | 4.7 | 4.4 | 5.5 | 4.8 | 5.1 | 5.1 | 5.2 | 4.7 |
| 3 | 4.0 | 4.3 | 4.5 | 3.9 | 4.5 | 4.3 | 5.8 | 5.0 | 4.5 | 4.6 | 4.6 | 4.6 |
| 4 | 3.9 | 4.0 | 3.9 | 3.5 | 4.5 | 4.4 | 4.7 | 4.1 | 4.3 | 4.9 | 4.3 | 4.4 |
| 5 | 4.0 | 3.6 | 4.0 | 3.4 | 3.6 | 4.1 | 3.5 | 4.4 | 4.2 | 4.1 | 4.0 | 4.5 |
| 6 | 4.0 | 3.9 | 3.4 | 3.2 | 3.9 | 3.5 | 4.4 | 3.4 | 3.9 | 3.9 | 3.7 | 3.5 |
| 7 | 4.0 | 3.5 | 3.2 | 3.5 | 3.9 | 3.9 | 3.7 | 4.0 | 4.0 | 3.5 | 3.8 | 2.5 |
| 8 | 3.7 | 3.7 | 3.7 | 3.7 | 3.9 | 3.5 | 4.0 | 3.4 | 4.1 | 3.5 | 3.9 | 2.5 |
| 9 | 3.6 | 3.4 | 3.5 | 3.4 | 3.6 | 3.8 | 3.8 | 3.5 | 3.6 | 3.6 | 3.5 | 2.5 |
| 10 | 3.9 | 3.9 | 3.3 | 3.7 | 3.5 | 3.5 | 3.5 | 3.4 | 3.9 | 3.6 | 4.3 | 2.6 |
| 11 | 3.6 | 3.8 | 3.2 | 3.2 | 3.4 | 3.7 | 3.8 | 3.5 | 3.8 | 3.4 | 3.5 | 2.1 |
| 12 | 3.7 | 3.3 | 3.4 | 3.7 | 3.4 | 3.5 | 3.7 | 3.5 | 3.7 | 3.8 | 3.2 | 2.6 |
| 13 | 3.5 | 3.5 | 3.6 | 3.8 | 3.8 | 3.6 | 3.8 | 3.5 | 3.6 | 3.4 | 3.7 | 2.4 |
| 14 | 4.1 | 3.5 | 3.6 | 3.7 | 3.6 | 3.6 | 3.5 | 3.5 | 3.8 | 3.9 | 3.5 | 2.7 |
| 15 | 3.5 | 3.4 | 4.1 | 3.7 | 3.6 | 4.2 | 3.8 | 3.7 | 3.4 | 3.9 | 3.9 | 2.1 |
| 16 | 3.4 | 3.8 | 3.6 | 3.5 | 3.7 | 3.8 | 3.6 | 3.6 | 3.2 | 4.2 | 3.5 | 2.9 |
| 17 | 3.5 | 3.6 | 3.5 | 3.6 | 3.9 | 3.9 | 3.6 | 3.5 | 3.8 | 3.8 | 3.8 | 2.2 |
| 18 | 3.5 | 3.4 | 3.6 | 3.7 | 3.3 | 3.8 | 3.9 | 3.7 | 3.5 | 3.6 | 3.6 | 2.7 |
| 19 | 3.5 | 3.6 | 3.7 | 4.0 | 3.4 | 3.9 | 3.8 | 3.5 | 3.5 | 3.8 | 3.6 | 2.5 |
| 20 | 3.5 | 3.7 | 3.5 | 3.9 | 3.8 | 3.7 | 3.9 | 3.6 | 3.4 | 3.9 | 3.7 | 2.6 |
| 21 | 3.6 | 3.8 | 3.8 | 4.0 | 3.8 | 3.7 | 3.8 | 3.5 | 3.4 | 3.7 | 3.7 | 2.8 |
| 22 | 3.7 | 3.6 | 3.5 | 4.0 | 3.5 | 3.8 | 3.4 | 3.6 | 3.4 | 3.9 | 3.8 | 3.0 |
| 23 | 3.5 | 3.6 | 3.9 | 3.9 | 4.0 | 3.7 | 3.5 | 3.6 | 3.4 | 3.9 | 3.8 | 3.1 |
| 24 | 3.6 | 3.7 | 3.7 | 4.1 | 3.5 | 4.2 | 3.7 | 4.1 | 3.3 | 4.1 | 3.8 | 3.1 |
| 25 | 3.7 | 4.0 | 4.0 | 4.0 | 3.6 | 3.8 | 3.7 | 3.7 | 3.5 | 3.9 | 3.8 | 3.0 |
| 26 | 3.6 | 3.8 | 3.9 | 4.2 | 3.5 | 4.2 | 3.7 | 4.6 | 3.4 | 4.0 | 3.6 | 3.1 |
| 27 | 3.5 | 3.7 | 4.0 | 4.0 | 3.6 | 4.2 | 3.8 | 3.7 | 3.5 | 4.1 | 3.7 | 3.3 |
| 28 | 3.7 | 4.3 | 3.9 | 4.3 | 3.9 | 4.3 | 3.6 | 3.9 | 3.5 | 3.9 | 2.9 | 3.4 |
| 29 | 3.7 | 3.7 | 3.7 | 4.0 | 3.8 | 4.0 | 3.7 | 3.2 | 3.6 | 3.9 | 3.4 | 3.5 |
| 30 | 3.7 | 4.0 | 3.7 | 4.0 | 3.9 | 3.9 | 3.6 | 3.9 | 3.5 | 3.8 | 3.7 | 3.5 |
| 31 | 3.6 | 3.9 | 3.9 | 4.0 | 3.8 | 4.0 | 3.6 | 3.8 | 3.4 | 4.0 | 3.4 | 3.6 |
| 32 | 3.8 | 3.9 | 3.7 | 4.2 | 3.9 | 4.1 | 3.6 | 3.8 | 3.6 | 3.9 | 3.7 | 3.6 |
| 33 | 3.7 | 4.5 | 3.6 | 4.2 | 3.9 | 4.1 | 3.3 | 3.8 | 3.6 | 4.0 | 3.5 | 3.7 |
| 34 | 4.2 | 4.2 | 3.6 | 3.9 | 3.8 | 4.1 | 3.9 | 4.0 | 3.7 | 4.0 | 3.6 | 4.9 |
| 35 | 3.8 | 4.2 | 3.8 | 4.0 | 4.0 | 4.2 | 3.8 | 4.1 | 3.7 | 3.8 | 3.7 | 3.6 |
| 36 | 3.8 | 4.3 | 3.8 | 4.1 | 4.1 | 4.1 | 3.7 | 4.2 | 3.5 | 4.0 | 3.6 | 3.3 |
| 37 | 3.8 | 4.2 | 3.8 | 3.9 | 4.0 | 4.4 | 3.7 | 4.0 | 3.7 | 4.0 | 3.6 | 3.4 |
| 38 | 3.7 | 4.0 | 3.7 | 3.9 | 3.9 | 4.4 | 3.8 | 3.9 | 3.6 | 4.0 | 3.6 | 3.9 |
| 39 | 4.0 | 4.1 | 3.8 | 4.0 | 4.1 | 4.1 | 3.7 | 3.9 | 3.7 | 4.2 | 3.4 | 3.5 |
| 40 | 3.6 | 4.3 | 3.9 | 4.1 | 4.2 | 4.4 | 3.9 | 4.2 | 3.8 | 3.8 | 3.5 | 3.7 |
| 41 | 3.9 | 4.2 | 4.3 | 4.2 | 3.9 | 4.4 | 3.9 | 4.2 | 3.3 | 4.1 | 3.5 | 3.4 |
| 42 | 4.2 | 4.5 | 4.1 | 4.1 | 3.9 | 4.3 | 3.4 | 4.2 | 3.7 | 4.2 | 3.5 | 3.7 |
| 43 | 3.8 | 4.3 | 3.9 | 4.1 | 4.2 | 4.4 | 4.0 | 4.1 | 3.7 | 4.3 | 3.6 | 4.0 |
| 44 | 3.9 | 4.2 | 3.9 | 3.9 | 4.2 | 5.4 | 3.7 | 4.9 | 3.7 | 4.1 | 3.3 | 3.8 |
| Average, 44 weeks | 3.8 | 3.9 | 3.8 | 3.9 | 3.9 | 4.0 | 3.8 | 3.8 | 3.8 | 4.0 | 3.8 | 3.2 |

*There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3. Tests represent results from a composite sample for each cow taken 2 successive days each week.

†One cow in group 4 during year 3 characteristically had a low fat test.

Table 18. *Average percentage of milk protein, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | percent | | | | | | | | | | | |
| 1 | 4.0 | 4.1 | 4.0 | 3.8 | 3.6 | 4.1 | 3.4 | 4.0 | 3.9 | 3.9 | 4.2 | 4.5 |
| 2 | 3.5 | 3.6 | 3.4 | 3.4 | 3.6 | 3.3 | 3.3 | 3.3 | 3.4 | 3.4 | 3.5 | 3.5 |
| 3 | 3.1 | 3.3 | 3.2 | 3.2 | 3.2 | 3.2 | 3.3 | 3.0 | 3.0 | 3.1 | 3.2 | 3.5 |
| 4 | 2.9 | 3.1 | 3.1 | 3.2 | 3.2 | 3.1 | 3.0 | 3.2 | 2.8 | 2.9 | 2.8 | 3.5 |
| 5 | 2.9 | 3.0 | 3.0 | 3.3 | 3.2 | 3.0 | 3.3 | 3.2 | 2.8 | 2.8 | 3.0 | 2.7 |
| 6 | 3.0 | 3.2 | 3.1 | 3.1 | 2.9 | 2.9 | 3.2 | 2.8 | 2.7 | 2.8 | 2.8 | 3.0 |
| 7 | 2.7 | 3.1 | 3.0 | 3.1 | 2.9 | 3.2 | 3.1 | 3.0 | 2.7 | 2.9 | 2.8 | 2.8 |
| 8 | 2.8 | 3.1 | 3.0 | 3.2 | 3.0 | 3.1 | 2.9 | 3.0 | 2.7 | 3.1 | 2.8 | 3.2 |
| 9 | 2.9 | 3.1 | 3.1 | 3.0 | 3.0 | 3.2 | 3.3 | 3.0 | 2.7 | 3.0 | 2.8 | 2.7 |
| 10 | 3.0 | 3.1 | 3.1 | 2.9 | 3.0 | 3.0 | 3.2 | 3.1 | 2.7 | 3.1 | 2.8 | 2.9 |
| 11 | 3.0 | 3.1 | 3.1 | 3.0 | 3.0 | 3.1 | 3.2 | 3.0 | 2.7 | 3.1 | 2.9 | 2.6 |
| 12 | 2.9 | 3.1 | 3.0 | 3.1 | 3.1 | 3.2 | 3.1 | 3.3 | 2.8 | 3.0 | 2.9 | 3.0 |
| 13 | 3.0 | 3.1 | 3.1 | 3.2 | 3.1 | 3.2 | 3.2 | 3.2 | 2.8 | 3.1 | 2.9 | 3.0 |
| 14 | 3.1 | 3.1 | 3.1 | 3.2 | 3.0 | 3.2 | 3.1 | 3.3 | 3.0 | 3.1 | 2.9 | 3.0 |
| 15 | 3.0 | 3.1 | 3.0 | 3.2 | 3.4 | 3.1 | 3.1 | 3.1 | 3.0 | 3.2 | 3.0 | 3.3 |
| 16 | 3.1 | 3.1 | 3.1 | 3.3 | 3.2 | 3.2 | 3.1 | 3.3 | 2.9 | 3.2 | 3.1 | 3.2 |
| 17 | 3.1 | 3.1 | 3.1 | 3.4 | 3.1 | 3.3 | 3.2 | 3.3 | 2.9 | 3.2 | 3.1 | 3.3 |
| 18 | 3.1 | 3.1 | 3.1 | 3.2 | 3.3 | 3.3 | 3.2 | 3.4 | 3.0 | 3.2 | 3.3 | 3.2 |
| 19 | 3.0 | 3.3 | 3.2 | 3.2 | 3.2 | 3.3 | 3.3 | 3.3 | 3.0 | 3.2 | 3.1 | 3.0 |
| 20 | 3.1 | 3.2 | 3.2 | 3.3 | 3.3 | 3.4 | 3.3 | 3.2 | 3.1 | 3.2 | 3.1 | 3.1 |
| 21 | 3.2 | 3.2 | 3.2 | 3.3 | 3.3 | 3.0 | 3.3 | 3.2 | 3.0 | 3.2 | 3.1 | 3.3 |
| 22 | 3.2 | 3.3 | 3.2 | 3.4 | 3.3 | 3.4 | 3.3 | 3.4 | 3.1 | 3.2 | 3.1 | 3.3 |
| 23 | 3.2 | 3.4 | 3.3 | 3.3 | 3.4 | 3.4 | 3.3 | 3.3 | 3.0 | 3.3 | 3.1 | 3.1 |
| 24 | 3.2 | 3.3 | 3.2 | 2.8 | 3.2 | 3.3 | 3.3 | 3.4 | 3.0 | 3.2 | 3.1 | 3.0 |
| 25 | 3.3 | 3.3 | 3.1 | 3.4 | 3.2 | 3.3 | 3.2 | 3.4 | 3.0 | 3.2 | 3.1 | 3.2 |
| 26 | 3.2 | 3.3 | 3.1 | 3.3 | 3.3 | 3.3 | 3.1 | 3.3 | 3.0 | 3.3 | 3.0 | 3.0 |
| 27 | 3.3 | 3.3 | 3.1 | 3.4 | 3.3 | 3.3 | 3.2 | 3.4 | 3.1 | 3.3 | 3.1 | 3.3 |
| 28 | 3.3 | 3.4 | 3.3 | 3.3 | 3.2 | 3.3 | 3.2 | 3.4 | 3.1 | 3.3 | 3.1 | 3.4 |
| 29 | 3.2 | 3.3 | 3.3 | 3.4 | 3.0 | 3.3 | 3.3 | 3.4 | 3.1 | 3.3 | 3.0 | 3.2 |
| 30 | 3.2 | 3.3 | 3.3 | 3.4 | 3.2 | 3.6 | 3.2 | 3.4 | 3.2 | 3.4 | 3.2 | 3.2 |
| 31 | 3.1 | 3.2 | 3.3 | 3.3 | 3.3 | 3.6 | 3.2 | 3.4 | 3.2 | 3.4 | 3.3 | 3.4 |
| 32 | 3.3 | 3.5 | 3.4 | 3.4 | 3.4 | 3.6 | 3.3 | 3.5 | 3.2 | 3.4 | 3.3 | 3.4 |
| 33 | 3.5 | 3.6 | 3.4 | 3.4 | 3.3 | 3.6 | 3.2 | 3.4 | 3.2 | 3.4 | 3.2 | 3.3 |
| 34 | 3.5 | 3.5 | 3.6 | 3.4 | 3.4 | 3.6 | 3.3 | 3.5 | 3.3 | 3.4 | 3.3 | 3.3 |
| 35 | 3.5 | 3.5 | 3.3 | 3.4 | 3.4 | 3.7 | 3.3 | 3.6 | 3.3 | 3.4 | 3.3 | 3.3 |
| 36 | 3.3 | 3.6 | 3.4 | 3.3 | 3.5 | 3.8 | 3.3 | 3.7 | 3.3 | 3.4 | 3.3 | 3.4 |
| 37 | 3.5 | 3.7 | 3.5 | 3.5 | 3.6 | 3.8 | 3.4 | 3.8 | 3.4 | 3.5 | 3.3 | 3.3 |
| 38 | 3.5 | 3.6 | 3.4 | 3.3 | 3.7 | 3.8 | 3.6 | 3.7 | 3.5 | 3.0 | 3.4 | 3.1 |
| 39 | 3.5 | 3.8 | 3.5 | 3.4 | 3.8 | 3.7 | 3.5 | 3.8 | 3.5 | 3.6 | 3.4 | 3.3 |
| 40 | 3.5 | 3.8 | 3.6 | 3.6 | 3.4 | 3.8 | 3.6 | 3.8 | 3.6 | 3.4 | 3.4 | 3.2 |
| 41 | 3.6 | 3.7 | 3.7 | 3.6 | 3.7 | 3.9 | 3.5 | 4.0 | 3.5 | 3.6 | 3.4 | 3.4 |
| 42 | 3.4 | 4.0 | 3.9 | 3.7 | 3.5 | 4.0 | 3.7 | 3.7 | 3.5 | 3.6 | 3.4 | 3.4 |
| 43 | 3.4 | 3.8 | 3.6 | 3.7 | 3.9 | 3.9 | 3.9 | 3.8 | 3.6 | 3.8 | 3.5 | 3.6 |
| 44 | 3.4 | 3.5 | 4.0 | 2.9 | 3.9 | 3.8 | 4.0 | 3.6 | 3.7 | 2.8 | 3.5 | 3.7 |
| Average, 44 weeks | 3.2 | 3.3 | 3.2 | 3.3 | 3.2 | 3.4 | 3.2 | 3.3 | 3.0 | 3.2 | 3.1 | 3.2 |

*Tests represent results from a composite sample for each cow taken 2 days each week. There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3.

Table 19. *Average percentage of solids-not-fat, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | percent | | | | | | | | | | | |
| 1 | 9.6 | 9.5 | 9.7 | 9.7 | 9.2 | 9.8 | 8.7 | 10.3 | 9.1 | 9.3 | 9.4 | 11.1 |
| 2 | 8.9 | 9.2 | 8.9 | 8.7 | 9.0 | 9.0 | 8.9 | 8.9 | 8.6 | 8.7 | 8.7 | 8.7 |
| 3 | 8.4 | 8.7 | 8.9 | 8.7 | 8.7 | 8.8 | 8.6 | 8.6 | 8.5 | 8.6 | 8.6 | 8.5 |
| 4 | 8.5 | 8.5 | 8.8 | 8.7 | 8.6 | 8.8 | 8.7 | 8.6 | 8.3 | 8.4 | 8.4 | 8.5 |
| 5 | 8.5 | 8.5 | 8.7 | 8.6 | 8.6 | 8.8 | 8.6 | 8.7 | 8.2 | 8.5 | 8.7 | 8.5 |
| 6 | 8.3 | 8.5 | 8.6 | 8.6 | 8.5 | 8.5 | 8.8 | 8.7 | 8.3 | 8.5 | 8.3 | 8.1 |
| 7 | 8.4 | 8.6 | 9.1 | 8.7 | 8.4 | 8.8 | 8.8 | 8.9 | 8.1 | 8.5 | 8.4 | 8.0 |
| 8 | 8.5 | 8.5 | 8.8 | 8.7 | 8.6 | 8.8 | 8.7 | 8.6 | 8.1 | 8.4 | 8.3 | 8.2 |
| 9 | 8.5 | 8.7 | 8.6 | 8.6 | 8.5 | 8.8 | 8.9 | 8.7 | 8.0 | 8.5 | 8.2 | 8.1 |
| 10 | 8.5 | 8.7 | 8.7 | 8.7 | 8.5 | 8.7 | 8.7 | 8.7 | 8.0 | 8.3 | 8.2 | 8.2 |
| 11 | 8.5 | 8.7 | 8.6 | 8.7 | 8.5 | 8.7 | 8.7 | 8.7 | 8.1 | 8.4 | 8.4 | 8.0 |
| 12 | 8.3 | 8.7 | 8.7 | 8.7 | 8.6 | 8.8 | 8.7 | 8.7 | 8.0 | 8.3 | 8.2 | 8.1 |
| 13 | 8.4 | 8.8 | 8.7 | 8.8 | 8.5 | 8.8 | 8.7 | 9.1 | 8.0 | 8.2 | 8.3 | 8.0 |
| 14 | 8.8 | 8.8 | 8.5 | 8.8 | 8.4 | 8.6 | 8.6 | 8.8 | 8.3 | 8.4 | 8.2 | 8.0 |
| 15 | 8.4 | 8.7 | 8.7 | 8.8 | 8.5 | 8.8 | 8.6 | 8.7 | 8.2 | 8.2 | 7.8 | 7.9 |
| 16 | 8.5 | 8.8 | 8.7 | 8.8 | 8.4 | 8.8 | 8.7 | 8.6 | 8.1 | 8.5 | 8.1 | 8.0 |
| 17 | 8.5 | 8.7 | 8.6 | 8.8 | 8.6 | 8.8 | 8.7 | 8.6 | 8.0 | 8.7 | 8.6 | 8.0 |
| 18 | 8.4 | 8.7 | 8.7 | 8.8 | 8.5 | 8.8 | 8.6 | 8.7 | 8.0 | 8.3 | 8.6 | 8.1 |
| 19 | 8.5 | 8.7 | 8.8 | 8.6 | 8.4 | 8.9 | 8.6 | 8.6 | 7.7 | 8.4 | 8.3 | 8.0 |
| 20 | 8.5 | 8.6 | 8.7 | 8.8 | 8.4 | 8.8 | 8.7 | 8.7 | 8.0 | 8.2 | 7.9 | 7.9 |
| 21 | 8.6 | 8.6 | 8.5 | 8.7 | 8.4 | 8.8 | 8.6 | 8.6 | 7.5 | 8.3 | 7.6 | 8.0 |
| 22 | 8.5 | 8.7 | 8.7 | 8.8 | 8.5 | 8.7 | 8.5 | 8.7 | 8.4 | 8.2 | 7.5 | 8.0 |
| 23 | 8.5 | 8.6 | 8.6 | 8.8 | 8.4 | 8.8 | 8.4 | 8.7 | 8.4 | 7.8 | 7.6 | 7.8 |
| 24 | 8.6 | 8.7 | 8.6 | 8.7 | 8.4 | 8.8 | 8.5 | 8.9 | 8.5 | 8.1 | 7.8 | 7.7 |
| 25 | 8.8 | 8.7 | 8.7 | 8.7 | 8.4 | 8.7 | 8.5 | 8.6 | 8.5 | 8.1 | 7.5 | 7.8 |
| 26 | 8.5 | 8.6 | 8.6 | 8.8 | 8.4 | 8.7 | 8.4 | 8.8 | 8.1 | 8.1 | 7.8 | 7.7 |
| 27 | 8.4 | 8.8 | 8.6 | 8.6 | 8.5 | 8.6 | 8.4 | 8.7 | 8.5 | 8.0 | 7.8 | 7.8 |
| 28 | 8.6 | 8.6 | 8.7 | 8.9 | 8.5 | 8.7 | 8.4 | 8.6 | 8.2 | 8.0 | 7.7 | 7.7 |
| 29 | 8.6 | 8.7 | 8.7 | 8.7 | 8.4 | 8.8 | 8.5 | 8.6 | 8.2 | 7.7 | 7.5 | 7.7 |
| 30 | 8.5 | 8.8 | 8.6 | 8.7 | 8.5 | 8.6 | 8.5 | 8.6 | 7.8 | 8.0 | 7.7 | 7.6 |
| 31 | 8.4 | 8.7 | 8.7 | 8.7 | 8.4 | 8.6 | 8.4 | 8.4 | 8.3 | 8.0 | 7.5 | 7.9 |
| 32 | 8.6 | 8.7 | 8.7 | 8.8 | 8.5 | 8.7 | 8.2 | 8.6 | 8.6 | 7.9 | 7.6 | 7.5 |
| 33 | 8.6 | 8.8 | 8.6 | 8.6 | 8.5 | 9.0 | 8.3 | 8.8 | 8.3 | 7.8 | 7.4 | 7.5 |
| 34 | 8.8 | 8.8 | 8.8 | 8.8 | 8.6 | 8.8 | 8.4 | 8.7 | 8.4 | 7.6 | 6.8 | 7.7 |
| 35 | 8.8 | 8.7 | 8.7 | 8.7 | 8.7 | 8.8 | 8.8 | 8.8 | 8.0 | 7.6 | 8.1 | 7.4 |
| 36 | 8.7 | 8.9 | 8.9 | 8.7 | 8.8 | 8.9 | 8.4 | 9.0 | 7.8 | 7.9 | 7.7 | 7.5 |
| 37 | 8.6 | 8.8 | 8.8 | 8.7 | 8.6 | 8.9 | 8.5 | 8.9 | 7.4 | 8.0 | 8.9 | 7.5 |
| 38 | 8.7 | 8.9 | 8.8 | 8.5 | 8.7 | 8.8 | 9.0 | 8.6 | 7.3 | 7.6 | 9.1 | 7.5 |
| 39 | 8.8 | 9.0 | 8.8 | 8.7 | 8.7 | 8.9 | 8.6 | 8.9 | 7.8 | 7.9 | 10.2 | 7.5 |
| 40 | 9.1 | 9.1 | 8.7 | 8.8 | 8.6 | 9.0 | 8.6 | 9.1 | 8.4 | 8.5 | 8.9 | 7.8 |
| 41 | 8.9 | 8.9 | 8.7 | 8.6 | 8.5 | 8.9 | 8.6 | 9.0 | 7.6 | 8.0 | 9.2 | 7.9 |
| 42 | 9.0 | 9.2 | 8.8 | 8.8 | 8.6 | 9.0 | 8.9 | 9.2 | 7.5 | 7.7 | 12.2 | 7.8 |
| 43 | 8.8 | 8.8 | 8.8 | 8.8 | 8.5 | 9.1 | 8.9 | 8.8 | 7.5 | 7.7 | 8.9 | 8.2 |
| 44 | 8.9 | 7.9 | 8.8 | 7.6 | 8.7 | 8.8 | 8.8 | 9.3 | 8.3 | 7.5 | 9.0 | 8.1 |
| Average, 44 weeks | 8.6 | 8.7 | 8.7 | 8.7 | 8.6 | 8.8 | 8.6 | 8.8 | 8.3 | 8.2 | 8.2 | 8.1 |

*Tests represent results from a composite sample for each cow taken 2 days each week. There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3.

## Milk Flavor Studies

As has been pointed out in two review articles by Shipe (1964a, b), feed may affect the flavor of milk. Therefore, milk flavor was evaluated in this study to determine whether these particular rations affected flavor. Special attention was given to variations in the oxidative stability of milk since several workers had reported that this depended partly on rations.

*Effect of ration on flavor.* The resistance of milk to oxidation decreased as the relative amount of grain in the ration was increased. As is shown in table 20, oxidized flavor was more common in the milks produced on liberal grain (group 2) and on restricted forage, liberal grain (group 3) rations than on the control ration (group 1). Parsons *et al.* (1970) reported that the incidence of oxidized flavor appears to be related to high grain-limited forage diets. Increased grain feeding increased the incidence of oxidized flavor in general and not from any specific treatment. The milk from the cows on the all-corn-silage, liberal-grain ration (group 4) showed about

Table 20. *Effect of ration on incidence of oxidized flavor**

| Group | Ration | Lactation† | | | |
|---|---|---|---|---|---|
| | | Year 1 | Year 2 | Year 3 | Average 3 years |
| | | percent | | | |
| 1 | Control | 22 | 25 | 38 | 28 |
| 2 | Liberal grain | 48 | 37 | 40 | 42 |
| 3 | Restricted forage, liberal grain | 40 | 45 | 55 | 47 |
| 4 | All silage, liberal grain | 26 | 19 | – | – |
| 1 | Control (young cows)†† | 36 | 26 | 34 | 32 |
| 3 | Restricted forage, liberal grain | 59 | 44 | 53 | 52 |

*Values represent percentage of samples oxidized after 7 days' storage at 41°F (5°C). Samples were taken from milkings Monday evenings and Tuesday mornings, and laboratory-pasteurized on Tuesday mornings.

†Each group started with 10 cows in second lactation or above. Data were not sufficient to calculate meaningful values for either third lactation year or for average in group 4.

††Five additional cows in groups 1 and 3; 4 in each group were first-calf heifers and other started with her second lactation.

the same susceptibility to oxidized flavor as the control milk, but the milk from group 4 had a higher incidence of feedy flavor than that from any of the other rations.

***Effect of stage of lactation on flavor.*** The highest frequency of oxidized flavor was observed in the early stage of lactation when the grain intake was maximum. The stage-of-lactation effect varied with the ration; it was most pronounced for control group 1 and least pronounced for group 3 on restricted forage and liberal grain, with a base of 15 pounds of grain for forage replacement. We attribute this phenomenon to the fact that the grain intake was more variable for group 1 than for group 3. The resistance of milk to oxidation was essentially the same throughout all 3 lactation periods.

***Individual cow variations.*** The resistance of milk from first-calf heifers was not significantly different from that produced by older cows on the same rations. Different cows responded differently to the four rations. For example, 95 percent of the samples from one cow became oxidized, as compared to only 39 percent of the samples from another cow on the same ration.

The potential off-flavor effects of certain rations were made apparent by this study, which indicated that the incidence of oxidized flavor increases as the ratio of grain to roughage increases. Therefore, if such rations are fed, special handling will be necessary, or additives (where legal) can be used to protect the milk quality. Similarly, to prevent feedy flavor, special precautions should be taken when feeding high levels of corn silage. Feeding silage after, rather than before, milking eliminates most of this problem.

## Body Weights and Gains or Losses

***Body weights.*** The average body weights of the cows in all 4 groups are given in table 21. The average weights during the 44-week lactation period for groups 1 to 4 in year 1 were 1366, 1350, 1369, and 1397 pounds, respectively. In year 2 the averages were 1440, 1442, 1401, and 1408 pounds, respectively. For year 3 the averages listed in the same order were 1462, 1486, 1432 and 1496 pounds. During the last two years of the experiment, the cows in group 3 (restricted forage with liberal grain plus a base allowance of 15 pounds of grain per day for forage replacement) had the lowest average weight during the 44-week lactation period but the highest during the 4-weeks dry period preceding the next calving. The cows in group 4, at an average weight of approximately 1600, had the lowest body weight of all groups in the month preceding the second calving at the start of year 2. Thus, as shown later, these cows were in good condition but were not excessively fat when this group ran into trouble.

Table 21. *Average body weight, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | pounds | | | | | | | | | | | |
| −4 | 1563 | 1580 | 1607 | 1492 | 1601 | 1595 | 1651 | 1595 | 1678 | 1681 | 1710 | 1670 |
| −3 | 1521 | 1590 | 1600 | 1537 | 1621 | 1589 | 1684 | 1611 | 1689 | 1702 | 1756 | 1660 |
| −2 | 1521 | 1593 | 1602 | 1537 | 1646 | 1597 | 1679 | 1567 | 1724 | 1706 | 1751 | 1680 |
| −1 | 1495 | 1551 | 1601 | 1548 | 1650 | 1624 | 1691 | 1603 | 1718 | 1677 | 1741 | 1680 |
| 1 | 1378 | 1415 | 1409 | 1420 | 1471 | 1414 | 1528 | 1398 | 1515 | 1498 | 1493 | 1500 |
| 2 | 1338 | 1361 | 1370 | 1376 | 1420 | 1391 | 1461 | 1388 | 1453 | 1473 | 1443 | 1460 |
| 3 | 1328 | 1354 | 1348 | 1358 | 1403 | 1390 | 1403 | 1362 | 1432 | 1425 | 1396 | 1445 |
| 4 | 1328 | 1346 | 1353 | 1354 | 1381 | 1368 | 1412 | 1327 | 1411 | 1393 | 1394 | 1410 |
| 5 | 1305 | 1301 | 1325 | 1353 | 1368 | 1366 | 1391 | 1326 | 1401 | 1382 | 1386 | 1400 |
| 6 | 1296 | 1322 | 1326 | 1345 | 1375 | 1372 | 1381 | 1324 | 1408 | 1372 | 1334 | 1420 |
| 7 | 1300 | 1325 | 1358 | 1336 | 1371 | 1349 | 1361 | 1322 | 1407 | 1382 | 1365 | 1450 |
| 8 | 1294 | 1321 | 1326 | 1336 | 1361 | 1358 | 1354 | 1322 | 1401 | 1402 | 1354 | 1405 |
| 9 | 1332 | 1328 | 1321 | 1348 | 1364 | 1370 | 1346 | 1340 | 1408 | 1386 | 1372 | 1390 |
| 10 | 1337 | 1320 | 1319 | 1349 | 1383 | 1382 | 1370 | 1345 | 1412 | 1387 | 1410 | 1400 |
| 11 | 1315 | 1320 | 1327 | 1345 | 1386 | 1396 | 1362 | 1339 | 1413 | 1394 | 1426 | 1400 |
| 12 | 1313 | 1311 | 1320 | 1342 | 1390 | 1382 | 1346 | 1349 | 1426 | 1416 | 1417 | 1390 |
| 13 | 1320 | 1330 | 1315 | 1351 | 1392 | 1397 | 1344 | 1351 | 1434 | 1419 | 1409 | 1450 |
| 14 | 1316 | 1330 | 1311 | 1364 | 1394 | 1394 | 1363 | 1355 | 1406 | 1434 | 1410 | 1435 |
| 15 | 1329 | 1336 | 1311 | 1366 | 1404 | 1387 | 1365 | 1346 | 1453 | 1428 | 1394 | 1440 |
| 16 | 1335 | 1324 | 1314 | 1373 | 1424 | 1385 | 1374 | 1356 | 1426 | 1446 | 1390 | 1455 |
| 17 | 1330 | 1330 | 1318 | 1383 | 1413 | 1392 | 1378 | 1385 | 1419 | 1463 | 1400 | 1470 |
| 18 | 1337 | 1353 | 1338 | 1368 | 1429 | 1410 | 1371 | 1362 | 1412 | 1461 | 1419 | 1475 |
| 19 | 1336 | 1354 | 1339 | 1392 | 1417 | 1418 | 1382 | 1380 | 1412 | 1488 | 1418 | 1490 |
| 20 | 1338 | 1347 | 1353 | 1403 | 1435 | 1424 | 1379 | 1407 | 1412 | 1482 | 1384 | 1580 |
| 21 | 1350 | 1338 | 1350 | 1396 | 1424 | 1426 | 1388 | 1401 | 1418 | 1488 | 1388 | 1510 |
| 22 | 1351 | 1340 | 1343 | 1394 | 1433 | 1416 | 1391 | 1384 | 1447 | 1482 | 1385 | 1525 |
| 23 | 1346 | 1334 | 1360 | 1406 | 1434 | 1425 | 1391 | 1395 | 1434 | 1502 | 1406 | 1540 |
| 24 | 1344 | 1327 | 1356 | 1409 | 1436 | 1419 | 1401 | 1404 | 1449 | 1494 | 1413 | 1550 |
| 25 | 1355 | 1342 | 1358 | 1402 | 1433 | 1439 | 1403 | 1398 | 1452 | 1512 | 1417 | 1565 |
| 26 | 1354 | 1346 | 1360 | 1402 | 1432 | 1451 | 1384 | 1392 | 1459 | 1506 | 1431 | 1575 |
| 27 | 1365 | 1348 | 1359 | 1404 | 1437 | 1463 | 1379 | 1395 | 1458 | 1520 | 1417 | 1580 |
| 28 | 1368 | 1347 | 1376 | 1406 | 1447 | 1470 | 1376 | 1393 | 1466 | 1523 | 1424 | 1585 |
| 29 | 1368 | 1352 | 1360 | 1410 | 1449 | 1476 | 1376 | 1392 | 1462 | 1498 | 1437 | 1570 |
| 30 | 1350 | 1366 | 1388 | 1408 | 1443 | 1474 | 1379 | 1420 | 1467 | 1538 | 1451 | 1580 |
| 31 | 1378 | 1363 | 1382 | 1405 | 1460 | 1482 | 1396 | 1418 | 1474 | 1523 | 1476 | 1580 |
| 32 | 1392 | 1364 | 1390 | 1405 | 1454 | 1492 | 1408 | 1438 | 1486 | 1528 | 1447 | 1590 |
| 33 | 1404 | 1350 | 1394 | 1404 | 1461 | 1484 | 1412 | 1465 | 1483 | 1538 | 1461 | 1480 |
| 34 | 1414 | 1342 | 1398 | 1410 | 1474 | 1486 | 1414 | 1456 | 1496 | 1548 | 1467 | 1460 |
| 35 | 1398 | 1344 | 1394 | 1420 | 1477 | 1494 | 1412 | 1460 | 1506 | 1549 | 1459 | 1470 |
| 36 | 1420 | 1357 | 1391 | 1424 | 1474 | 1506 | 1422 | 1479 | 1501 | 1551 | 1464 | 1490 |
| 37 | 1458 | 1367 | 1400 | 1428 | 1503 | 1510 | 1423 | 1482 | 1514 | 1556 | 1455 | 1500 |
| 38 | 1442 | 1371 | 1418 | 1438 | 1487 | 1507 | 1429 | 1488 | 1524 | 1559 | 1484 | 1510 |
| 39 | 1436 | 1386 | 1446 | 1428 | 1497 | 1528 | 1454 | 1506 | 1543 | 1559 | 1480 | 1530 |
| 40 | 1444 | 1396 | 1445 | 1454 | 1507 | 1533 | 1466 | 1522 | 1548 | 1546 | 1509 | 1540 |
| 41 | 1454 | 1389 | 1455 | 1472 | 1521 | 1546 | 1462 | 1528 | 1549 | 1562 | 1511 | 1550 |
| 42 | 1471 | 1392 | 1478 | 1477 | 1534 | 1534 | 1462 | 1542 | 1563 | 1571 | 1515 | 1555 |
| 43 | 1482 | 1407 | 1481 | 1502 | 1587 | 1566 | 1479 | 1553 | 1576 | 1581 | 1535 | 1560 |
| 44 | 1490 | 1430 | 1510 | 1488 | 1574 | 1573 | 1494 | 1570 | 1621 | 1614 | 1547 | 1574 |
| Average, 44 weeks | 1366 | 1350 | 1369 | 1397 | 1440 | 1442 | 1401 | 1408 | 1462 | 1486 | 1432 | 1496 |

*There were 10 cows in each group during year 1; 9, 9, 8, and 6, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3.

***Body weight changes.*** Average body weight gains and losses, by weeks, for groups 1 to 4 during a 44-week lactation are given in table 22 and in figure 26. The starting point was the weight of each cow during the first week after parturition. Body weight losses were high during the first 8 weeks of lactation; then body weight slowly increased over a period of 24 weeks, followed by a marked increase in weight during the last 12 weeks of the 44-week lactation. However, group 3 followed a different pattern from those of the other 3 groups, showing greater losses in body weight during the first 8 weeks, when the cows were offered grain to their capacity. This again indicated a limit to grain intake when large quantities of grain are fed, and also the advantage of feeding high-quality forage *ad lib.* when the practice of liberal grain feeding is followed. The slower rate of gain in group 3 is reflected in the body weights observed during lactation in years 2 and 3. In each year, group 3 had the lowest average body weights during lactation, even though these cows had the highest average during each of the 3 dry periods.

Table 22. *Average body weight gain or loss, by weeks**

| Week | Year 1 | | | | Year 2 | | | | Year 3 | | | | Average 3 years | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Group | | | | Group | | | | Group | | | | Group | | | |
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| | pounds | | | | | | | | | | | | | | | |
| −3 | − 42 | + 10 | − 7 | + 45 | + 20 | + 5 | + 33 | + 16 | + 11 | + 21 | + 26 | − 10 | − 5.1 | + 11.6 | + 15.0 | + 31.5 |
| −2 | 0 | + 3 | + 2 | 0 | + 25 | + 8 | − 5 | − 44 | + 35 | + 4 | + 15 | + 20 | + 19.3 | + 5.0 | + 3.4 | − 14.4 |
| −1 | − 26 | − 42 | − 1 | + 11 | + 4 | + 27 | + 12 | + 36 | − 6 | − 29 | − 10 | 0 | − 9.9 | − 15.1 | + 0.6 | + 19.2 |
| 1 | −117 | −136 | −192 | −128 | −179 | −210 | −163 | −205 | −203 | −179 | −248 | −180 | −164.6 | −173.4 | −193.3 | −158.2 |
| 2 | − 40 | − 54 | − 39 | − 44 | − 51 | − 23 | − 67 | − 10 | − 62 | − 25 | − 50 | − 40 | − 50.6 | − 35.1 | − 51.0 | − 31.8 |
| 3 | − 10 | − 7 | − 22 | − 18 | − 17 | − 1 | − 58 | − 26 | − 21 | − 48 | − 47 | − 15 | − 15.8 | − 17.1 | − 40.5 | − 20.6 |
| 4 | 0 | − 8 | − 15 | − 4 | − 22 | − 22 | + 9 | − 35 | − 21 | − 32 | − 2 | − 35 | − 13.8 | − 19.8 | − 3.8 | − 16.8 |
| 5 | − 23 | − 45 | − 8 | − 1 | − 13 | − 2 | − 21 | − 1 | − 10 | − 11 | − 8 | − 10 | − 15.6 | − 20.6 | − 12.2 | − 1.5 |
| 6 | − 9 | + 21 | + 1 | − 8 | + 5 | + 6 | − 10 | − 2 | + 2 | − 10 | − 52 | + 20 | − 1.0 | + 6.8 | − 17.4 | − 4.2 |
| 7 | + 4 | + 1 | + 32 | − 9 | − 2 | − 23 | − 20 | − 2 | + 4 | + 10 | + 31 | + 30 | + 2.1 | − 4.3 | + 15.1 | − 4.2 |
| 8 | − 6 | − 2 | − 32 | 0 | − 10 | + 9 | − 27 | 0 | − 6 | + 20 | − 11 | − 45 | − 7.3 | + 8.2 | − 24.5 | − 2.6 |
| 9 | + 38 | + 7 | − 5 | + 12 | + 3 | + 12 | + 12 | + 18 | + 7 | − 16 | + 18 | − 15 | + 16.8 | + 1.9 | + 6.9 | + 12.5 |
| 10 | + 5 | − 8 | − 2 | + 1 | + 19 | + 12 | + 24 | + 5 | + 4 | + 1 | + 38 | + 10 | + 9.2 | + 1.3 | + 17.5 | + 2.9 |
| 11 | − 22 | 0 | + 8 | − 4 | + 3 | + 14 | − 8 | − 6 | + 1 | + 7 | + 16 | 0 | − 6.6 | + 6.7 | + 5.2 | − 4.5 |
| 12 | − 2 | − 9 | − 7 | − 3 | + 4 | − 14 | − 16 | + 10 | + 13 | + 22 | − 9 | − 10 | + 4.8 | − 1.5 | − 10.5 | + 1.2 |
| 13 | + 7 | + 19 | − 5 | + 9 | + 2 | + 15 | − 2 | + 2 | + 8 | + 3 | − 8 | + 60 | + 5.7 | + 12.9 | − 4.9 | + 9.5 |
| 14 | − 4 | 0 | − 4 | + 13 | + 2 | − 3 | + 19 | + 4 | − 28 | + 15 | + 1 | − 15 | − 9.8 | + 3.4 | + 4.8 | + 8.2 |
| 15 | + 13 | + 6 | 0 | + 2 | + 10 | − 7 | + 2 | − 9 | + 27 | − 6 | − 16 | + 5 | + 16.5 | − 1.9 | − 3.8 | − 1.7 |
| 16 | + 6 | − 12 | + 3 | + 7 | + 20 | − 2 | + 9 | + 10 | − 7 | + 18 | − 4 | + 15 | + 6.3 | + 0.2 | + 3.0 | + 8.5 |
| 17 | − 5 | + 6 | + 4 | + 10 | − 11 | + 7 | + 4 | + 29 | − 7 | + 17 | + 10 | + 15 | − 7.6 | + 9.6 | + 5.7 | + 17.0 |
| 18 | + 7 | + 3 | + 20 | − 15 | + 16 | + 18 | − 7 | − 23 | − 7 | − 2 | + 19 | + 5 | + 5.4 | + 6.5 | + 11.1 | − 16.6 |
| 19 | − 1 | + 1 | + 1 | + 24 | − 12 | + 8 | + 11 | + 18 | 0 | + 27 | − 1 | + 15 | − 4.2 | + 11.0 | + 3.6 | + 21.4 |
| 20 | + 2 | + 13 | + 14 | + 11 | + 18 | + 6 | − 3 | + 27 | 0 | − 6 | − 34 | + 90 | + 6.5 | + 5.0 | − 4.9 | + 21.3 |
| 21 | + 12 | − 9 | − 23 | − 7 | − 11 | + 2 | + 9 | − 6 | + 6 | + 6 | + 4 | − 70 | + 2.7 | − 0.9 | − 5.2 | − 10.4 |
| 22 | + 1 | + 2 | + 13 | − 2 | + 9 | − 10 | + 3 | − 17 | + 29 | − 6 | − 3 | + 15 | + 12.6 | − 4.4 | + 5.3 | − 6.3 |
| 23 | − 5 | − 6 | + 17 | + 12 | + 1 | + 9 | 0 | + 11 | − 13 | + 20 | + 21 | + 15 | − 5.6 | + 6.7 | + 12.7 | + 11.8 |
| 24 | − 2 | − 7 | − 4 | + 3 | + 2 | − 6 | + 10 | + 9 | + 15 | − 8 | + 7 | + 10 | + 4.8 | − 7.0 | + 3.6 | + 5.5 |
| 25 | + 9 | + 15 | + 2 | − 7 | − 3 | + 20 | + 2 | − 6 | + 3 | + 18 | + 4 | + 15 | + 3.2 | + 17.6 | + 2.6 | − 5.4 |
| 26 | + 1 | + 4 | + 2 | 0 | − 1 | + 12 | − 19 | − 6 | + 7 | − 6 | + 14 | + 10 | + 2.3 | + 3.7 | − 1.4 | − 1.5 |
| 27 | + 11 | + 2 | − 1 | + 2 | + 5 | + 12 | − 5 | + 1 | − 1 | + 14 | − 14 | + 5 | + 5.2 | + 8.9 | − 5.5 | + 1.8 |
| 28 | + 3 | − 1 | + 17 | + 2 | + 10 | + 7 | − 3 | 0 | + 8 | + 3 | + 7 | + 5 | + 6.9 | + 2.8 | + 7.8 | + 1.5 |
| 29 | 0 | + 5 | − 16 | + 4 | + 2 | + 6 | 0 | − 1 | − 4 | − 25 | + 13 | − 15 | − 0.6 | − 3.6 | − 2.8 | + 1.1 |
| 30 | − 18 | + 14 | + 28 | − 2 | − 6 | − 2 | + 3 | + 28 | + 5 | + 40 | + 14 | + 10 | − 6.8 | + 16.4 | + 16.1 | + 9.3 |
| 31 | + 28 | − 3 | − 6 | − 5 | + 17 | + 8 | + 17 | − 2 | + 7 | − 15 | + 25 | 0 | + 17.7 | − 2.9 | + 10.0 | − 3.6 |
| 32 | + 14 | + 1 | + 8 | 0 | − 6 | + 10 | + 12 | + 20 | + 12 | + 5 | − 29 | + 10 | + 6.9 | + 5.2 | − 1.1 | + 7.6 |
| 33 | + 12 | − 14 | + 4 | + 1 | + 7 | − 8 | + 4 | + 27 | − 3 | + 10 | + 14 | −110 | + 5.6 | − 4.9 | + 6.8 | + 3.6 |
| 34 | + 10 | − 8 | + 4 | + 6 | + 13 | + 2 | + 2 | − 9 | + 13 | + 10 | + 6 | − 20 | + 11.9 | + 0.7 | + 3.9 | − 0.8 |
| 35 | − 16 | + 2 | − 4 | + 10 | + 3 | + 8 | − 2 | + 4 | + 10 | + 1 | − 8 | + 10 | − 1.5 | + 3.7 | − 4.5 | + 7.9 |
| 36 | + 22 | + 13 | − 3 | + 4 | − 3 | + 12 | + 10 | + 19 | − 5 | + 2 | + 5 | + 20 | + 5.3 | + 9.4 | + 3.4 | + 10.2 |
| 37 | + 18 | + 10 | + 9 | + 4 | + 29 | + 4 | + 1 | + 3 | + 13 | + 5 | − 9 | + 10 | + 19.9 | + 6.5 | + 1.4 | + 4.0 |
| 38 | + 4 | + 4 | + 18 | + 10 | − 16 | − 3 | + 6 | + 6 | + 10 | + 3 | + 29 | + 10 | − 0.5 | + 1.4 | + 17.2 | + 8.6 |
| 39 | − 6 | + 15 | + 28 | − 10 | + 10 | + 21 | + 25 | + 18 | + 19 | 0 | − 4 | + 20 | + 7.2 | + 12.6 | + 17.7 | + 1.6 |
| 40 | + 8 | + 10 | − 1 | + 26 | + 10 | + 5 | + 12 | + 16 | + 5 | − 13 | + 29 | + 10 | + 7.7 | + 1.5 | + 11.6 | + 21.5 |
| 41 | + 10 | − 7 | + 10 | + 18 | + 14 | + 13 | − 4 | + 6 | + 1 | + 16 | + 2 | + 10 | + 8.4 | + 6.5 | + 3.3 | + 13.3 |
| 42 | + 17 | + 3 | + 23 | + 5 | + 13 | + 8 | 0 | + 14 | + 14 | + 9 | + 4 | + 5 | + 14.8 | + 6.4 | + 10.3 | + 8.2 |
| 43 | + 11 | + 15 | + 3 | + 25 | + 53 | + 12 | + 17 | + 11 | + 13 | + 10 | + 20 | + 5 | + 25.1 | + 12.5 | + 12.2 | + 18.9 |
| 44 | + 8 | + 23 | + 29 | − 14 | − 13 | + 7 | + 15 | + 17 | + 45 | + 33 | + 12 | + 14 | + 13.1 | + 20.6 | + 19.8 | − 1.4 |
| Average, 44 weeks | +2.55 | +0.34 | +2.30 | +1.55 | +2.34 | +3.61 | −0.77 | +3.91 | +2.41 | +2.64 | +1.23 | +1.68 | + 2.44 | + 2.11 | + 1.01 | + 2.39 |

*The 3-year weighted average is based on 10 cows in each group during year 1; on 9, 9, 8, and 6 cows, respectively, during year 2; and 9, 8, 7, and 1, respectively, during year 3.

Because energy intakes lag behind maximum milk energy output cows can be expected to lose weight during the time of peak production, Clharron (1961), Brown *et al.* (1962), Swanson *et al.* (1967), McCaffree and Merrill (1968a,b), Davenport and Rakes (1969), and Miller *et al.* (1969) reported that cows lost weight even when fed concentrates *ad lib.,* or nearly so, during early lactation.

Van Soest (1963) reported that metabolic processes geared to produce milk efficiently and those that produce high gains in body weight are entirely different. This may explain why it is so difficult to prevent weight losses in high producers during early lactation. Van Soest postulated that maximum efficiency for milk production probably exists at that hay-grain ratio at which milk fat begins to be depressed. Hooven and Plowman (1963) reported that liberal grain feeding resulted in increased weight gains but no increase in milk yield.

Kesler and Spahr (1964) speculated that either a high proportion of concentrates *per se* or simply overfeeding affects milk production of cows that do not respond to liberal feeding of concentrates. If the change in type of metabolism had not occurred, they might have produced more milk even though they consumed less feed. It is also possible that the shift to a body-fat-producing type of metabolism could have a long-term effect. We planned to feed the cows in our experiment the predetermined rate of grain in accordance with production, even if they put on excessive weight. But body weights, condition ratings, and general observations all show that the cows did not become excessively fat during lactation or the dry period.

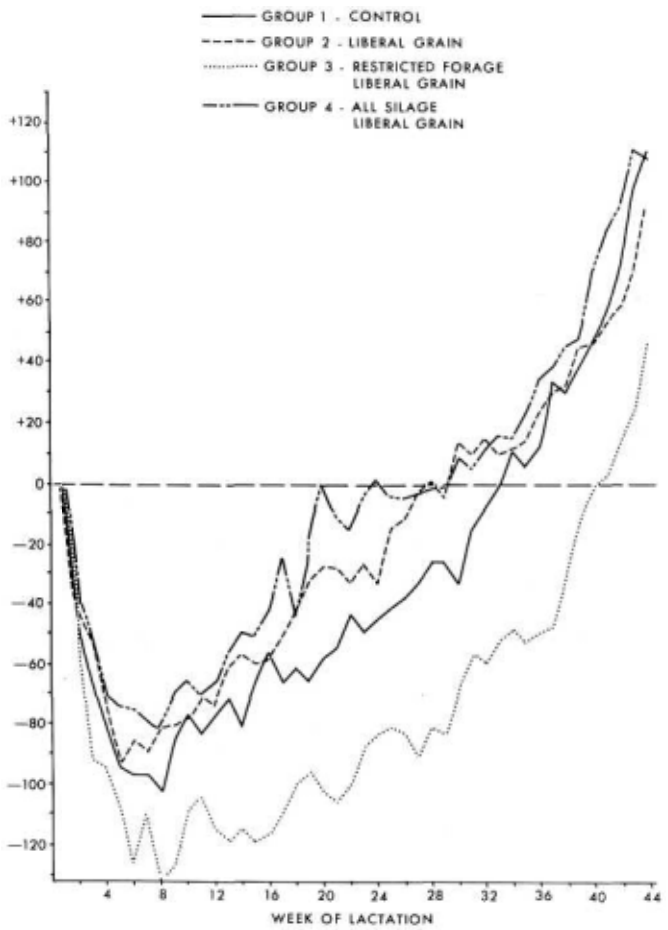


Figure 26. *Body weight gain or loss, by weeks, average for 3 years.*

Although energy intake of the high-producing cow can be effectively increased by liberal concentrate feeding soon after calving, this should be especially geared to the appetite of the cow, which is not keen at that time, and should also be adjusted in accordance with the production level of each cow when peak production has been achieved. Underfeeding is a major dairy problem in many herds; overfeeding also causes trouble and is profit-robbing. Thus, good management is important.

*Peak grain intake.* Associated with the question of maintaining body weight during early lactation is the week during lactation when the maximum grain intake is reached, the average daily grain consumption during the peak week of intake, and the number of weeks with an average daily grain intake of 35 pounds or over. This information is presented in table 23 for groups 2, 3, and 4, which received liberal grain in their ration. The 3-year average for the lactation week with peak intake of grain, the average daily intake at the peak, and the number of weeks per cow with an average intake of 35 pounds or over daily for 3 successive days were: group 2, liberal grain, 8, 44, and 9; group 3, restricted forage liberal grain, 11, 47, and 12; and group 4, all-corn silage liberal grain, 8, 45, and 9, respectively. Group 3 averaged only 2 and 3 pounds, respectively, above groups 4 and 2 for average

Table 23. *Peak grain intake of cows on liberal grain feeding, years 1-3**

| Group | Cow | Peak grain intake (week) Year 1 | 2 | 3 | Avg. | Average daily for peak* (pounds) Year 1 | 2 | 3 | Avg. | Intake with 35 lbs. or over daily* (no. of weeks) Year 1 | 2 | 3 | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 Liberal grain | 215 | 6 | 17 | 10 | 11 | 40 | 44 | 48 | 44 | 7 | 15 | 9 | 10 |
| | 218 | 7 | – | – | 7 | 46 | – | – | 46 | 11 | – | – | 11 |
| | 241 | 5 | 8 | 5 | 6 | 41 | 44 | 33 | 40 | 4 | 6 | 1 | 4 |
| | 249 | 9 | 10 | – | 10 | 55 | 38 | – | 46 | 8 | 7 | – | 8 |
| | 304 | 2 | 7 | 7 | 5 | 39 | 55 | 47 | 47 | 5 | 6 | 15 | 9 |
| | 312 | 8 | 10 | 11 | 10 | 62 | 41 | 50 | 51 | 24 | 7 | 14 | 15 |
| | 325 | 4 | 12 | 10 | 9 | 58 | 41 | 37 | 39 | 5 | 7 | 2 | 4 |
| | 329 | 10 | 10 | 8 | 9 | 51 | 48 | 45 | 48 | 8 | 24 | 8 | 13 |
| | 337 | 2 | 10 | 8 | 7 | 38 | 49 | 41 | 43 | 5 | 14 | 10 | 9 |
| | 342 | 4 | 11 | 15 | 10 | 40 | 33 | 45 | 39 | 4 | 0 | 14 | 6 |
| Average | | 6 | 11 | 9 | 8 | 45 | 44 | 44 | 44 | 8 | 10 | 9 | 9 |
| 3 Restricted forage, liberal grain | 251 | 3 | 3 | 11 | 6 | 49 | 45 | 47 | 47 | 8 | 11 | 15 | 11 |
| | 239 | 26 | 19 | 6 | 17 | 38 | 32 | 30 | 33 | 1 | 0 | 0 | 0 |
| | 302 | 11 | – | – | 11 | 55 | – | – | 55 | 18 | – | – | 18 |
| | 303 | 7 | 14 | 17 | 13 | 55 | 56 | 47 | 53 | 22 | 22 | 16 | 20 |
| | 308 | 7 | 9 | 12 | 9 | 50 | 44 | 41 | 45 | 15 | 18 | 12 | 15 |
| | 309 | 6 | 13 | – | 10 | 45 | 42 | – | 44 | 10 | 9 | – | 10 |
| | 328 | 10 | 14 | 13 | 12 | 45 | 47 | 46 | 46 | 12 | 8 | 10 | 10 |
| | 335 | 8 | 7 | 9 | 8 | 48 | 51 | 56 | 52 | 8 | 14 | 18 | 13 |
| | 339 | 3 | – | – | 3 | 45 | – | – | 45 | 9 | – | – | 9 |
| | 344 | 11 | 15 | 12 | 12 | 51 | 44 | 56 | 50 | 9 | 19 | 12 | 13 |
| Average | | 9 | 12 | 11 | 11 | 48 | 45 | 46 | 47 | 11 | 13 | 12 | 12 |
| 4 All-corn silage, liberal grain | 210 | 6 | – | – | 6 | 47 | – | – | 47 | 13 | – | – | 13 |
| | 220 | 9 | 7 | – | 8 | 50 | 40 | – | 45 | 8 | 10 | – | 9 |
| | 223 | 5 | 11 | – | 8 | 44 | 48 | – | 46 | 10 | 13 | – | 12 |
| | 246 | 5 | – | – | 5 | 37 | – | – | 37 | 3 | – | – | 3 |
| | 247 | 5 | – | – | 5 | 41 | – | – | 41 | 5 | – | – | 5 |
| | 280 | 5 | 9 | 7 | 7 | 45 | 61 | 46 | 51 | 9 | 17 | 10 | 12 |
| | 510 | 11 | 2 | – | 6 | 44 | 51 | – | 38 | 9 | 0 | – | 4 |
| | 541 | 7 | 13 | – | 10 | 50 | 47 | – | 48 | 6 | 13 | – | 10 |
| | 543 | 7 | 17 | – | 12 | 43 | 41 | – | 42 | 9 | 10 | – | 10 |
| | 550 | 6 | – | – | 6 | 42 | – | – | 42 | 7 | – | – | 7 |
| Average | | 7 | 10 | 7 | 8 | 44 | 45 | 46 | 45 | 8 | 10 | 10 | 9 |

*Based on average intake for 3 successive days once during a particular week of lactation.

daily intake during the peak week. This shows again that cows have a definite ceiling for grain intake. Groups 2 and 4, with additional forage intake under the *ad lib.* forage allowance, consumed more total feed dry matter and TDN than did group 3, which resulted in less weight loss during this critical period early in lactation.

The uniform results among group averages do not reflect the wide differences among individual cows. The week of maximum grain intake for groups 2 and 4 ranged from 2 to 17 with an average of 8. For group 3 the range was much greater (3 to 26) with an average of 11. Both Stone *et al.* (1960) and Johnson *et al.* (1966) emphasized the large variation among individual cows in appetite and feed intake. The uniform results among groups indicates that the cows originally were well grouped in accordance with established production, size, and other factors that reflect appetite, as reported by Stone *et al.* (1960). The characteristic of appetite measured by level of feed intake was persistent in the individual cow regardless of type of ration.

## Additional 5 Cows in Groups 1 and 3

Control group 1 and group 3 each had 5 additional young cows, 4 of which were in their first lactation and 1 in her second for year 1. These 5 cows followed the same

patterns as did the 10 cows in each of these 2 groups. Therefore, to meet space and publication-cost restrictions, tables of data for the 5 additional cows, and totals and averages for the entire 15 cows are presented herein only where essential. Those not included are available from the authors upon request.

*Feed intake.* The average daily feed intake, by weeks, for the 5 additional young cows in groups 1 and 3, years 1—3 and the 3-year average for the 5 cows and all 15 cows are available in table form. For hay, silage, and grain these were, for 5 cows in group 1: 20.8, 35.7, and 11.5; and in group 3: 7.8, 11.9, and 26.7 pounds per day, respectively, for 44 weeks of lactation. The 15 cows averaged 21.0, 35.5, and 12.3, respectively, for group 1, and 7.8, 12.0, and 27.7 pounds per day for group 3. Total feed intakes for the 5 and the 15 cows in groups 1 and 3 during a 44-week lactation are given in table 6.

The amount of dry matter (DM) consumed daily, and grain as percentage of total DM during 44 weeks of lactation, are available in table form upon request. The average daily dry-matter intake for the 5 additional young cows during a 44-week lactation in group 1 for years 1, 2, 3 and the 3-year average was 34.4, 40.4, 39.6, and 38.1 pounds, respectively. For group 3, dry-matter intakes were 32.7, 33.5, 33.7 and 33.3 pounds, respectively. These results again show the advantage of feeding forage *ad lib.* with liberal grain feeding and the inadvisability of replacing forage with grain for cows on a ration with markedly restricted forage. The percentages of total DM from grain were 26.4, 25.3, and 25.3, respectively, for group 1 during years 1 to 3, and 68.6, 67.5, and 67.6 for group 3.

Averages for daily crude protein intakes and average daily TDN consumed and required by the 5 additional cows in groups 1 and 3 are available in table form upon request. These results are consistent with those previously presented and discussed for the 10 cows in both of these groups.

The average percentages of total TDN from grain for years 1 to 3 for the 5 additional young cows and for all 15 cows in groups 1 and 3 are presented in table 24.

Table 24. *Average percentage of total TDN from grain, by weeks**

| Week | 5 additional young cows* | | | | | | 15 cows* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 1 | | Year 2 | | Year 3 | | Year 1 | | Year 2 | | Year 3 | |
| | Group | | Group | | Group | | Group | | Group | | Group | |
| | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 |
| | percent | | | | | | percent | | | | | |
| 1 | 47.5 | 73.9 | 36.9 | 56.2 | 35.7 | 62.9 | 41.8 | 72.6 | 51.8 | 62.4 | 34.7 | 62.0 |
| 2 | 56.8 | 75.8 | 47.9 | 70.7 | 47.3 | 70.6 | 50.5 | 75.5 | 45.6 | 69.7 | 46.5 | 70.4 |
| 3 | 56.1 | 78.0 | 45.6 | 73.7 | 50.2 | 74.1 | 51.4 | 79.4 | 46.1 | 73.1 | 49.1 | 74.3 |
| 4 | 51.8 | 75.7 | 44.2 | 77.8 | 47.4 | 74.0 | 48.7 | 78.2 | 45.8 | 75.7 | 46.9 | 74.8 |
| 5 | 47.3 | 76.9 | 45.6 | 78.5 | 46.4 | 73.6 | 46.8 | 78.1 | 45.6 | 77.7 | 45.9 | 72.6 |
| 6 | 48.2 | 79.2 | 44.1 | 79.0 | 43.9 | 73.7 | 46.2 | 78.7 | 44.4 | 77.6 | 44.8 | 74.6 |
| 7 | 45.3 | 78.4 | 42.6 | 80.0 | 40.1 | 76.1 | 43.2 | 79.5 | 44.1 | 77.8 | 43.0 | 76.3 |
| 8 | 45.4 | 81.8 | 40.7 | 81.6 | 39.8 | 76.4 | 45.6 | 80.1 | 41.0 | 79.2 | 42.2 | 77.9 |
| 9 | 41.5 | 80.5 | 38.4 | 80.0 | 37.1 | 78.5 | 44.5 | 79.5 | 40.3 | 79.6 | 41.3 | 78.9 |
| 10 | 37.3 | 78.1 | 37.5 | 77.7 | 35.4 | 78.7 | 42.2 | 78.3 | 39.3 | 78.2 | 40.2 | 78.6 |
| 11 | 36.4 | 77.1 | 38.3 | 73.7 | 34.5 | 78.4 | 39.5 | 77.7 | 39.2 | 76.3 | 39.4 | 79.0 |
| 12 | 35.3 | 75.7 | 37.6 | 76.8 | 33.8 | 78.4 | 38.8 | 77.9 | 37.5 | 76.6 | 38.8 | 79.0 |
| 13 | 32.8 | 76.1 | 34.7 | 77.6 | 34.4 | 77.9 | 36.9 | 77.0 | 36.4 | 78.3 | 38.4 | 78.6 |
| 14 | 32.8 | 73.8 | 34.0 | 76.6 | 33.0 | 78.3 | 36.3 | 76.5 | 36.3 | 77.8 | 37.8 | 78.5 |
| 15 | 33.4 | 70.9 | 32.6 | 77.5 | 31.1 | 78.1 | 36.2 | 74.8 | 35.2 | 78.2 | 36.9 | 77.8 |
| 16 | 32.9 | 72.0 | 31.6 | 76.2 | 30.8 | 78.2 | 35.5 | 75.4 | 33.8 | 77.4 | 35.6 | 77.5 |
| 17 | 30.8 | 71.8 | 31.4 | 75.8 | 30.9 | 76.6 | 34.7 | 75.4 | 33.1 | 77.6 | 33.7 | 77.4 |
| 18 | 28.0 | 71.5 | 31.9 | 75.1 | 30.4 | 75.7 | 32.9 | 74.8 | 33.6 | 76.5 | 32.7 | 76.5 |
| 19 | 30.0 | 72.4 | 29.1 | 75.2 | 30.4 | 75.6 | 33.1 | 75.1 | 31.5 | 77.1 | 31.6 | 76.2 |
| 20 | 29.6 | 72.2 | 29.1 | 75.6 | 31.1 | 74.9 | 33.2 | 75.1 | 31.2 | 77.5 | 31.7 | 75.4 |
| 21 | 27.4 | 72.5 | 30.5 | 74.6 | 30.5 | 73.3 | 32.5 | 74.6 | 31.9 | 76.1 | 31.5 | 74.1 |
| 22 | 26.9 | 71.9 | 28.8 | 74.1 | 29.1 | 73.0 | 31.7 | 73.2 | 30.6 | 76.4 | 31.2 | 73.9 |
| 23 | 26.0 | 71.1 | 28.7 | 73.5 | 28.7 | 72.8 | 31.2 | 73.4 | 30.2 | 75.8 | 29.6 | 73.7 |
| 24 | 25.4 | 71.3 | 29.4 | 72.4 | 29.0 | 72.1 | 30.5 | 73.1 | 29.9 | 74.7 | 29.8 | 73.1 |
| 25 | 24.6 | 72.2 | 29.0 | 71.4 | 29.7 | 71.5 | 29.5 | 73.9 | 29.6 | 73.8 | 29.8 | 72.5 |
| 26 | 25.2 | 71.3 | 28.6 | 71.0 | 29.4 | 71.3 | 27.5 | 73.2 | 28.2 | 73.2 | 29.0 | 71.6 |
| 27 | 25.2 | 71.4 | 27.1 | 70.0 | 28.8 | 70.6 | 27.6 | 72.7 | 27.0 | 72.1 | 28.8 | 71.6 |
| 28 | 24.9 | 71.1 | 26.4 | 69.4 | 27.5 | 70.2 | 26.8 | 71.6 | 27.0 | 71.7 | 27.7 | 70.4 |
| 29 | 25.0 | 71.3 | 26.6 | 66.5 | 26.6 | 69.5 | 25.7 | 71.0 | 27.0 | 69.9 | 27.1 | 70.1 |
| 30 | 24.0 | 71.1 | 26.3 | 64.1 | 27.5 | 69.4 | 25.6 | 70.7 | 27.1 | 68.3 | 26.7 | 69.7 |
| 31 | 24.6 | 70.8 | 25.4 | 65.4 | 27.8 | 68.9 | 25.1 | 70.3 | 25.8 | 68.4 | 26.6 | 69.8 |
| 32 | 23.9 | 71.5 | 26.2 | 69.0 | 21.5 | 66.8 | 24.0 | 70.4 | 25.4 | 69.7 | 24.6 | 69.0 |
| 33 | 21.5 | 70.7 | 24.7 | 68.7 | 22.5 | 67.3 | 22.3 | 69.8 | 24.8 | 67.9 | 24.8 | 68.6 |
| 34 | 21.1 | 70.2 | 22.9 | 68.0 | 20.8 | 67.1 | 21.8 | 69.3 | 24.2 | 68.0 | 23.6 | 68.3 |
| 35 | 21.4 | 70.1 | 21.3 | 67.9 | 19.3 | 67.1 | 20.9 | 68.4 | 22.2 | 68.3 | 21.6 | 67.8 |
| 36 | 20.6 | 69.9 | 19.0 | 67.2 | 17.3 | 67.2 | 19.5 | 68.2 | 20.8 | 68.1 | 19.7 | 67.6 |
| 37 | 20.1 | 69.7 | 17.0 | 66.4 | 14.7 | 66.9 | 19.0 | 68.3 | 19.2 | 66.9 | 18.0 | 66.9 |
| 38 | 20.4 | 69.4 | 14.8 | 66.2 | 12.2 | 66.5 | 18.5 | 68.1 | 17.4 | 66.0 | 16.1 | 66.4 |
| 39 | 17.3 | 68.8 | 13.6 | 65.8 | 12.7 | 66.4 | 15.9 | 67.5 | 15.0 | 66.5 | 15.7 | 66.3 |
| 40 | 15.7 | 68.2 | 12.2 | 65.4 | 12.8 | 65.5 | 15.4 | 66.5 | 13.0 | 66.5 | 15.6 | 65.4 |
| 41 | 13.3 | 67.5 | 12.7 | 65.4 | 14.2 | 64.9 | 13.4 | 65.2 | 11.9 | 66.0 | 15.0 | 64.9 |
| 42 | 12.2 | 66.5 | 10.7 | 64.8 | 14.0 | 64.6 | 12.1 | 66.2 | 10.1 | 65.7 | 13.2 | 64.5 |
| 43 | 11.4 | 66.5 | 9.7 | 64.6 | 14.0 | 64.8 | 10.7 | 66.0 | 9.4 | 65.2 | 12.7 | 64.2 |
| 44 | 12.6 | 67.2 | 9.1 | 64.1 | 14.1 | 63.8 | 9.8 | 65.8 | 10.3 | 64.7 | 12.5 | 64.0 |
| Average, 44 weeks | 29.8 | 72.6 | 29.0 | 71.6 | 28.8 | 71.6 | 30.8 | 73.1 | 29.8 | 72.6 | 30.5 | 72.1 |

*The same 5 additional young cows were in groups 1 and 3 for all 3 years. When they joined the 10 cows in groups 1 and 3, there were 15 cows in both groups during year 1; 14 in group 1 during years 2 and 3; and 13 and 12 in group 3 during years 2 and 3, respectively.

Averages of daily actual milk and 4% FCM, by weeks, for the 5 additional young cows in groups 1 and 3 are presented in tables 25 and 26, respectively.

Percentages of milk fat, by weeks, for the 5 additional young cows in groups 1 and 3 are available in table form upon request. These were 4.0, 4.0, and 4.0 percent for control group 1 during year 1, 2, and 3, respectively. For group 3, these were 3.6, 3.8, and 3.7, respectively. Information on milk protein content is available in table form. These averages were 3.3, 3.4, and 3.2 percent for 44 weeks of lactation during years 1 to 3 for group 1, and 3.3, 3.3, and 3.1 percent, respectively, for group 3. There were no differences in protein content of the milk between groups 1 and 3. The percentages of solids-not-fat also are available in table form. Again these were nearly identical for both groups with averages during a 44-week lactation of 9.0, 8.9, and 8.6 percent for group 1 during years 1, 2, and 3, and with 9.1, 8.9, and 8.4 for group 3,respectively.

Average body weights, body weight changes, and condition ratings for the 5 additional cows in groups 1 and 3 are available in table form upon request.

All results for the 10 cows and the 5 additional young cows in groups 1 and 3 were consistent; no further summation is given for the 15 cows in these groups other than total feed intake (table 6), average percentage of total TDN from grain (table 24), and total lactation production (table 16).

The results from the 15 cows in group 3 on restricted forage and liberal grain, including 15 pounds of forage-replacement grain, indicate that, compared to control group 1, the cows in group 3 consumed an average of 4725 pounds more grain per cow in lieu of 4069 pounds of hay and 7262 pounds of silage per lactation over a 3-year period to produce an average of 266 pounds more actual milk, 5 pounds less fat, and 13 pounds more 4% fat-corrected milk during a 44-week lactation.

Table 25. *Average daily actual milk production, by weeks, for 5 additional young cows*

| Week | Year 1 | | Year 2 | | Year 3 | | Average 3 years | |
|---|---|---|---|---|---|---|---|---|
| | Group | | Group | | Group | | Group | |
| | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 |
| | pounds | | | | | | | |
| 1 | 44.1 | 41.0 | 52.9 | 57.3 | 52.0 | 52.9 | 49.7 | 50.4 |
| 2 | 53.1 | 52.9 | 65.9 | 65.0 | 61.9 | 64.4 | 60.3 | 60.8 |
| 3 | 58.0 | 56.9 | 70.8 | 66.8 | 68.6 | 68.3 | 65.8 | 64.0 |
| 4 | 61.3 | 60.6 | 72.5 | 75.2 | 69.4 | 74.3 | 67.7 | 70.0 |
| 5 | 61.3 | 60.6 | 71.6 | 75.8 | 71.0 | 71.9 | 68.0 | 69.4 |
| 6 | 60.6 | 61.7 | 74.1 | 74.5 | 69.9 | 73.2 | 68.2 | 69.8 |
| 7 | 59.5 | 60.0 | 71.0 | 75.8 | 69.0 | 75.8 | 66.5 | 70.5 |
| 8 | 60.6 | 63.5 | 71.4 | 76.3 | 67.5 | 75.6 | 66.5 | 71.8 |
| 9 | 59.7 | 62.6 | 69.0 | 73.2 | 65.7 | 76.1 | 64.8 | 70.6 |
| 10 | 58.2 | 61.7 | 68.6 | 69.4 | 64.4 | 77.2 | 63.7 | 69.4 |
| 11 | 56.4 | 60.0 | 63.7 | 63.3 | 62.6 | 76.7 | 60.9 | 66.7 |
| 12 | 56.0 | 58.6 | 61.3 | 65.0 | 62.4 | 72.5 | 59.9 | 65.4 |
| 13 | 55.3 | 57.1 | 60.4 | 64.2 | 59.5 | 71.0 | 58.4 | 64.1 |
| 14 | 54.0 | 55.6 | 59.3 | 63.5 | 56.9 | 72.1 | 56.7 | 63.7 |
| 15 | 50.5 | 52.0 | 58.0 | 62.4 | 56.9 | 70.1 | 55.1 | 61.5 |
| 16 | 47.6 | 52.0 | 57.3 | 60.8 | 57.1 | 61.1 | 54.0 | 58.0 |
| 17 | 48.7 | 52.2 | 54.9 | 58.2 | 57.5 | 58.4 | 53.7 | 56.3 |
| 18 | 47.8 | 51.4 | 52.9 | 57.3 | 56.0 | 58.2 | 52.2 | 55.6 |
| 19 | 47.4 | 49.6 | 53.8 | 56.2 | 54.9 | 57.1 | 52.0 | 54.3 |
| 20 | 47.2 | 50.0 | 52.9 | 54.5 | 54.2 | 53.1 | 51.4 | 52.5 |
| 21 | 45.6 | 49.6 | 52.9 | 53.8 | 52.7 | 52.7 | 50.4 | 52.0 |
| 22 | 45.0 | 49.6 | 51.8 | 52.5 | 51.6 | 51.8 | 49.5 | 51.3 |
| 23 | 43.6 | 49.6 | 50.7 | 49.2 | 50.7 | 48.5 | 48.3 | 49.1 |
| 24 | 43.2 | 48.9 | 50.5 | 47.6 | 51.4 | 45.9 | 48.4 | 47.5 |
| 25 | 42.5 | 48.3 | 50.0 | 46.3 | 49.6 | 46.1 | 47.4 | 46.9 |
| 26 | 42.8 | 46.5 | 50.0 | 43.4 | 49.4 | 45.2 | 47.4 | 45.0 |
| 27 | 41.7 | 45.4 | 48.9 | 41.0 | 50.0 | 43.2 | 46.9 | 43.2 |
| 28 | 41.0 | 46.3 | 48.1 | 39.2 | 48.7 | 41.9 | 45.9 | 42.5 |
| 29 | 40.6 | 44.5 | 46.7 | 38.8 | 47.6 | 40.3 | 45.0 | 41.2 |
| 30 | 39.2 | 45.2 | 46.3 | 37.7 | 41.2 | 39.5 | 42.2 | 40.8 |
| 31 | 38.1 | 45.2 | 45.2 | 36.8 | 40.6 | 35.3 | 41.3 | 39.1 |
| 32 | 36.6 | 43.4 | 42.5 | 36.2 | 40.3 | 29.8 | 39.8 | 36.5 |
| 33 | 37.0 | 42.3 | 40.8 | 34.4 | 38.6 | 32.0 | 38.8 | 36.2 |
| 34 | 37.7 | 41.9 | 37.7 | 32.6 | 35.5 | 32.4 | 37.0 | 35.6 |
| 35 | 36.6 | 40.3 | 35.7 | 30.9 | 32.6 | 31.5 | 35.0 | 34.2 |
| 36 | 36.2 | 39.9 | 33.1 | 27.8 | 29.5 | 30.2 | 32.9 | 32.6 |
| 37 | 33.7 | 36.4 | 30.2 | 25.8 | 26.2 | 29.1 | 30.0 | 30.4 |
| 38 | 32.2 | 32.6 | 27.6 | 23.6 | 22.7 | 27.1 | 27.5 | 27.8 |
| 39 | 29.5 | 30.0 | 24.0 | 21.8 | 19.8 | 26.7 | 24.4 | 26.2 |
| 40 | 27.1 | 26.9 | 21.8 | 19.4 | 16.1 | 23.4 | 21.7 | 23.2 |
| 41 | 24.0 | 24.2 | 19.0 | 17.4 | 14.3 | 21.4 | 19.1 | 21.0 |
| 42 | 21.8 | 22.0 | 15.9 | 15.4 | 12.3 | 19.2 | 16.7 | 18.9 |
| 43 | 18.7 | 19.4 | 12.8 | 13.2 | 10.4 | 17.2 | 14.0 | 16.6 |
| 44 | 16.3 | 17.0 | 9.3 | 11.7 | 8.2 | 13.0 | 11.3 | 13.9 |
| Average, 44 weeks | 44.0 | 46.7 | 48.9 | 48.0 | 47.2 | 49.6 | 46.7 | 48.1 |

Table 26. *Average daily 4% fat-corrected milk production, by weeks, for 5 young cows*

| Week | Year 1 | | Year 2 | | Year 3 | | Average 3 years | |
|---|---|---|---|---|---|---|---|---|
| | Group | | Group | | Group | | Group | |
| | 1 | 3 | 1 | 3 | 1 | 3 | 1 | 3 |
| | pounds | | | | | | | |
| 1 | 45.4 | 42.5 | 60.0 | 73.6 | 61.5 | 64.8 | 55.6 | 60.3 |
| 2 | 59.7 | 54.0 | 73.0 | 82.0 | 65.0 | 76.5 | 65.9 | 70.8 |
| 3 | 60.6 | 53.1 | 76.9 | 76.9 | 68.8 | 73.9 | 68.8 | 68.0 |
| 4 | 59.7 | 58.0 | 78.5 | 78.0 | 68.3 | 76.5 | 68.8 | 70.8 |
| 5 | 63.5 | 57.3 | 70.8 | 78.7 | 69.9 | 76.1 | 68.1 | 70.7 |
| 6 | 59.7 | 58.2 | 70.3 | 72.1 | 69.2 | 75.2 | 66.4 | 68.5 |
| 7 | 59.5 | 55.8 | 73.0 | 69.2 | 66.1 | 70.8 | 66.2 | 65.3 |
| 8 | 58.6 | 58.4 | 72.3 | 71.2 | 64.8 | 71.2 | 65.2 | 66.9 |
| 9 | 58.2 | 54.5 | 67.0 | 67.5 | 65.7 | 72.1 | 63.6 | 64.7 |
| 10 | 58.2 | 55.8 | 64.4 | 64.6 | 62.2 | 72.1 | 61.6 | 64.2 |
| 11 | 55.1 | 52.7 | 63.5 | 60.4 | 62.2 | 65.0 | 60.3 | 59.4 |
| 12 | 52.9 | 58.9 | 58.2 | 65.7 | 58.9 | 67.0 | 56.7 | 63.9 |
| 13 | 53.1 | 50.7 | 60.0 | 59.5 | 56.9 | 58.0 | 56.7 | 56.1 |
| 14 | 52.7 | 52.0 | 62.4 | 55.3 | 56.2 | 63.3 | 57.1 | 56.9 |
| 15 | 49.4 | 48.9 | 62.2 | 58.9 | 56.0 | 61.7 | 55.9 | 56.5 |
| 16 | 49.2 | 48.7 | 54.7 | 55.8 | 56.0 | 58.2 | 53.3 | 54.2 |
| 17 | 47.0 | 48.7 | 52.0 | 54.0 | 55.1 | 54.0 | 51.4 | 52.2 |
| 18 | 46.5 | 45.6 | 46.5 | 54.0 | 55.8 | 52.2 | 49.6 | 50.6 |
| 19 | 46.3 | 47.8 | 54.5 | 51.1 | 52.9 | 49.2 | 51.2 | 49.4 |
| 20 | 45.2 | 46.7 | 49.8 | 54.0 | 53.6 | 50.7 | 49.5 | 50.5 |
| 21 | 44.5 | 45.2 | 51.1 | 55.6 | 51.6 | 49.4 | 49.1 | 50.1 |
| 22 | 43.9 | 44.5 | 52.0 | 48.3 | 52.2 | 48.7 | 49.4 | 47.2 |
| 23 | 42.8 | 44.5 | 51.1 | 45.0 | 49.6 | 44.3 | 47.8 | 44.6 |
| 24 | 43.0 | 45.0 | 50.3 | 45.4 | 51.6 | 42.3 | 48.3 | 44.2 |
| 25 | 43.2 | 43.2 | 50.5 | 40.6 | 49.4 | 42.5 | 47.7 | 42.1 |
| 26 | 42.3 | 41.9 | 49.6 | 39.0 | 50.3 | 41.7 | 47.4 | 40.9 |
| 27 | 42.3 | 41.0 | 48.9 | 37.9 | 49.2 | 40.6 | 46.8 | 39.8 |
| 28 | 41.4 | 44.8 | 48.7 | 37.3 | 48.5 | 40.3 | 46.2 | 40.8 |
| 29 | 40.6 | 42.8 | 44.8 | 35.0 | 48.7 | 36.2 | 44.7 | 38.0 |
| 30 | 40.6 | 42.1 | 46.7 | 37.7 | 41.9 | 36.8 | 43.1 | 38.9 |
| 31 | 38.8 | 41.7 | 47.2 | 33.3 | 42.5 | 32.4 | 42.8 | 35.8 |
| 32 | 37.0 | 41.4 | 43.0 | 34.2 | 40.8 | 28.4 | 40.3 | 34.7 |
| 33 | 38.8 | 39.7 | 40.8 | 32.4 | 39.5 | 30.4 | 39.7 | 34.2 |
| 34 | 38.8 | 39.9 | 37.7 | 30.9 | 35.9 | 31.1 | 37.5 | 34.0 |
| 35 | 37.7 | 37.9 | 37.0 | 29.1 | 33.3 | 29.3 | 36.0 | 32.1 |
| 36 | 36.6 | 38.6 | 34.0 | 27.3 | 29.8 | 29.3 | 33.5 | 31.7 |
| 37 | 34.2 | 35.7 | 32.4 | 24.5 | 27.1 | 27.1 | 31.2 | 29.1 |
| 38 | 32.6 | 32.8 | 28.2 | 22.7 | 23.6 | 25.8 | 28.1 | 27.1 |
| 39 | 30.0 | 30.0 | 24.5 | 20.5 | 20.9 | 24.5 | 25.1 | 25.0 |
| 40 | 28.7 | 27.6 | 21.8 | 18.7 | 16.1 | 20.9 | 22.2 | 22.4 |
| 41 | 24.7 | 24.0 | 20.0 | 17.2 | 14.3 | 19.8 | 19.7 | 20.3 |
| 42 | 22.9 | 22.3 | 15.9 | 15.4 | 12.1 | 20.3 | 17.0 | 19.3 |
| 43 | 19.6 | 20.5 | 13.2 | 13.4 | 10.6 | 16.3 | 14.5 | 16.7 |
| 44 | 17.2 | 16.3 | 9.9 | 11.2 | 8.4 | 14.3 | 11.8 | 13.9 |
| Average, 44 weeks | 44.1 | 43.9 | 49.3 | 46.7 | 47.1 | 47.3 | 46.9 | 46.0 |

As mentioned earlier, space limitations and publication cost did not permit inclusion of all tables for the 15 cows in groups 1 and 3, but a complete list of tables is available from the authors upon request. Also available are tables with weights expressed in kilograms rather than in pounds.

## Reproductive Performance

The experimental cows were turned out at least once a day and observed for signs of estrus. Special attention was given to those expected to be in estrus; these were turned out twice or more a day if no signs of estrus had been noted during the routine exercise period, and were watched for approximately 20 minutes each time. Post-partum examinations of each cow's genital organs were begun within a week after calving and continued twice weekly, or oftener if necessary, until 75 days after pregnancy. Then each cow was examined at least once a month through the fifth month of pregnancy. Uterine and cervical size and tone were determined and recorded to define the rate of involution of the postparturient uterus and cervix.

All ovarian changes including regression of the corpus luteum in the postparturient period, persistence of smooth nonfunctional ovaries, silent estrus, first postparturient ovulation, cystic follicles, cystic corpus luteum, various ovarian changes, and any abnormalities of the ovaries or genital organs were recorded. Any abnormalities noted during routine examinations were treated by the veterinarian.

If genital health was normal, each cow was bred during the first estrus period after she had been fresh 60 days. The service sire for all cows during a particular lactation on experiment was the same. In addition, each cow was bred with frozen semen from the same ejaculate to eliminate semen quality as a variable affecting across-treatment groups within a particular lactation on experiment.

## Standing and Silent Estrus with Ovulation

Standing estrus was considered to have occurred when the cow stood to be mounted. It was recorded in relation to date at time of initial observation, regardless of the duration of estrus. Each estrous period was verified by palpation *per rectum* to identify a follicle and/or at time of routine genital examination to determine the presence or absence of a corpus luteum on the ovary after the development and rupture of a follicle.

Silent estrus was characterized by the presence of a mature follicle (15-20 mm in diameter) in conjunction with increased uterine tone, hyperemia and edema of the vulva, and a mucous discharge from the vulva. Silent estrus was considered to have occurred when no behavioral signs of standing estrus were observed, even though the other signs were present. It was recorded as occurring 1 day before ovulation as detected by palpation *per rectum.* The estrous cycle was the period measured in days between a consecutive silent or standing estrus to either of the next one of these. The first estrus and ovulation or ovulation from a silent period identified the interval from parturition to the first estrus and/or ovulation.

***Postpartum estrous cycle intervals and silent estrus before time for service.*** Follicular activity began soon after parturition and was detected by palpation *per rectum* in most cows 10 days after parturition. These follicles continued to grow until the time of first estrus and ovulation. Occasionally the first estrus was anovulatory. When ovulation failed to occur, most follicles enlarged to form cysts. The mean interval from parturition to the first silent or standing estrus and ovulation was 22.9 days for the 40 cows in groups 1 to 4 during the 3 lactations (table 27). An interval of 20.4 days was previously reported for 139 cows during one lactation by Morrow *et al.* (1969a). The interval ranged from 19.3 days for group 3 to 27.9 days for group 4 (figure 27). These differences approached significance at the 0.05 level of probability. The interval for group 4 was prolonged due to periparturient diseases, previously reported by Morrow *et al.* (1969a), to delay the onset of first estrus. There was an indication in this research that the all-corn silage and liberal concentrate diet had an indirect effect on prolonging the interval from parturition to first ovulation. In another study of 206 calving intervals, by Saiduddin *et al.* (1967), the interval

Table 27. *Estrous cycle and related criteria, 40 experimental cows during 3 lactations*

| Criteria | Groups* | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | Mean |
| 1. Calving to first ovulation (days) | 23.6 | 21.0 | 19.3 | 27.9 | 22.9 |
| 2. Estrous cycle length (days) | | | | | |
| First to second estrus | 20.2 | 19.8 | 19.9 | 21.8 | 19.9 |
| Second to third estrus | 22.0 | 22.0 | 21.1 | 23.3 | 21.2 |
| 3. Standing estrus before breeding (percent) | | | | | |
| First | 17 | 29 | 17 | 0 | 16 |
| Second | 39 | 13 | 33 | 45 | 32 |
| Third | 60 | 10 | 33 | 67 | 38 |
| 4. Standing estrus at time of breeding (percent) | | | | | |
| First | 79 | 93 | 76 | 78 | 82 |
| Second | 91 | 100 | 89 | 100 | 95 |
| Third | 100 | 67 | 63 | 100 | 79 |
| 5. Ovarian activity before breeding during first 60 postpartum days (percent) | | | | | |
| Corpora lutea | 67 | 60 | 54 | 61 | 61 |
| Cystic corpora lutea | 11 | 9 | 13 | 6 | 10 |
| Cystic follicles | 22 | 31 | 33 | 33 | 29 |
| 6. Ovarian activity during time of breeding, starting 60 days after parturition (percent) | | | | | |
| Corpora lutea | 72 | 76 | 72 | 75 | 74 |
| Cystic corpora lutea | 23 | 22 | 21 | 25 | 22 |
| Cystic follicles | 5 | 2 | 7 | 0 | 4 |
| 7. Calving interval (days) | 374 | 411 | 400 | 392 | 394 |
| 8. Services per conception | 1.6 | 2.0 | 1.9 | 1.9 | 1.8 |
| 9. Abortions (percent of cows calving) | 6 | 11 | 4 | 25 | 10 |
| 10. Retained placenta (percent) | 7 | 0 | 7 | 8 | 6 |

*Group 1, control; group 2, liberal grain; group 3, restricted forage and liberal grain; group 4, all-corn silage and liberal grain.

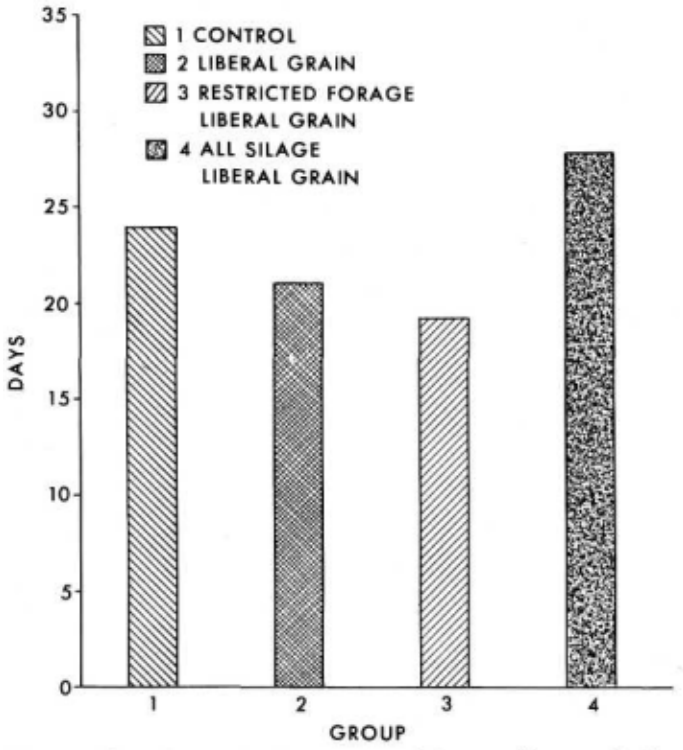


Figure 27. *Intervals from parturition to first ovulation.*

from parturition to first estrus was 32 days for the controls and 37 days in the high-concentrate group ($P<0.1$).

The second estrus and ovulation occurred 19.9 days after the first; the third occurred 21.2 days after the second. The small variation between treatment groups indicated that liberal grain feeding did not affect the interval between ovulations, nor did the other treatments. The interactions between treatment groups and years were not significant ($P>0.05$).

A standing estrus and ovulation occurred in 16 percent of the first ovulations, 32 percent of the second, and 38 percent of the third (table 27). The mean percentage of standing estrous periods for the first 3 postpartum cycles in 50 cows during a 3-year period was 27 percent. In a previous study by Morrow, Roberts and McEntee (1969a), 43 percent of 139 cows showed standing estrus during the first 3 estrous periods. The occurrence of standing estrus in this previous study also increased with each subsequent cycle. The greatest percentage of standing estrous periods occurred in group 1, controls; but this number was not significantly greater than for the 3 groups fed liberal grain ($P>0.05$). In another study by Saiduddin *et al.* (1967) for 206 calving intervals, the proportion of first postpartum ovulations accompanied by standing estrus was 67 percent for controls and 51 percent for cows fed high concentrates ($P<0.05$).

*Standing and silent estrus during time of breeding after 60 days following parturition.* Standing estrus was observed in 85 percent of 164 first, second, and third breedings (table 27). Differences between treatment groups were not significant ($P>0.05$). The time for the other 15 percent of the breedings during silent estrus was based on follicle size and uterine tone determined by palpation *per rectum.* The conception rate was 1.8 for both groups of cows bred during silent and standing estrus. Previously Trimberger and Fincher (1956) had reported identical conception rates (65 percent) for cows bred during silent estrus and during standing estrus.

The major difficulty in breeding cows during silent estrus was to time the service properly in relation to ovulation. This required daily or twice daily palpations of the reproductive tract *per rectum.* The uterus was firm and turgid during proestrus. The ovaries contained one or more follicles 10 to 20 millimeters in diameter. There was a mucous discharge from the hyperemic edematous vulva near the onset of estrus. During estrus the uterus became more pliable and had a silky edematous feeling on palpation *per rectum.* A thin-walled 20- to 25-millimeter follicle was present. It was quite firm in consistency early in estrus but began to soften as ovulation approached.

Liberal grain feeding did not significantly increase the occurrence of silent estrus and ovulation at breeding, but the relatively high rate in all 4 groups may possibly have been related to the confinement and lack of exercise. The cows were confined to a stanchion barn for 22 or 23 hours daily during the 3-year period. The results of this study document the difficulty frequently encountered in estrus detection and indicate the need for improved estrous-synchronization methods for dairy cattle.

***Normal corpora lutea.*** The corpus luteum of pregnancy regressed rapidly until 14 days after parturition and did not delay the expulsion of uterine lochia at 4 to 14 days after parturition. The corpus luteum of pregnancy at 10 to 14 days after parturition closely resembled a small, developing, thick-walled follicle when palpated *per rectum.* It was difficult to palpate after this period.

Normal corpora lutea occurred after 61 percent of the 196 postpartum ovulations during the 60-day postpartum period before breeding (table 27). Another study by Morrow *et al.* (1966) reported that normal corpora lutea developed after 62 percent of 357 postpartum ovulations. The variation in the number of corpora lutea between groups (figure 28) for cycles during the 60-day postpartum period was not significant ($P>0.05$). The proportion of normal corpora lutea increased from the first to the third postpartum cycles as the occurrence of cystic follicles decreased.

A persistent or retained corpus luteum was not observed during the 196 postpartum cycles. Cycles longer than 25 days were occasionally observed in cows in poor physical condition; but the corpus luteum in these cows began to regress about the 17th day of the cycle and the ovaries were inactive for a variable period. These cows had no follicular activity, and their estrous cycles did not begin until their physical condition approached normal again.

Normal corpora lutea developed during 74 percent of 164 cycles during time of breeding starting 60 days after

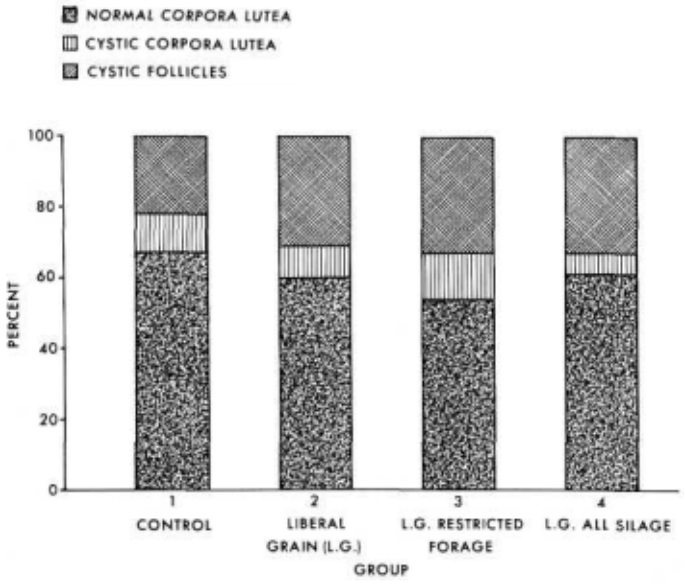


Figure 28. *Ovarian activity during first 60 days after parturition.*

calving (table 27). The variation between treatment groups ranged from 72 percent for groups 1 and 3 to 76 percent for group 2 (figure 29). These differences were not significant **(P>0.05).**

***Cystic corpora lutea.*** The cystic corpus luteum was a smooth spherical, fluctuating mass, with a fluid-filled central cavity approximately 10 millimeters or more in diameter which developed in the ovary after ovulation. It was often larger than a normal corpus luteum and was most easily diagnosed at the 5th to 10th day of the cycle. The cystic corpus luteum can be differentiated from the an-ovulatory luteinized follicle by a rosette of lutein tissue usually present at the site of ovulation.

Cystic corpora lutea occurred after 10 percent of 196 cycles during the 60-day postpartum period (table 27). Another study by Morrow *et al.* (1966) reported that cystic corpora lutea developed after 25 percent of 357 postpartum ovulations. The variation in the number of cystic corpora lutea between groups or cycles during the 60-day postpartum period was not significant (P>0.05). Cystic corpora lutea did not affect the length of the subsequent estrous cycle in this study or in a previous one reported by Morrow, Roberts, and McEntee (1969a). The interval was essentially the same after the formation of cystic corpora lutea and normal corpora lutea.

Cystic corpora lutea developed during 22 percent of 164 breeding cycles (table 27). The variation between treatment groups ranged from 21 percent for group 3 to 25 percent for group 4 (figure 29), and was not significant (P>0.05).

In the study by Morrow, Roberts, and McEntee (1969a), cystic corpora lutea occurred at time of conception in 18 percent of 190 cows and seemed to have no adverse effect on pregnancy. In both studies, the central fluid-filled cyst eventually filled in with luteal or connective tissue, the fluid was absorbed, and the cyst disappeared during the first 2 to 3 months of pregnancy.

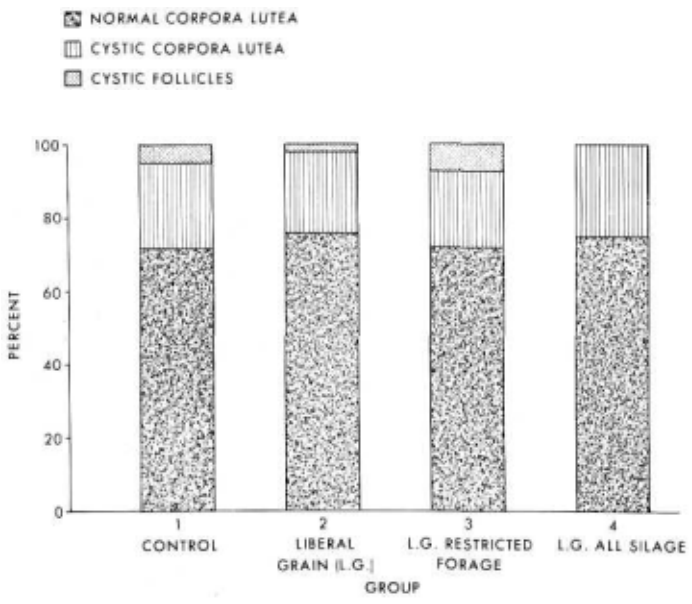


Figure 29. *Ovarian activity during time of breeding, starting 60 days after parturition.*

***Cystic follicles.*** A cystic follicle was one larger than 2.5 centimeters in diameter on 3 successive examinations in a 10-day period. Luteal cysts (anovulatory luteinized follicles) were difficult to differentiate from cystic follicles in a *per rectum* examination. The apparent frequency was low, and they were included in the same category with follicular cysts.

The postpartum follicular cysts were usually large single ones on one or both ovaries. The primary behavioral sign associated with these follicular cysts was anestrus rather than nymphomania.

The mean occurrence of cystic follicles for 196 postpartum cycles was 29 percent (table 27). In another study by Morrow *et al.* (1966), cystic follicles developed after only 12 percent of 357 ovulations. There was no explanation for the relatively high occurrence of cystic follicles in this study; it was greater for the 3 liberal-grain-fed groups than for the controls, and the difference approached significance at the 5 percent level of probability. Most cystic follicles occurred before and during first estrus in all treatment groups. The cows with cystic follicles were not treated until 60 days after parturition unless there were signs of nymphomania. Cystic follicles were noted in 4 percent of the cycles at time of breeding, as compared with 10 and 7 percent, respectively, in two groups of 200 cows (Trimberger and Fincher, 1956). The differences in ovarian activity, especially in cystic follicles during the first 60 postpartum days and during time of breeding starting 60 days after birth, again reflect on the soundness of the recommendation to withhold service until cows have reached the minimum of 60 days after parturition. The increased occurrence of standing estrus after the 60-day postpartum period also supports the recommendation. It is further substantiated by conception rates at various intervals after parturition reported by Trimberger (1954).

## Calving Interval and Services per Conception

The calving interval, defined as the period from one parturition to the next, and services per conception were the final criteria used to determine the effect of liberal grain feeding on reproduction. These two measures of breeding efficiency were recently reviewed by Morrow, Roberts, and McEntee (1969). The number of services per conception (average of 1.8) was computed by dividing the total number of services to fertile cows by the number of conceptions. This eliminated 1 cow each from groups 3 and 4 because they were not pregnant at 305 days of lactation, and they were sold.

Services required per conception were 1.6, 2.0, 1.9, and 1.9 for the control, liberal grain, restricted forage with

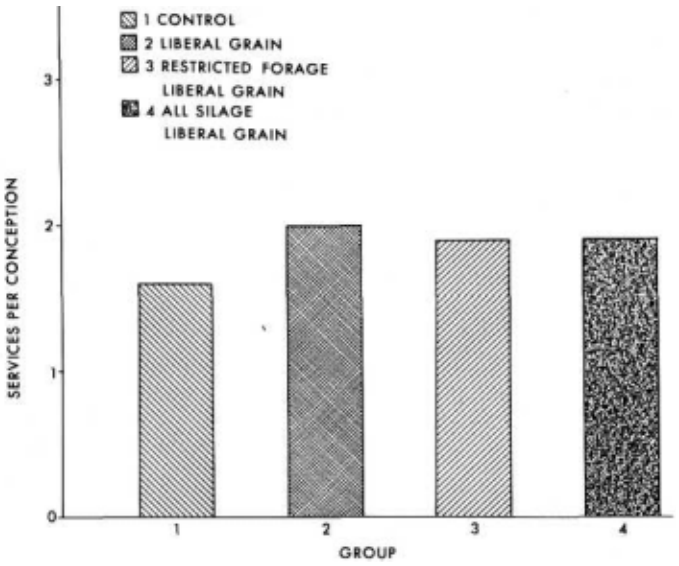


Figure 30. *Services required per conception, 3-year acerage.*

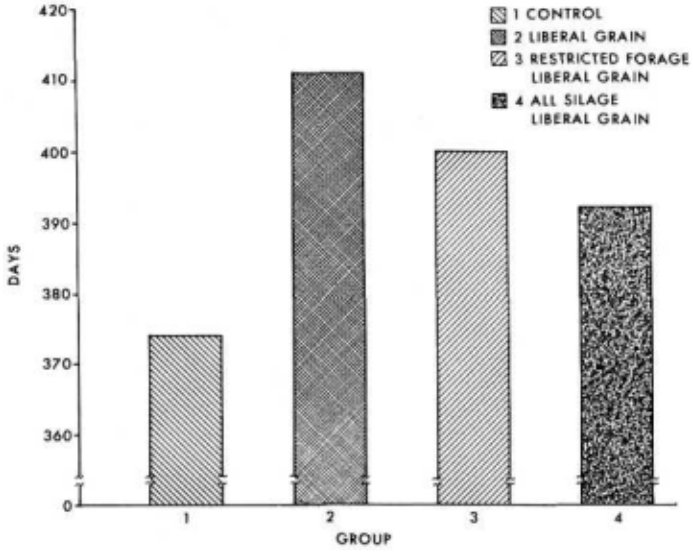


Figure 31. *Calving interval, in days, 3-year average.*

liberal grain, and the all-silage, liberal grain groups, re-spectivley (figure 30). The differences were not significant ($P>0.05$).

The 94 cows that conceived had an average calving interval of 394 days and required 1.8 services per conception (table 27). The cows in groups 2, 3, and 4, fed a liberal grain ration, had significantly longer calving intervals ($P<0.01$) than the average of 374 days for the control cows (figure 31). The average calving interval for groups 2, 3, and 4 was 411, 400, and 392 days, respectively. Results from a 4-year study by Armstrong *et al.* (1966) with 170 cows fed varying levels of concentrates from 464 to 4790 kilograms per lactation indicated that high levels of concentrate feeding were not related to the conception rate. Gardner (1969) found no significant differences in calving intervals from low and high prepartum and post-partum feeding.

Twelve cows were bred 4 or more times to achieve conception. A uterine biopsy was taken for histologic examination after the fourth service to these cows. They were all negative for endometritis, which helped to rule out uterine infection as a cause of infertility.

Ten abortions were detected in 40 cows during the 3-year period, representing about 10 percent of the parturitions. Three of the 4 abortions in group 4 occurred in the same cow at 84, 84, and 86 days of gestation. The 10 abortions all occurred early in the gestation period at approximately the same time that the cow would have been expected to come into estrus had she not conceived.

Close observation was responsible for detecting some of these abortions and was possibly related to the relatively high occurrence. In other studies (Wiltbank *et al,* 1961), fetal mortality was recorded in 9.0 percent of 53 cows from 35 to 80 days after conception, and in 7.9 percent of 452 cows from 28 to 95 days after conception (Belling, 1964). Abortions were detected by Morrow (1968) in 8 percent of 290 conceptions in 1 herd during a 6-year period.

In our study, there were 2 cows with retained placenta in each of groups 1, 3, and 4, and none in group 2. The percentages of retained placenta were 7 in group 1, 7 in group 3, and 8 in group 4. When combined with group 2 the overall average for all 4 groups was 6 percent of retained placenta, which is very satisfactory.

### Conclusions

The interval from parturition to first estrus and the subsequent estrous intervals were not affected by liberal concentrate feeding in the 50 cows studied during the 3-year period. The occurrence of standing estrus and ovula-tion during the first 60 postpartum days and the first 3 estrous periods during time of breeding starting 60 days after parturition were not affected by liberal concentrate feeding. The occurrence of normal corpora lutea, cystic corpora lutea, and cystic follicles during the 196 post-partum and 164 breeding estrous cycles was not significantly affected by liberal concentrate feeding. But cystic follicles occurred more frequently during the first 60 post-partum days in the cows fed concentrates liberally. The cows fed a liberal concentrate ration had significantly longer calving intervals and required more services per conception than the controls.

## General Health Aspects

In addition to reproductive health, complete health records were kept on each cow throughout the experiment. The aim was to study the effects of liberal grain feeding

on wearability, general health, and incidence of mastitis over 3 consecutive lactations in high-producing cows.

Previous reports by Emery *et al.* (1969) indicated that prepartum feeding of grain at high levels increased the incidence of milk fever and mastitis but had no effect on metritis, retained placenta, and indigestion. Armstrong *et al.* (1966) reported that high levels of grain feeding involving 170 cows over a 4-year period showed no relation to the incidence of diseases such as mastitis, metritis, keto-sis, and indigestion.

Various health disorders treated were: mastitis by udder quarter, both clinical and acute; various "off-feed" conditions such as ketosis, indigestion, scours, milk fever, foreign bodies; abomasal displacement; lameness due to various causes such as hoof rot, cracked heel, bruise, or unknown cause; and various types of udder injuries.

## Veterinary Attention and Treatments

A summary of non-reproductive diseases is presented in table 28. The purpose was to differentiate between cows that required treatment on several consecutive days or occasions and those that responded to a single treatment. The cow-year, computed by dividing the total number of cow-days in each group by 365, corrects for differences in number of cows among groups and also the length of time cows survived or that they required to complete 3 lactations. There were 15, 10, 15, and 10 cows respectively in groups 1 to 4 at the start of the experiment.

***Mastitis.*** Information on clinical mastitis with an average of 10.42 treatments per cow-year, and on acute mastitis with an average of 0.72 treatments per cow-year, is given in table 28. The low number of acute-mastitis cases indicated that the experimental cows were relatively free from mastitis. No group had any chronic-mastitis cows to seriously bias the figures. There were no statistically significant differences in the incidence of mastitis among the cows of the various groups.

***Displaced abomasum.*** Control group 1 and group 2 (liberal grain) each had 2 cases of displaced abomasum, but the incidence was much higher in the other 2 groups for the cows on restricted forage and the all-corn-silage rations with liberal grain. These differences were significant at the 5 percent level.

Abomasal displacements corrected by surgery to avoid recurrence included 2 cows in the controls, 2 in group 2, 5 in group 3, and 4 in group 4.

In evaluating the incidence of displaced abomasum and surgery to correct the situation, it should be considered that groups 1 and 3 each started with 15 cows, as compared to only 10 each in groups 2 and 4. Also, 2 cows in group 4 had surgery to avoid recurrence of displaced abomasum a year before starting on experiment, which limits

Table 28. *Non-reproductive diseases summary*

| Abnormal condition* | Group 1 Treatments† | | Group 2 Treatments† | | Group 3 Treatments† | | Group 4 Treatments† | | All cows Treatments† | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Per cow-year | Total | Per cow-year | Total | Per cow-year | Total | Per cow-year | Total | Per cow-year |
| Clinical mastitis | 536 | 12.72 | 308 | 10.81 | 224 | 5.56 | 284 | 15.12 | 1352 | 10.42 |
| Left rear | 135 | | 91 | | 70 | | 61 | | | |
| Left fore | 140 | | 54 | | 51 | | 48 | | | |
| Right rear | 119 | | 81 | | 46 | | 75 | | | |
| Right fore | 142 | | 82 | | 57 | | 100 | | | |
| Acute mastitis | 38 | 0.90 | 13 | 0.46 | 18 | 0.45 | 24 | 1.28 | 93 | 0.72 |
| Left rear | 13 | | 8 | | 2 | | 6 | | | |
| Left fore | 2 | | 3 | | 2 | | 5 | | | |
| Right rear | 11 | | 1 | | 8 | | 6 | | | |
| Right fore | 12 | | 1 | | 6 | | 7 | | | |
| Ketosis | 25 | 0.60 | 25 | 0.89 | 37 | 0.92 | 36 | 1.89 | 123 | 0.95 |
| Milk fever treatment | 52 | 1.23 | 28 | 0.98 | 20 | 0.50 | 24 | 1.28 | 124 | 0.96 |
| To prevent | 4 | | 1 | | 2 | | 2 | | | |
| Regular | 28 | | 21 | | 15 | | 13 | | | |
| Continued paralysis | 20 | | 6 | | 3 | | 9 | | | |
| Sore feet or lameness | 6 | 0.14 | 13 | 0.46 | 13 | 0.32 | 2 | 0.11 | 34 | 0.26 |
| Hoof rot | 0 | | 0 | | 1 | | 0 | | | |
| Cracked heel | 1 | | 1 | | 0 | | 0 | | | |
| Bruise | 1 | | 0 | | 0 | | 1 | | | |
| No diagnosis | 4 | | 12 | | 12 | | 1 | | | |
| Udder injuries | 1 | 0.02 | 18 | 0.63 | 8 | 0.20 | 10 | 0.53 | 37 | 0.28 |
| Scours | 3 | 0.07 | 1 | 0.04 | 7 | 0.18 | 3 | 0.16 | 14 | 0.11 |
| Foreign body | 2 | 0.05 | 1 | 0.04 | 2 | 0.05 | 1 | 0.05 | 6 | 0.05 |
| Undetermined sickness | 3 | 0.07 | 4 | 0.14 | 6 | 0.15 | 4 | 0.21 | 17 | 0.13 |
| Other treatments | 8 | 0.19 | 10 | 0.35 | 12 | 0.30 | 3 | 0.16 | 33 | 0.25 |

*The information for displaced abomasum was not included but is discussed in the text. There were 2, 2, 5, and 4 cases of displaced abomasum in groups 1 to 4, respectively, that received surgery to avoid recurrence.

†During years 1, 2, and 3 the following numbers were in each group respectively: control group 1: 15, 14, and 14; group 2, liberal grain: 10, 9, and 8; group 3, restricted forage, liberal grain: 15, 13, and 12; group 4, all-corn silage, liberal grain: 10, 8, and 1.

group 4 to 8 possibilities for displaced abomasum. The veterinary costs involved for this surgery must be considered from the economic standpoint. In addition to the cows that had surgery, 9 others in group 3, and 6 in group 4, had a displaced abomasum, accompanied by a decrease in appetite and lower production during the time of treatment. After recovery from surgery, the cows resumed high production; in 2 groups the highest producer was a cow on which surgery had been performed to correct a displaced abomasum. Some other cows that had recovered from displaced-abomasum surgery ranked among the highest producers in their respective groups.

Svendsen (1969, 1970) showed that high-concentrate feeding increased the amount and changed the composition of the fatty acids entering the abomasum. He found that the high-concentrate ration increased the amount of gas released and also increased the methane and carbon dioxide content of the gas. His results showed that the high-concentrate diet significantly decreased the rate of abomasal contractions. Almost identical results were obtained by the injection of 300 ml of rumen fluid from cows fed the high-concentrate diet into the abomasum of cows fed only hay. Injection of 300 ml of a solution containing a mixture of volatile fatty acids in concentrations equivalent to that of the rumen fluid from animals fed a high-concentrate diet produced similar results. This indicated that high concentrate feeding inhibited abomasal motility by increasing the amount and influencing the kind of fatty acids entering the abomasum. Svendsen (1970) concluded that the inhibition of abomasal motility and the increase in abomasal gas production may be the cause of abomasal displacement in cows fed a high-concentrate diet. The feeding of large quantities of grain causes a large volume of ingesta to enter the abomasum while the abomasal motility is inhibited by the increased volatile fatty acid concentration. As a consequence, both fluid and gas may accumulate to cause abomasal displacement.

This also emphasizes the importance of feeding high-quality forage *ad lib.* with liberal concentrate feeding; e.g. the cows in group 2 had less trouble with displaced abomasum than those in group 3 (restricted forage, liberal grain) and those in group 4 (all-corn silage and liberal grain). Occasionally, however, some cows on liberal grain feeding decrease forage intake on high grain consumption and thereby provide the conditions conducive to abomasal displacement.

*Off-feed for grain.* A cow to which excess grain was offered was listed as off-feed for grain if she had an average drop of 20 percent in grain intake for 2 successive days, or a 10 percent drop in grain intake for any particular week as compared to the previous week. Once cows go off-feed they return slowly and for this reason a particular cow was recorded off-feed only once per week. Thus the off-feed situations listed can be considered on a weekly basis.

During the first year most of those concerned with this research wished to see grain offered to cows in ample amounts at all times, regardless of appetite, so a cow was completely on *ad lib.* grain feeding until peak production was reached. When milk production declined from the peak for 2 consecutive weeks, then the liberal grain was adjusted to the amounts specified in appendix tables 2, 3, and 4.

For the second and third years of the experiment the grain allowance was modified to a daily total of 36 pounds until the sixth week before *ad lib.* feeding of grain was started. The exception to this was group 3 which had an additional 15 pounds of grain substituted in lieu of forage. Also once a cow indicated a lack of enthusiasm in her appetite for grain during the second and third years, the amount offered was temporarily reduced; this is considered good management in liberal grain feeding.

Differences between groups and the incidence of off-feed for grain during each year is presented in table 29. It is evident from the data shown that liberal grain feeding was conducive to cows going off-feed. This was especially pronounced during the first 6 weeks of lactation when appetities were not keen. In groups 1 and 2, the first 6-week period included 58 and 57 percent, respectively, of the weeks during which cows were off-feed. The cows in groups 3 and 4, with 33 and 30 percent, respectively, of the weeks off-feed included during the first 6 weeks, followed a different pattern. This may be due to continued liberal grain feeding with a base allowance of grain for forage replacement, throughout the lactation for group 3, and to the cumulative effect of additional corn grain in the silage, plus liberal grain, for group 4.

Thus groups 3 and 4 continually had more cases of off-feed later in the lactation than did groups 1 and 2. The latter followed the pattern previously reported by Trim-berger *et al.* (1963), in which appetite starts at a low point and increases progressively during the first several months of lactation. Warner (1963) outlined some of the factors involved in voluntary feed intake. Tremere, Merrill, and Loosli (1968) concluded from research on off-feed conditions and physiological changes involved in the rumen pH that a number of factors, acting separately or in combination with high ruminal acidity, cause the disturbance in appetite and off-feed conditions. Loosli (1963) cautioned about cows going off-feed if allowed excessive grain.

During the first year but not during succeeding lactations, some of the signs of acute indigestion or of acidosis syndrome noted in the liberal grain experiment were sore or tender feet due to laminitis with borderline cases of founder. This leads one to speculate that the change-over to feeding large amounts of grain early in the first lactation was too rapid and did not allow enough time for the cows to become adapted to such a feeding system. The sore feet condition, referred to as laminitis, is listed in

Table 29. *Cows off-feed for grain by groups, years, and number of cows involved**

| Group | Year 1 | | | Year 2 | | | Year 3 | | | 3 years | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cows | Cows off-feed | Weeks involved | Cows | Cows off-feed | Weeks involved | Cows | Cows off-feed | Weeks involved | Cows | Cows off-feed | | Weeks involved |
| | no. | no. | no. | no. | no. | no. | no. | no. | no. | no. | no. | % | no. |
| 1 | 10 | 4 | 7 | 9 | 1 | 1 | 9 | 1 | 4 | 28 | 6 | 21 | 12 |
| 2 | 10 | 9 | 35 | 9 | 4 | 12 | 8 | 7 | 32 | 27 | 20 | 74 | 79 |
| 3 | 10 | 7 | 19 | 8 | 6 | 20 | 7 | 5 | 18 | 25 | 18 | 72 | 57 |
| 4 | 10 | 7 | 14 | 6 | 6 | 37 | 1 | 1 | 2 | 17 | 14 | 82 | 53 |

*Off-feed for grain was based on a once-per-week basis when a cow had an average drop of 20 percent in grain intake for 2 successive days or a 10 percent drop in grain intake for a particular week as compared to the previous week, provided that excess grain was offered. There were 10 cows in each group at the start of the experiment.

table 28 and illustrated in figures 32 and 33. Kesler and Spahr (1964) reviewed the adverse effects observed in shifting too rapidly to high grain feeding.

The above suggests the advantage of a gradual change-over to liberal grain feeding, with a minimum of a month to properly condition the cow to large amounts of grain. This is probably still more important when cows have been on previous forage-feeding experiments or under a management procedure with major emphasis on feeding high-quality forage.

***Developments at calving time.*** A tabulation of normal or abnormal developments at calving time indicated a definite advantage for control group 1 and a specific disadvantage for group 4 on all-silage and liberal grain. About 85 percent of the calvings were normal in group 1. Next was group 3 (restricted forage and liberal grain) with 74 percent of normal calvings; then group 2 (liberal grain) with 57 percent; and last, **group 4,** with **only 40** percent. Apparently these results were influenced by a cow's ability to stand stress. **The** cows in group 4 seemed very deficient in this respect during the second and **third** calvings.

***Cow losses.*** Animals were removed from the experiment for 2 reasons — death and failure to conceive by the 305th day of lactation. The reasons for removal are listed by treatment group in table 30. Six of the 13 deaths were due to complications after calving. Included were: displaced abomasum, metritis which in 2 cows was secondary to retention of fetal membrane, acute mastitis, ketosis, and milk fever. A fatty liver and large amounts of abdominal fat were common findings in all of the cows that died. The clinical signs observed with these conditions did not

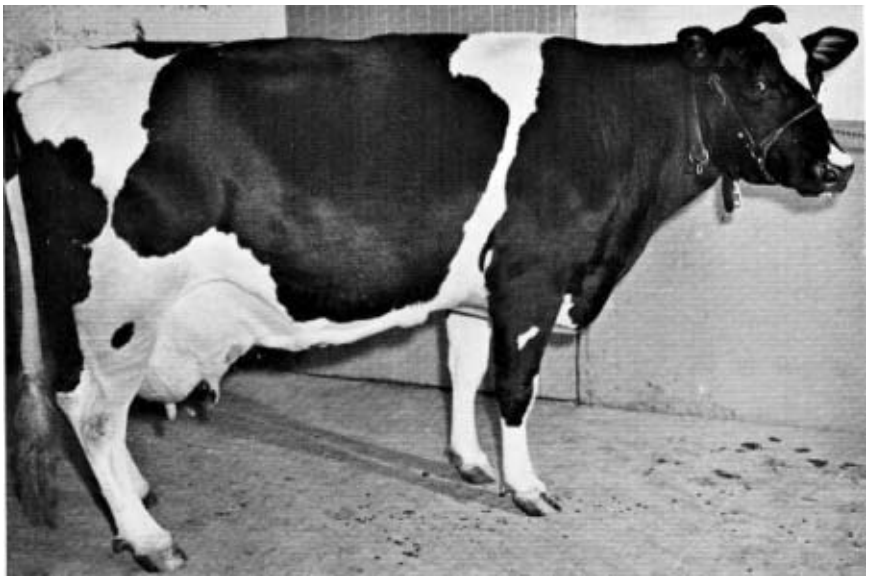

Figure 32. *Cow with sore feet resulting from too rapid increase in grain feeding early in lactation, year 1.*

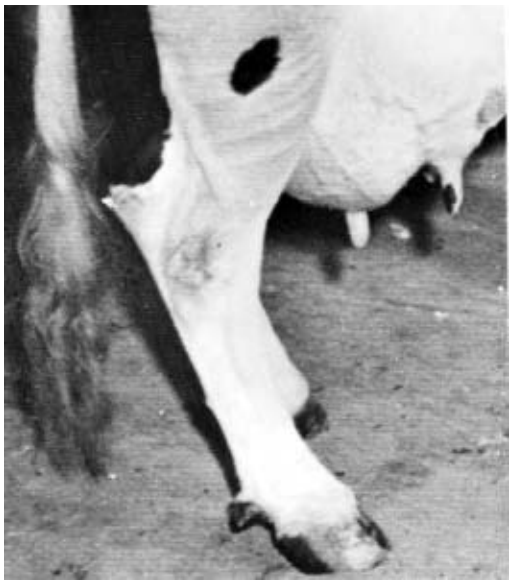

Figure 33. *Close-up of sore feet of cow shown at left.*

Table 30. *Reasons for removing cows from experiment during 3-year study*

| Group | Disease conditions | | | | |
|---|---|---|---|---|---|
| | Infertility | Mastitis * | Postpartum complications * | Other * | Total |
| 1 | 0 | 1 | 0 | 0 | 1 |
| 2 | 0 | 0 | 1 | 1 | 2 |
| 3 | 1 | 0 | 1 | 1 | 3 |
| 4 | 1 | 2 | 6 | 0 | 9 |
| | 2 | 3 | 8 | 2 | 15 |

* All cows listed died while on experiment.

seem severe enough to cause death, but the cows in group 4 were unable to tolerate the additional stress. The history of cows removed from the experiment due to postpartum complications is presented in table 31. Cows in control group 1 and in liberal grain groups 2 and 3 with similar disease conditions responded to treatment. The liberal grain feeding *per se* did not have a significant effect on cow losses in this study. Of the 6 cows lost from treatment groups 1, 2, and 3; 1 was lost as a result of sterility, 1 died of acute mastitis, 1 as a result of a tumor, 2 from difficulties associated with calving, and for 1 the primary cause was unknown.

A similar condition has been observed clinically in other herds in over-conditioned fresh cows permitted to remain on free-choice corn-silage diets during late lactation and for the duration of the dry period. This condition can be corrected and prevented by restricting the intake of concentrates and corn silage during late gestation to meet nutritional requirements, and by the simultaneous feeding of a small amount of hay. The effect on cow survival of corn silage as the sole source of roughage needs further evaluation and another experiment is now in progress. Thomas *et dl.* (1970) fed corn silage as the only roughage for 3 lactations, and maintained normal levels of milk production, reproduction, and health.

The high death losses in group 4 (all-corn silage and liberal grain ration fed continuously over 3 successive lactations) had not been experienced in any previous experiment or in the normal operation of the Cornell herd. This situation was considered alarming and challenging. A follow-up experiment is now in progress to determine whether these losses are repeatable; if so, we will attempt to determine the cause especially as it may concern the cow's ability to cope with stress, which is always high at, or shortly after, calving.

In evaluating the situation in relation to cow losses, consideration should be given to body condition as described from ratings each month (table 32). Differences in body condition were greater among groups during the dry period than during the months of lactation. But seldom did any receive a rating of very fat (1.0). Only one cow in group 2 and 2 in group 4 were rated excessively fat. All groups fed liberal grain (except group 2, year 1, when the allowance was too low) were rated as showing slightly more body condition and fleshing than the control group.

When a comparison is made on the specific body weights of these cows before freshening, the weight of each cow during the dry period for 4 weeks before parturition is given in table 33. This table includes all cows before

Table 31. *History of cows that died during experiment, due to postpartum complications*

| Animal | Group | Age and date of death | Postpartum interval | History | Diagnosis |
|---|---|---|---|---|---|
| | | years | days | | |
| 218 | 2 | 9<br>08-05-66 | 16 | Hydrops allantois with 240-pound fetus; Cesarean performed; unable to stand following surgery | 1. Suppurative metritis<br>2. Peritonitis<br>3. Pulmonary thrombosis |
| 309 | 3 | 7<br>12-07-66 | 4 | Developed milk fever after parturition but did not respond to treatment; mastitis and metritis developed while down | 1. Mastitis<br>2. Endometritis<br>3. Abomasal ulcers |
| 210 | 4 | 9<br>12-24-66 | 6 | Retained placenta and metritis; developed acute mastitis | 1. Endometritis<br>2. Acute mastitis |
| 220 | 4 | 9<br>05-01-67 | 7 | Calved with twins; retained placenta; metritis and enteritis | 1. Endometritis<br>2. Acute hemorrhagic enteritis<br>3. Degenerative arthritis |
| 223 | 4 | 9<br>08-02-66 | 60 | Impacted abomasum prepartum; milk fever at parturition followed by displaced abomasum, salmonellosis, and acute mastitis | 1. Acute mastitis<br>2. Chronic gastroenteritis |
| 341 | 4 | 6<br>02-11-67 | 22 | Metritis and displaced abomasum | 1. Endometritis<br>2. Retroperitoneal abscess |
| 343 | 4 | 5<br>11-28-66 | 7 | Developed milk fever after calving but did not respond to treatment; acute mastitis developed while down | 1. Acute mastitis |
| 350 | 4 | 5<br>05-19-66 | 30 | Milk fever, mastitis, acetonemia, and metritis, with hematoma of udder | 1. Acute mastitis<br>2. Endometritis |

Table 32. *Condition rating for 12 months after parturition and 2 months before calving, years 1 and 2*

Control group 1, year 1

| Lactation month | Cow no. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 233 | 257 | 283 | 319 | 323 | 326 | 336 | 351 | 360 | 366 | Avg. |
| | rating* | | | | | | | | | | |
| 1 | – | 3 | 2.5 | 3 | 2 | 4 | – | 3 | 3 | 4 | 3.1 |
| 2 | – | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 4 | 4 | 3.3 |
| 3 | – | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 3.5 | 4 | 3.4 |
| 4 | 3.5 | 3 | 3 | 3 | 3.5 | 4 | 3 | 3.5 | 3.5 | 4 | 3.4 |
| 5 | 3 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 3.5 | 4 | 3.4 |
| 6 | 3 | 2.5 | 3 | 3.5 | 4 | 4 | 3 | 3.5 | 3.5 | 3 | 3.3 |
| 7 | 3.5 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 3.5 | 4 | 3.4 |
| 8 | 3 | 3 | 3 | 3 | 3.5 | 3.5 | 3 | 3 | 3.5 | 3.5 | 3.2 |
| 9 | 3 | 3 | 3 | 3 | 3.5 | 3.5 | 3 | 3 | 3 | 3.5 | 3.2 |
| 10 | 3 | 3 | 3 | 3 | 3 | 3.5 | 3 | 2 | 3 | 3.5 | 3.0 |
| 11 | 3 | 2.5 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2.8 |
| 12 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 2.6 |
| –2 | 3 | 2.5 | 3 | 3 | 2 | 3.5 | 2 | 2 | 3 | 3 | 2.7 |
| –1 | 3 | 2 | 2.5 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 2.4 |

Group 2, year 1 (liberal grain)

| Lactation month | Cow no. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 215 | 218 | 241 | 249 | 304 | 312 | 325 | 329 | 337 | 342 | Avg. |
| | rating* | | | | | | | | | | |
| 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 2.5 | 3 | 3.0 |
| 2 | 3 | 4 | 3 | 3 | 3 | 3 | 3.5 | 5 | 3.5 | 3 | 3.4 |
| 3 | 3 | 3.5 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3.2 |
| 4 | 3 | 3 | 4 | 3 | 3 | 3.5 | 3 | 4 | 3 | 3 | 3.2 |
| 5 | 3 | 4 | 4 | 3 | 3 | 3.5 | 3 | 4.5 | 3 | 3.5 | 3.4 |
| 6 | 3 | 3 | 4 | 3 | 3 | 3.5 | 3 | 4 | 3 | 3 | 3.2 |
| 7 | 3 | 4 | 4 | 3 | 2 | 3.5 | 3 | 4 | 3 | 3.5 | 3.3 |
| 8 | 3 | 3.5 | 4 | 3 | 2.5 | 3 | 3 | 3.5 | 3 | 3.5 | 3.2 |
| 9 | 2 | 3 | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 4 | 3.2 |
| 10 | 2.5 | 3.5 | 3.5 | 2 | 2.5 | 3 | 3 | 3.5 | 3 | 3 | 3.0 |
| 11 | 2.5 | 3.5 | 3.5 | 3 | 2 | 3.5 | 3 | 3.5 | 2.5 | 3 | 3.0 |
| 12 | 2.5 | 3 | 3 | 3 | 2 | 3 | 2.5 | 3 | 2 | 3 | 2.7 |
| –2 | 2.5 | 3 | 3.5 | 2 | 2.5 | 2.5 | 2.5 | 3 | 2 | 3 | 2.6 |
| –1 | 2.5 | 4 | 3 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2.6 |

Group 3, year 1 (restricted forage, liberal grain)

| Lactation month | Cow no. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 231 | 239 | 302 | 303 | 308 | 309 | 328 | 335 | 339 | 344 | Avg. |
| | rating* | | | | | | | | | | |
| 1 | – | 2 | 3 | 3 | 3 | 2.5 | 3.5 | – | 3 | 3 | 2.9 |
| 2 | 3.5 | 2 | 3.5 | 3.5 | 3 | 3 | 3 | 3 | 3 | 3.5 | 3.1 |
| 3 | 3.5 | 3 | 3.5 | 3 | 3 | 3.5 | 3.5 | 3 | 3 | 3.5 | 3.2 |
| 4 | 3 | 3 | 3.5 | 3.5 | 2.5 | 3 | 3 | 3 | 3 | 3.5 | 3.1 |
| 5 | 3 | 3 | 4 | 3 | 2.5 | 3 | 4 | 3 | 3 | 3 | 3.2 |
| 6 | 3 | 3 | 3.5 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 3.2 |
| 7 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 2 | 3 | 3 | 3.0 |
| 8 | 3 | 3 | 3 | 3 | 2.5 | 3 | 3 | 2.5 | 3 | 3 | 2.9 |
| 9 | 2.5 | 3 | 3 | 3 | 2.5 | 3 | 3 | 2 | 3 | 3 | 2.8 |
| 10 | 3 | 3 | 2 | 2.5 | 3 | 3 | 3 | 2 | 3 | 2 | 2.6 |
| 11 | 2.5 | 2.5 | – | 2.5 | 2.5 | 2 | 3 | 2 | 2 | 2 | 2.3 |
| 12 | 2.5 | 2.5 | – | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2.2 |
| –2 | 2.5 | 2 | – | 2.5 | 2.5 | 3 | 2 | 2 | 2 | 2 | 2.3 |
| –1 | 2 | 2 | – | 2 | 2 | 2 | 2 | 1.5 | 2 | 2 | 1.9 |

Group 4, year 1 (all silage, liberal grain)

| Lactation month | Cow no. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 210 | 220 | 223 | 246 | 247 | 280 | 310 | 341 | 343 | 350 | Avg. |
| | rating* | | | | | | | | | | |
| 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2.9 |
| 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3.0 |
| 3 | 3 | 3.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3.5 | 3.1 |
| 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3.5 | 3.5 | 3.1 |
| 5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3.1 |
| 6 | 3 | 3 | 3 | 2.5 | 3 | 3 | 3.5 | 3 | 3 | 3 | 3.0 |
| 7 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3.0 |
| 8 | 2 | 3 | 3 | 3 | 3 | 3 | 3.5 | 3 | 3 | 3 | 3.0 |
| 9 | 3 | 3 | 2.5 | 2 | 3 | 2.5 | 3 | 3 | 3 | 3 | 2.8 |
| 10 | 2.5 | 3 | 2.5 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2.7 |
| 11 | 3 | 2 | 3 | 2 | 2.5 | 2.5 | 3 | 3 | 3 | 2 | 2.6 |
| 12 | 2 | 2 | 3.5 | 3 | 2 | 2 | 3 | 2.5 | 3 | 2 | 2.5 |
| –2 | 2 | 2 | 2.5 | 2 | – | 2.5 | 2 | 2 | 2 | 2 | 2.1 |
| –1 | 1 | 2 | 3 | 3 | – | 2 | 2 | 2 | 2 | 2 | 2.1 |

Control group 1, year 2

| Lactation month | Cow no. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 233 | 257 | 283 | 319 | 323 | 326 | 336 | 351 | 360 | 366 | Avg. |
| | rating* | | | | | | | | | | |
| 1 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3.5 | 3.5 | 3.2 |
| 2 | 3.5 | 3 | 3.5 | 3.5 | 4 | 4 | 3.5 | 3 | 3 | 3 | 3.4 |
| 3 | 3.5 | 3 | 3 | 3 | 4 | 4.5 | 3 | 3 | 4 | 3.5 | 3.4 |
| 4 | 3.5 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 3 | 3.5 | 3.3 |
| 5 | 3.5 | 3 | 3 | 3 | 4 | 4 | 3 | 3 | 3.5 | 3.5 | 3.4 |
| 6 | 3 | 3 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 3.5 | 3.2 |
| 7 | 3 | 3 | 4 | 3 | 3.5 | 4 | 3 | 3 | 3.5 | 3.5 | 3.4 |
| 8 | 3 | 3 | – | 3 | 3.5 | 4 | 3 | 3 | 3 | 3 | 3.2 |
| 9 | 3 | 3 | – | 3 | 3.5 | 3.5 | 3 | 3 | 3 | 3 | 3.1 |
| 10 | 3 | 3 | – | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 2.8 |
| 11 | 2.5 | 2.5 | – | 2 | 3 | 3.5 | 3 | 2 | 3 | 2.5 | 2.7 |
| 12 | 2.5 | 2 | – | 2 | 2.5 | 3 | 2 | 2 | 2 | 2 | 2.2 |
| –2 | 2.5 | 2.5 | – | 2 | 2.5 | 3.5 | 3 | 2 | 2 | 2.5 | 2.5 |
| –1 | 2.5 | 2 | – | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2.2 |

Group 2, year 2 (liberal grain)

| Lactation month | Cow no. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 215 | 218 | 241 | 249 | 304 | 312 | 325 | 329 | 337 | 342 | Avg. |
| | rating* | | | | | | | | | | |
| 1 | 3 | – | 4.5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3.2 |
| 2 | 3 | – | 4 | 3 | 3 | 3 | 3 | 4 | 3 | 3.5 | 3.3 |
| 3 | 3 | – | 4 | 3 | 3 | 4 | 3 | 3.5 | 2.5 | 3.5 | 3.3 |
| 4 | 3 | – | 3.5 | 3 | 2.5 | 4 | 3 | 4 | 2 | 3.5 | 3.2 |
| 5 | 3 | – | 3.5 | 3 | 2 | 3.5 | 3 | 4 | 2 | 3 | 3.0 |
| 6 | 3 | – | 3.5 | 3 | 2.5 | 4 | 3 | 3 | 2.5 | 3 | 3.1 |
| 7 | 3 | – | 3 | 3 | 2 | 3 | 2.5 | 3.5 | 2 | 3 | 2.8 |
| 8 | 3 | – | 3 | 3 | 2 | 3 | 2 | 3.5 | 2 | 3 | 2.7 |
| 9 | 2 | – | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 2.6 |
| 10 | 2 | – | 3 | 3 | 2 | 3.5 | 2 | 3 | 2 | 3 | 2.6 |
| 11 | 2 | – | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2.2 |
| 12 | 2 | – | 2.5 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2.3 |
| –2 | 1 | – | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1.9 |
| –1 | 2 | – | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2.1 |

*Rating for condition: 1, very fat; 2, fat including good dry cow condition; 3, medium condition (good milking condition); 4, thin; 5, very thin.

*(table continued on opposite page)*

Table 32. (*concluded*)

| Lactation month | Group 3, year 2 (restricted forage, liberal grain) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 231 | 239 | 302 | 303 | 308 | 309 | 328 | 335 | 339 | 344 | Avg. |
| | rating* | | | | | | | | | | |
| 1 | 3 | 3 | – | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3.0 |
| 2 | 3 | 3 | – | 3 | 3 | 3 | 4 | 3 | – | 4 | 3.2 |
| 3 | 3.5 | 3.5 | – | 3 | 3 | 3 | 4 | 3 | – | 4 | 3.4 |
| 4 | 3.5 | 3 | – | 3 | 3 | 3 | 4 | 3 | – | 4 | 3.3 |
| 5 | 3.5 | 3 | – | 3 | 3 | 3 | 3.5 | 3 | – | 4 | 3.2 |
| 6 | 3.5 | 3 | – | 3 | 3 | 3 | 3 | 2.5 | – | 3.5 | 3.1 |
| 7 | 3 | 3 | – | 3 | 3 | 3 | 3.5 | 3 | – | 3.5 | 3.1 |
| 8 | 3 | 3.5 | – | 3 | 3 | 3 | 3.5 | 2 | – | 4 | 3.1 |
| 9 | 3 | 3 | – | 3 | 3 | 3 | 3 | 2.5 | – | 3 | 2.9 |
| 10 | 3 | 3 | – | 3 | 2.5 | 3 | 3 | 2.5 | – | 3 | 2.9 |
| 11 | 3 | 3 | – | 3 | 2.5 | 2 | 2 | 2 | – | 2 | 2.4 |
| 12 | 2.5 | 2 | – | 2 | 2 | 2 | 2 | 2 | – | 2 | 2.1 |
| –2 | 2 | 2 | – | 2 | 2 | 2 | 2 | 2 | – | 2 | 2.0 |
| –1 | 2 | 2 | – | 2 | 2 | 2 | 2 | 3 | – | 2 | 2.1 |

| Lactation month | Group 4, year 2 (all silage, liberal grain) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 210 | 220 | 223 | 246 | 247 | 280 | 310 | 341 | 343 | 350 | Avg. |
| | rating* | | | | | | | | | | |
| 1 | – | 4 | 4 | 3 | – | 3 | 3 | 3 | 3.5 | – | 3.4 |
| 2 | – | 4 | 3.5 | – | – | 3 | 3 | 3 | 3 | – | 3.2 |
| 3 | – | 4 | 3.5 | – | – | 3 | 3 | 3 | 3 | – | 3.2 |
| 4 | – | 4 | 3 | – | – | 3 | 3.5 | 3 | 3 | – | 3.2 |
| 5 | – | 4 | 3 | – | – | 3 | 4 | 3 | 3 | – | 3.3 |
| 6 | – | 4 | 3 | – | – | 3 | 4 | 3 | 3 | – | 3.3 |
| 7 | – | 4 | 3 | – | – | 3 | 4 | 3 | 3 | – | 3.3 |
| 8 | – | 3.5 | 2.5 | – | – | 3 | 4 | 2 | 3 | – | 3.0 |
| 9 | – | 3.5 | 2 | – | – | 3 | 3 | 2 | 3 | – | 2.8 |
| 10 | – | 3 | 2 | – | – | 3 | 3 | 2 | 2 | – | 2.5 |
| 11 | – | 3 | 2 | – | – | 3 | 2.5 | 2 | 2 | – | 2.4 |
| 12 | – | 3 | 2 | – | – | 2 | 2 | 2 | 2 | – | 2.2 |
| –2 | – | – | 2 | – | – | 3 | 2.5 | 2 | 2 | – | 2.3 |
| –1 | – | – | 2 | – | – | 2 | 2 | 1 | 2 | – | 1.8 |

calving, even though they died subsequently and are therefore not included in table 21. The cows that died early in the next lactation are indicated with an asterisk and can be compared to the others in the same group and in the other groups. In comparing the groups at the start of year 2, the average body weights were 1615, 1603, 1675, and 1665 for groups 1 to 4, respectively. At the start of the third year the average body weights were 1707, 1686, 1718, and 1712, respectively. Among the cows that died in group 4 only 2 were higher than the average and this was by an average of only 63 and 83 pounds for the 4 weeks before calving. Average body weights during and at the end of 44 weeks of lactation (table 21) showed no differences between the groups, and actually the cows in group 4 averaged less than did those in groups 1 and 2 at the end of the 44-week lactation.

Extra, and supposedly ample, vitamins and minerals were provided in the grain ration fed in this experiment.

Table 33. *Body weights during dry period for 4 weeks before parturition*

| Weeks before calving | Control group 1, starting year 2 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 233 | 257 | 283* | 319 | 323 | 326 | 336 | 351 | 360 | 366 | Avg. |
| | pounds | | | | | | | | | | |
| –4 | 1730 | 1720 | 1500 | 1600 | 1670 | 1490 | 1720 | 1565 | 1490 | 1420 | 1590 |
| –3 | 1720 | 1730 | 1480 | 1660 | 1720 | 1510 | 1740 | 1570 | 1500 | 1440 | 1607 |
| –2 | 1760 | 1760 | 1500 | 1685 | 1740 | 1550 | 1780 | 1560 | 1520 | 1460 | 1632 |
| –1 | 1780 | 1770 | 1480 | 1680 | 1690 | 1570 | 1780 | 1570 | 1535 | 1475 | 1633 |

| Weeks before calving | Group 2, starting year 2 (liberal grain) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 215 | 218* | 241 | 249 | 304 | 312 | 325 | 329 | 337 | 342 | Avg. |
| | pounds | | | | | | | | | | |
| –4 | 1650 | 1615 | 1700 | 1670 | 1510 | 1570 | 1570 | 1560 | 1565 | 1460 | 1587 |
| –3 | 1670 | 1620 | 1680 | 1660 | 1520 | 1600 | 1580 | 1575 | 1540 | 1480 | 1592 |
| –2 | 1660 | 1600 | 1700 | 1690 | 1590 | 1585 | 1600 | 1630 | 1570 | 1450 | 1608 |
| –1 | 1670 | 1620 | 1750 | 1710 | 1600 | 1595 | 1600 | 1650 | 1580 | 1465 | 1624 |

| Weeks before calving | Group 3, starting year 2 (restricted forage, liberal grain) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 231 | 239 | 302 | 303 | 308 | 309 | 328 | 335 | 339* | 344 | Avg. |
| | pounds | | | | | | | | | | |
| –4 | 1670 | 1650 | – | 1585 | 1680 | 1545 | 1610 | 1690 | 1660 | 1775 | 1652 |
| –3 | 1760 | 1660 | – | 1590 | 1680 | 1560 | 1620 | 1680 | 1675 | 1820 | 1672 |
| –2 | 1780 | 1670 | – | 1580 | 1685 | 1570 | 1640 | 1670 | 1680 | 1840 | 1679 |
| –1 | 1770 | 1680 | – | 1610 | 1730 | 1610 | 1660 | 1675 | 1700 | 1850 | 1698 |

| Weeks before calving | Group 4, starting year 2 (all silage, liberal grain) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 210* | 220 | 223 | 246* | 247 | 280 | 310 | 341 | 343 | 350 | Avg. |
| | pounds | | | | | | | | | | |
| –4 | 1850 | 1680 | 1480 | 1730 | – | 1680 | 1640 | 1570 | 1520 | 1650 | 1644 |
| –3 | 1870 | 1685 | 1520 | 1730 | – | 1680 | 1660 | 1590 | 1530 | 1700 | 1663 |
| –2 | 1930 | 1600 | 1500 | 1750 | – | 1670 | 1670 | 1600 | 1560 | 1730 | 1668 |
| –1 | 1950 | 1580 | 1500 | 1700 | – | 1680 | 1700 | 1640 | 1575 | 1750 | 1675 |

| Weeks before calving | Control group 1, starting year 3 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 233 | 257 | 283 | 319 | 323 | 326 | 336 | 351 | 360 | 366 | Avg. |
| | pounds | | | | | | | | | | |
| –4 | 1750 | 1665 | – | 1785 | 1720 | 1510 | 1685 | 1710 | 1680 | 1575 | 1676 |
| –3 | 1670 | 1780 | – | 1800 | 1740 | 1540 | 1740 | 1700 | 1720 | 1610 | 1700 |
| –2 | 1700 | 1790 | – | 1820 | 1720 | 1600 | 1770 | 1720 | 1750 | 1640 | 1723 |
| –1 | 1720 | 1780 | – | 1830 | 1700 | 1620 | 1800 | 1750 | 1710 | 1650 | 1729 |

| Weeks before calving | Group 2, starting year 3 (liberal grain) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 215 | 218 | 241 | 249* | 304 | 312 | 325 | 329 | 337 | 342 | Avg. |
| | pounds | | | | | | | | | | |
| –4 | 1760 | – | 1820 | 1590 | 1690 | 1590 | 1730 | 1630 | 1620 | 1570 | 1667 |
| –3 | 1780 | – | 1830 | 1560 | 1700 | 1610 | 1750 | 1650 | 1640 | 1585 | 1678 |
| –2 | 1780 | – | 1850 | 1575 | 1740 | 1620 | 1760 | 1610 | 1650 | 1620 | 1689 |
| –1 | 1790 | – | 1870 | 1630 | 1760 | 1670 | 1775 | 1610 | 1665 | 1630 | 1711 |

| Weeks before calving | Group 3, starting year 3 (restricted forage, liberal grain) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 231 | 239 | 302 | 303 | 308 | 309* | 328 | 335 | 339 | 344 | Avg. |
| | pounds | | | | | | | | | | |
| –4 | 1722 | 1620 | – | 1680 | 1770 | 1575 | 1600 | 1650 | – | 1890 | 1688 |
| –3 | 1740 | 1635 | – | 1695 | 1800 | 1590 | 1640 | 1660 | – | 1900 | 1708 |
| –2 | 1760 | 1620 | – | 1725 | 1840 | 1600 | 1675 | 1680 | – | 1930 | 1729 |
| –1 | 1790 | 1670 | – | 1735 | 1860 | 1610 | 1700 | 1690 | – | 1940 | 1749 |

| Weeks before calving | Group 4, starting year 3 (all silage, liberal grain) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cow no. | | | | | | | | | | |
| | 210 | 220 | 223* | 246 | 247 | 280 | 310* | 341* | 343* | 350 | Avg. |
| | pounds | | | | | | | | | | |
| –4 | – | – | 1710 | – | – | 1670 | 1630 | 1800 | 1680 | – | 1698 |
| –3 | – | – | 1740 | – | – | 1660 | 1650 | 1780 | 1720 | – | 1710 |
| –2 | – | – | 1740 | – | – | 1680 | 1650 | 1805 | 1750 | – | 1725 |
| –1 | – | – | 1690 | – | – | 1680 | 1670 | 1800 | 1740 | – | 1716 |

*Cows died during next lactation, usually soon after calving.

Haenlein (1963) called attention to the possibility that vitamin and mineral requirements of dairy cows may change when the dietary ratio of grain to forage is increased. Hemken *et al.* (1971) reported a goitrogenic effect of a corn-silage and soybean-meal ration. This was attributed to the soybean meal, and cows not fed supplemental iodine gave birth to calves with significantly larger thyroid glands, consumed less feed, and produced less milk with a lower milk-fat content than those fed supplemental iodine. Cows given additional iodine apparently were able to mobilize body fat more readily than those not receiving iodine. Hemken speculated that the soybean meal prevented normal reabsorption of iodine from the intestine, which results in larger than normal losses of iodine in the feces.

The experimental cows in group 3 showed a craving for forage and sometimes even chewed on metal pipes and the blades of the electric cow trainers when the electricity was turned off. It required some rigid controls to guide these cows in and out of the barn for daily exercise to prevent them from stealing hay from other cows.

Table 34 comprises a summary of the birth dates, age, and calving dates for the different lactations.

Table 34. *Birth dates, age, and lactation number for calving at start of year 1, and calving dates for lactations of cows during experiment*

| Group | Cow | Birth dates | Age at calving for year 1 | | Lactation for year 1 | Calving dates for lactations on experiment | | |
|---|---|---|---|---|---|---|---|---|
| | | | yr. | mo. | no. | Year 1 | Year 2 | Year 3 |
| 1 Control | 233 | 3-17-58 | 6 | 0 | 4 | 3-31-64 | 3-10-65 | 3-07-66 |
| | 257 | 12-13-58 | 5 | 9 | 4 | 8-29-64 | 8-29-65 | 9-04-66 |
| | 283 | 10-02-59 | 4 | 9 | 3 | 7-14-64 | 8-18-65 | – |
| | 319 | 1-08-61 | 4 | 1 | 3 | 2-09-65 | 3-24-66 | 3-21-67 |
| | 323 | 1-15-61 | 4 | 3 | 3 | 4-15-65 | 5-04-66 | 6-06-67 |
| | 326 | 3-16-61 | 4 | 2 | 3 | 5-25-65 | 5-11-66 | 4-28-67 |
| | 336 | 1-01-61 | 3 | 11 | 2 | 11-17-64 | 12-01-65 | 12-08-66 |
| | 351 | 8-17-61 | 3 | 2 | 2 | 10-16-64 | 10-10-65 | 11-03-66 |
| | 360 | 10-24-61 | 3 | 3 | 2 | 1-10-65 | 12-26-65 | 1-25-67 |
| | 366 | 10-05-61 | 3 | 4 | 2 | 2-03-65 | 1-18-66 | 1-14-67 |
| 2 Liberal grain | 215 | 9-14-57 | 6 | 11 | 5 | 8-01-64 | 7-26-65 | 10-24-66 |
| | 218 | 9-25-57 | 7 | 10 | 5 | 7-19-65 | 7-20-66 | – |
| | 241 | 9-29-58 | 5 | 9 | 4 | 6-19-64 | 7-02-65 | 9-07-66 |
| | 249 | 10-10-58 | 6 | 4 | 5 | 1-31-65 | 6-20-66 | 7-11-67 |
| | 504 | 9-15-60 | 4 | 0 | 3 | 9-22-64 | 9-10-65 | 10-21-66 |
| | 512 | 10-11-60 | 4 | 4 | 3 | 2-15-65 | 4-14-66 | 7-22-67 |
| | 525 | 1-31-61 | 3 | 5 | 2 | 6-16-64 | 7-16-65 | 8-10-66 |
| | 329 | 4-12-61 | 3 | 11 | 2 | 3-20-65 | 8-29-66 | 8-30-67 |
| | 337 | 3-27-61 | 3 | 4 | 2 | 7-14-64 | 10-17-65 | 10-11-66 |
| | 342 | 3-15-61 | 3 | 7 | 2 | 10-03-64 | 10-07-65 | 10-05-66 |
| 3 Restricted forage, liberal grain | 231 | 9-22-57 | 6 | 9 | 4 | 6-19-64 | 8-01-65 | 8-19-66 |
| | 239 | 8-29-58 | 6 | 7 | 5 | 3-16-65 | 4-20-66 | 6-11-67 |
| | 302 | 3-26-60 | 5 | 0 | 3 | 3-23-65 | – | – |
| | 303 | 5-04-60 | 5 | 1 | 3 | 6-04-65 | 5-30-66 | 6-20-67 |
| | 308 | 10-18-60 | 4 | 5 | 3 | 5-11-65 | 3-15-66 | 5-04-67 |
| | 309 | 3-25-60 | 4 | 9 | 3 | 12-15-64 | 11-29-65 | 12-03-66 |
| | 328 | 4-09-61 | 3 | 5 | 2 | 9-24-64 | 1-09-66 | 1-10-67 |
| | 335 | 3-27-61 | 3 | 5 | 2 | 9-11-64 | 9-29-65 | 10-15-66 |
| | 339 | 8-20-61 | 3 | 1 | 2 | 9-11-64 | 9-04-65 | – |
| | 344 | 5-15-61 | 3 | 4 | 2 | 9-23-64 | 11-22-65 | 1-26-67 |
| 4 All-corn silage, liberal grain | 210 | 9-06-57 | 7 | 11 | 6 | 8-17-65 | 12-18-66 | – |
| | 220 | 11-30-57 | 7 | 4 | 6 | 4-09-65 | 4-24-66 | – |
| | 223 | 1-07-58 | 6 | 6 | 5 | 7-05-64 | 6-10-65 | 6-03-66 |
| | 246 | 10-11-58 | 5 | 10 | 5 | 8-13-64 | 7-18-65 | – |
| | 247 | 9-23-58 | 5 | 11 | 5 | 8-30-64 | – | – |
| | 280 | 10-09-59 | 4 | 11 | 4 | 9-03-64 | 9-12-65 | 9-11-66 |
| | 310 | 1-05-60 | 4 | 10 | 3 | 11-02-64 | 1-12-66 | 1-01-67 |
| | 341 | 3-03-61 | 3 | 7 | 2 | 10-07-64 | 11-29-65 | 1-20-67 |
| | 343 | 7-13-61 | 3 | 3 | 2 | 10-05-64 | 11-21-65 | 11-21-66 |
| | 350 | 3-12-61 | 4 | 1 | 2 | 3-31-65 | 4-19-66 | – |
| 1 Control, 5 additional young cows | 338 | 4-14-61 | 3 | 7 | 2 | 11-11-64 | 10-29-65 | 11-02-66 |
| | 370 | 7-27-62 | 2 | 1 | 1 | 8-22-64 | 8-27-65 | 8-24-66 |
| | 371 | 2-16-62 | 2 | 6 | 1 | 8-18-64 | 8-19-65 | 7-26-66 |
| | 380 | 4-08-62 | 2 | 6 | 1 | 10-15-64 | 9-24-65 | 7-29-66 |
| | 385 | 9-11-62 | 2 | 3 | 1 | 12-10-64 | 1-12-66 | 1-18-67 |
| 3 Restricted forage, liberal grain, 5 additional young cows | 362 | 9-14-61 | 3 | 5 | 2 | 2-19-65 | 3-17-66 | 4-17-67 |
| | 375 | 1-17-62 | 2 | 8 | 1 | 9-13-64 | 12-19-65 | 1-30-67 |
| | 376 | 5-24-62 | 2 | 3 | 1 | 9-04-64 | 9-03-65 | 8-23-66 |
| | 377 | 7-31-62 | 2 | 1 | 1 | 9-14-64 | 10-10-65 | 10-19-66 |
| | 381 | 6-27-62 | 2 | 4 | 1 | 11-08-64 | 11-06-65 | 11-17-66 |

## Feed Composition and Digestibility

### Composition of Experimental Feeds

Detailed information on the average proximate composition of the experimental feeds and the overall average during the 4 years of the experiment is given in table 35.

The silage was somewhat lower in dry matter than is recommended, especially the first year, but this was influenced by prevailing weather conditions and the need to start harvesting early in September because of the large total tonnage required. The legume and grass hay was of high quality, and was harvested by crushing and barn-drying.

### Digestibility of Mixed Rations

The calculated feed-energy requirements used for estimating the needs of the high-producing Holstein cows on the liberal grain feeding experiment allowed for a depression in digestibility for increasing levels of intake of mixed rations when fed at high levels. Reid (1956, 1961, 1964), Reid *et al.* (1966), and Wagner and Loosli (1967) have described the decrease in digestibility of the ration that results from a marked increase in feed consumption.

Moe *et al.* (1963) reported that as the intake level of mixed rations increases, the digestibility of energy of the diet decreases,and that the drop is greatest in diets high in concentrates. Also the decrease is greater for low-quality than for high-quality forage in mixed rations, but the principle does not apply to all-forage rations. Moe *et al.* (1965) and Wagner and Loosli (1967) demonstrated that high-producing cows on rations composed of forage and concentrates apparently absorb a smaller portion of the dietary energy than when the same rations are fed at the maintenance level. The depression in digestibility ranged from 3.4 to 6.2 percent for each increment of intake equivalent to that of maintenance. The depression was less when high-quality early-cut hay was used.

More recent research (Flatt *et al.,* 1969) has shown considerable variation among different feeds in the effect of intake level on nutrient digestibility. The decline in digestibility is greatest on corn silage, coarse-textured grain mixtures, and forages with high cell wall content (Van Soest, 1968). Fiber content and rate of passage may be associated with this decline of digestibility.

The following information on digestibilty of feeds used for the liberal grain feeding experiment is essentially as presented by Robb (1967) in his M.S. thesis, in coopera-

tion with Dr. J. T. Reid and Dr. H. F. Tyrrell, who are also co-authors of this bulletin.

## Digestibility of Individual Feeds and the Total Diet

The digestibility of the experimental rations with different levels of grain intake was determined with milking cows in the first year only, as outlined in the experimental plans. The cows used were not on the liberal grain feeding experiment but the same rations were used. The results supplement the data from the digestibility trials with steers, determined on feeds harvested each year.

Specifically the objective was to examine the effect of different levels of grain, corn silage, and hay in the ration on the digestibility of the total diet. The statistical design used was based on a 6 X 6 Latin Square. Six cows selected from the Cornell University herd were fed 6 different rations. The design of the experiment is shown in tables 36 and 37.

***Digestibility of rations studied.*** A summary of the digestion coefficients and standard deviations for each combination of hay and corn silage and level of grain feeding is given in table 38. The total carbohydrate is defined as dry matter less crude protein, ether extract, and ash, and includes the conventional crude fiber and nitrogen-free extract.

***Level of intake and digestibility.*** The regression of energy digestibility on level of intake, expressed in terms of multiples of maintenance, was determined to find whether there was any significant depression in energy digestibility with increasing levels of intake. The results are illustrated in figure 34. Increasing levels of intake

Table 35. *Dry-matter content and proximate composition of the feeds, by years, during 4-year experiment*

| Feed | Dry matter | Protein | Ether extract | Ash | Total carbohydrate |
|---|---|---|---|---|---|
| | percent | percent of dry matter | | | |
| 1964 grain | 86.43 | 22.11 | 4.02 | 7.01 | 66.86 |
| 1965 grain | 86.33 | 19.92 | 4.41 | 6.65 | 69.02 |
| 1966 grain | 86.91 | 21.30 | 3.37 | 7.04 | 68.29 |
| 1967 grain | 86.16 | 18.97 | 3.04 | 6.86 | 71.13 |
| Average grain | 86.46 | 20.58 | 3.71 | 6.89 | 68.82 |
| 1964 hay | 89.39 | 13.37 | 1.07 | 5.88 | 79.68 |
| 1965 hay | 89.29 | 13.53 | 1.34 | 6.36 | 78.77 |
| 1966 hay | 89.41 | 13.76 | 1.68 | 7.01 | 77.55 |
| 1967 hay | 87.00 | 13.32 | 1.80 | 7.65 | 77.23 |
| Average hay | 88.77 | 13.50 | 1.47 | 6.72 | 78.31 |
| 1964 corn silage | 24.99 | 9.16 | 1.52 | 3.89 | 85.43 |
| 1965 corn silage | 25.87 | 9.32 | 1.82 | 4.16 | 84.70 |
| 1966 corn silage | 27.64 | 8.52 | 2.35 | 4.23 | 84.90 |
| 1967 corn silage | 30.68 | 8.35 | 3.25 | 3.44 | 84.96 |
| Average silage | 27.30 | 8.84 | 2.24 | 3.93 | 85.00 |
| Average soybean meal | 89.72 | 50.71 | 2.70 | 5.99 | 40.60 |

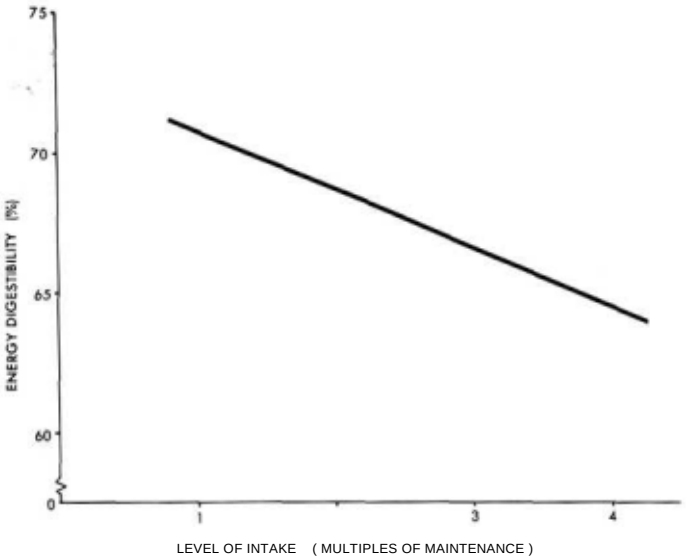


Figure 34. *Relationship between level of intake and energy digestibility of rations containing hay, corn silage, and grain.*

Table 36. *Dry-matter contributions of different feeds in the various rations tested for digestibility*

| Ration | Grain | Forage | Forage ratio | |
|---|---|---|---|---|
| | | | Silage | Hay |
| | percent | | | |
| A | 25 | 75 | 50 | 50 |
| B | 50 | 50 | 50 | 50 |
| C | 75 | 25 | 50 | 50 |
| D | 25 | 75 | 75 | 25 |
| E | 50 | 50 | 75 | 25 |
| F | 75 | 25 | 75 | 25 |

Table 37. *Statistical design of the experiment to determine the effect of different levels of grain, corn silage, and hay on the digestibility of the total diet*

| Cow number | Experimental period number | | | | | |
|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI |
| | rations | | | | | |
| 1 | A | C | B | D | F | E |
| 2 | B | E | D | F | C | A |
| 3 | C | F | E | A | B | D |
| 4 | D | B | C | E | A | F |
| 5 | E | A | F | B | D | C |
| 6 | F | D | A | C | E | B |

Table 38. *Digestion coefficients and standard deviations for the different rations*

| Ration | Type of ration | Dry matter | Crude protein | Ether extract | CHO | TDN | Digestible energy | Metabolizable energy |
|---|---|---|---|---|---|---|---|---|
| | dry matter basis | | | percent | | | percent of gross energy | |
| A | 25% grain, 75% forage, equal silage and hay | 65.62 ±2.29 | 67.71 ±3.96 | 72.96 ±6.73 | 66.48 ±2.00 | 69.42 ±2.42 | 64.68 ±2.85 | 47.51 |
| B | 50% grain, 50% forage, equal silage and hay | 67.98 ±2.96 | 70.18 ±4.39 | 73.92 ±7.07 | 69.26 ±3.15 | 72.76 ±3.29 | 67.37 ±2.87 | 49.66 |
| C | 75% grain, 25% forage, equal silage and hay | 69.18 ±2.59 | 71.53 ±5.72 | 73.76 ±7.68 | 70.27 ±2.52 | 74.33 ±3.42 | 68.96 ±2.88 | 50.12 |
| D | 25% grain, 75% forage, silage-hay ratio 3:1 | 66.22 ±2.24 | 62.98 ±5.91 | 74.34 ±4.03 | 68.31 ±2.95 | 70.52 ±2.34 | 65.04 ±2.21 | 47.81 |
| E | 50% grain, 50% forage, silage-hay ratio 3:1 | 67.89 ±3.38 | 68.29 ±5.02 | 74.96 ±7.83 | 69.34 ±3.09 | 72.65 ±3.66 | 67.34 ±3.50 | 49.90 |
| F | 75% grain, 25% forage, silage-hay ratio 3:1 | 69.99 ±1.24 | 71.53 ±2.73 | 75.30 ±7.48 | 71.53 ±1.52 | 75.48 ±2.01 | 69.93 ±1.79 | 51.48 |

caused a significant depression of the energy digestibility. The regression coefficient was -2.08 percentage units of energy digestibility per unit of intake. This was significantly different from zero when tested by the "F-test". The relationship: Y = 72.74 - 2.082IX where Y is the energy digestibility and X is the level of intake was derived from all rations. The standard error was 2.81. The depression of digestibility associated with increasing levels of intake above maintenance may be associated with rate of passage of feed, because the mean retention time in the gastrointestinal tract is less at high levels of intake. Las-siter *et al.* (1957) and Conrad *et al.* (1966) reported that an increase in the concentrate portion of the ration lowered the digestibility of the fiber portion of the ration.

The results are consistent with the well established concept that, as the level of intake of grain-and-hay mixed diets increases, the digestibility of energy in the diet decreases. The depression is more marked in diets that are high in concentrates.

*Effect of level of grain intake on energy digestability.* The regression of energy digestibility on level of grain intake expressed as percentage of total dry matter intake is illustrated in figure 35. The regression coefficient was + .0893 percentage units of energy digestibility per percentage-unit increase in grain intake. This statistically significant increase in energy digestiblity with increasing proportions of grain in the ration agrees with a generally recognized feeding principle. Since grain is considerably higher in energy digestibility than forage in the ration, the amount of digestible energy would logically increase as the percentage of grain in the total dry-matter intake increases. This in turn usually increases milk production (Coppock *et al.*, 1964).

From the regression equation: Y = 0.0893X + 62.86 where Y is the energy digestibility and X is the level of grain intake as a percentage of the total dry-matter intake, the predicted energy digestibility of the grain itself is 71.8 percent, assuming that there is no interaction between percentage of grain in the ration and level of intake.

*Effect of level and type oi forage intake on energy digestibility.* The 2 different forages used in the experiment were examined separately regarding their effects on digestibility. The effect of proportion of hay and of silage intake on digestibility is illustrated in figure 36. The regression coefficients for the hay and silage were -0.1476 and -0.1096, respectively. The regression coefficient for hay was almost significantly different and that for the silage was significantly different from zero ($P < .05$). The negative coefficients of regression indicate a decrease in energy digestibility as the proportion of forage intake increases in the ration. This again is a generally accepted principle and the effect is opposite to that of increasing proportions of concentrates in the ration.

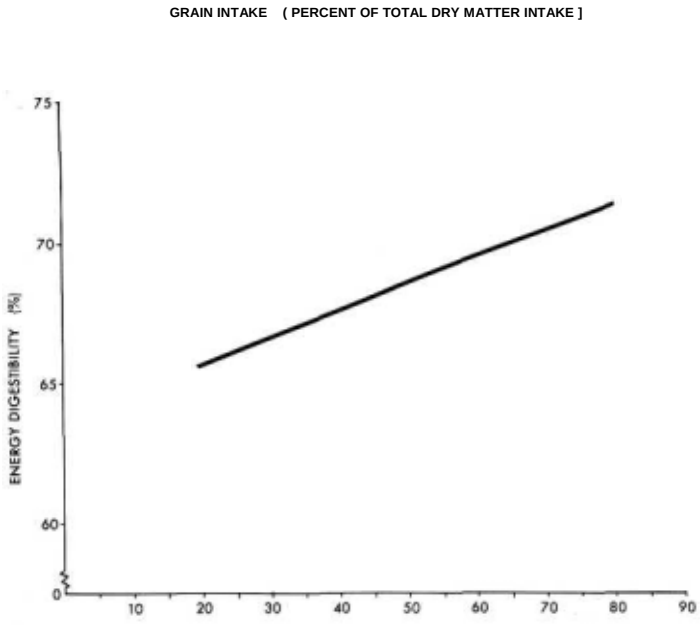


Figure 35. *Relationship between percentage of total dry matter from grain and energy digestibility of mixed rations.*

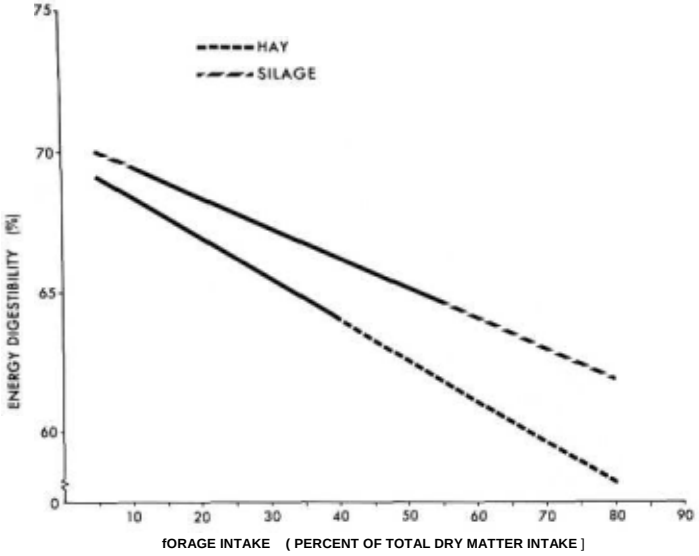


Figure 36. *Kind and level of forage intake and energy digestibility of mixed rations.*

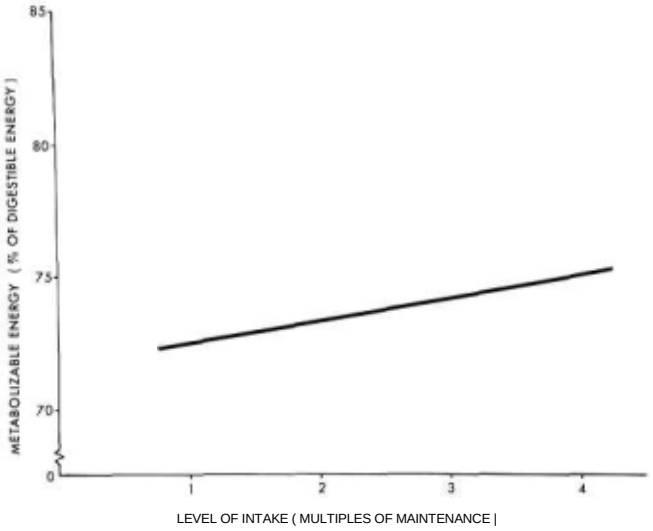


Figure 37. *Level of intake and metabolizable energy value of mixed rations.*

Using the "t test", there was no significant difference between the regression slopes for proportions of hay and silage intake on energy digestibility; thus we conclude that the source of forage (hay or corn silage) had no significant effect on the rate of change in energy digestibility of the mixed rations.

*Estimated metabolizable energy.* The "available" metabolizable energy intake was computed by subtracting the energy losses as feces, urine, methane, and heat of fermentation from the gross energy intake. The energy lost as feces was measured directly with a bomb calorimeter. The urine energy loss was estimated from the nitrogen concentration in the urine by use of the prediction equation formulated by Elliot and Loosli (1959), Y =23.8 + 125X, where Y = urine energy (kcal./kg.), and X = % nitrogen in the urine. The energy lost as methane was estimated as 8 percent of the gross energy of the feed and the total loss of energy as methane and heat of fermentation combined as 1.8 times the caloric value of the methane.

The regression coefficient for the effect of level of intake on metabolizable energy as a percentage of digestible energy was computed by Robb (1967) to be + 0.6728 as shown in figure 37. The slope was not significantly different from zero. This suggests that the effect of level of intake on energy utilization takes place before absorption.

## Digestibility Trials with Steers at Maintenance Level of Intake

For the 1965, 1966, and 1967 feeds, steers were fed, at maintenance level of intake, 25 different combinations of hay, corn silage and concentrate feeds used in the liberal grain feeding experiment so the digestion data derived therefrom could be used to develop a multiple regression equation to predict the digestibility of all possible combinations of the three experimental feeds. The general form of the prediction equation developed was:

$$Y = A + b_1X_1 + (b_2 + b_3X_1)Y$$

Where: = digestion coefficie $X_1$ = corn-silage dry matte: nsumed as percent of total forage dry matter. $X_2$ = concentrate dry matter consumed as percent of total dry matter

The regression model used assumes that digestibility changes linearly with a change in the proportion of concentrate and/or corn silage in the ration. Furthermore, the model assumes that the regression coefficient relating digestibility to percent of concentrate is a linear function of percent of corn silage in the forage dry matter. Therefore, the regression model to which the digestion data were fitted is a linear model and does not take into account any nonlinear functions that may exist. Although the magnitude of the prediction errors were relatively small (well below 1% except for protein digestibility, where the magnitude approached a level of *2%* digestible protein), the prediction equation consistently overestimated the digestibility of low hay or low corn silage and very low or very high grain rations. Thus, one must be cautious in using the prediction equations, although they are the best means of estimating the digestibility of the various rations.

The digestion coefficients for each feed for each year were calculated (table 39).

The digestion coefficients for grain presented in the table are average values, since they will change as the

Table 39. *Digestion coefficients of liberal grain experimental feeds*

| Feed | Year | DDM | DP | DEE | DCHO | TDN |
|---|---|---|---|---|---|---|
| | | | | percent | | |
| Hay | 1964 | 58.61 | 67.92 | | | |
| | 1965 | 59.32 | 65.19 | 45.76 | 59.98 | 57.38 |
| | 1966 | 65.77 | 69.22 | 49.77 | 66.92 | 62.81 |
| | 1967 | 64.65 | 68.85 | 49.06 | 66.04 | 61.91 |
| Corn silage | 1964 | 68.90 | 60.60 | _ | ___ | ___ |
| | 1965 | 70.16 | 59.09 | 86.10 | 73.76 | 72.15 |
| | 1966 | 71.49 | 55.84 | 82.79 | 75.77 | 73.38 |
| | 1967 | 72.71 | 54.26 | 83.96 | 76.78 | 75.47 |
| Concentrate | 1965 | 78.78 | 84.24 | 86.07 | 80.30 | 79.84 |
| | 1966 | 78.32 | 85.56 | 74.30 | 79.70 | 77.02 |
| | 1967 | 79.32 | 82.00 | 75.67 | 82.11 | 79.15 |

percentage of corn silage in the ration changes.

Regression equations based on results of the digestion trials were constructed and average determinations made for dry matter digestibility (DDM), protein (DP), and TDN content by electronic processing of the data:

*1965 liberal grain feeds (30 trials)**

$$\% \text{ DDM} = 59.32 + .1084\ X_1 + (.1878 - .000949X_1)\ X_2$$
$$\% \text{ DP} = 65.19 - .0610\ X_1 + (.1867 + .000686X_1)\ X_2$$
$$\% \text{ TDN} = 57.38 + .1477\ X_1 + (.2152 - .001288X_1)\ X_2$$

*1966 liberal grain feeds (25 trials)**

$$\% \text{ DDM} = 65.77 + .0572\ X_1 + (.1073 - .000208X_1)\ X_2$$
$$\% \text{ DP} = 69.22 - .1364\ X_1 + (.1338 + .001931X_1)\ X_2$$
$$\% \text{ TDN} = 62.81 + .1057\ X_1 + (.1281 - .000776X_1)\ X_2$$

*1967 liberal grain feeds (15 trials)**

$$\% \text{ DDM} = 64.65 + .0806\ X_1 + (.1265 - .000403X_1)\ X_2$$
$$\% \text{ DP} = 68.85 - .1459\ X_1 + (.0842 + .002405X_1)\ X_2$$
$$\% \text{ TDN} = 61.91 + .1356\ X_1 + (.1473 - .000854X_1)\ X_2$$

* $X_1$ represents corn silage dry matter and $X_2$ concentrate dry matter, as percent of total dry matter. The equations apply to the components of hay, silage and grain used in these rations, but should not be applied to materials grown elsewhere because of environmental effect on plant composition.

## SUMMARY AND CONCLUSIONS

A continuous feeding experiment covering 3 complete lactations with 50 high-producing Holstein cows was conducted to determine the effects of feeding liberal amounts of grain on level of milk production, efficiency of production, postpartum reproductive health, reproductive efficiency, general health, and other associated factors. Treatment groups comprised a control, group 1, with 15 cows fed *ad lib.* hay, a fixed 36.0 pounds of corn silage and a maximum of 20.0 pounds of grain; group 2 in which 10 cows were fed liberal grain plus hay *ad lib.* and 36.0 pounds of corn silage; group 3 in which 15 cows were fed restricted forage of 8.0 pounds of hay, 12.0 pounds of silage per day, plus 15.0 pounds of grain for forage replacement plus liberal grain; and group 4 in which 10 cows were fed an all-corn-silage ration *ad lib.* with liberal grain allowances.

The control group was very consistent in feed intake and milk production from year to year. The cows in groups 2, 3, and 4 were somewhat more erratic in feed intake and production response. They frequently went off-feed or nearly off-feed early in lactation. The average actual milk production of groups 1-4 during a 44-week lactation for the 3 years was 16,424, 17,508, 16,682, and 17,293 pounds, respectively. On a basis of 4% FGM the cows, by groups, averaged 15,932, 17,345, 16,188, and 16,785 pounds, respectively. Group 2 averaged 17,813 and 18,307 pounds of milk for years 2 and 3, respectively. The cows in group 2, with approximately twice the grain intake of the control group and approximately 50 percent of the DM and TDN intake from grain, peaked at a higher level of production and averaged 1084 pounds of milk more than did the controls. This was accomplished with 3031 pounds of extra grain and 1976 pounds less hay. Economic advantages or disadvantages can be determined by applying prevailing feed and milk prices. A maximum daily grain allowance of 25 to 35 pounds may be justified, depending on the appetite and capabilities of the individual cow.

Group 3 averaged only 258 pounds more in milk production than did the control group. It is evident that feeding liberal amounts of grain to compensate for restricted forage is not a satisfactory procedure in a continuous program under normal economic conditions. In this group, 4766 pounds of grain was substituted for 4099 pounds of hay plus 7226 pounds of silage, as compared to the control group. It was apparent that these cows had a definite ceiling for grain intake, and with 70 percent of the total DM and TDN from grain they had the lowest total DM and TDN intake of all groups for the average of 3 lactations.

The cows in group 4 had an average feed intake of 21,971 pounds of corn silage and 6712 pounds of grain (6048 pounds of grain mixture and 664 pounds of soybean meal) for the average of 3 lactations of 44 weeks each. This group had an advantage in average production of 869 pounds of milk over the control group. They were the most erratic in feed consumption and milk production. Feed intake during late lactation and the dry period needs to be carefully adjusted to avoid over-conditioning of cows on an all-corn-silage ration, but only 2 of these experimental cows were allowed to become excessively fat or overweight. Thus, the average body weights and body

weight changes, in general, were normal in this experiment.

The time of peak production for a week ranged from the 3rd to the 20th week and averaged near the 90-pound level; but the peak production was higher in the groups on liberal grain. A total of 12 cows exceeded an average of 100 pounds of actual milk and 32 cows reached this production level on the basis of 4% FCM average over the period of a week. Peak grain intake came later than peak production and all cows lost considerable weight, but this was minimized with liberal grain feeding.

There were no differences in milk composition including fat, protein, and solids-not-fat. Milk flavors were influenced by the proportion of grain in the ration and the percentage of samples with unfavorable oxidized flavors increased with liberal grain feeding.

Liberal grain feeding had no significant effect on factors associated with reproduction except that the cows fed a liberal concentrate ration had significantly ($P<0.01$) longer calving intervals and required more services per conception than the controls.

A study of the health aspects of liberal grain feeding showed no statistical significance on the incidence of mastitis, milk fever, ketosis, and other troubles, but digestive disturbance and off-feed and abomasal displacements were significantly increased ($P<0.05$).

Cow losses in groups 1, 2, and 3 were very modest at 1, 2, and 3 cows, respectively. Most unexpected, however, was the loss of 9 of the 10 cows assigned to group 4. Although 6 cows of group 4 completed the second lactation, only one completed the third lactation. Eight of the 10 cows in group 4 on the all-corn-silage ration died, and one additional cow was removed for infertility. Apparently these cows had a decreased ability to withstand stress, and 6 of the deaths were due to complications at parturition, such as displaced abomasum, metritis, retained placenta, and acute mastitis. Liberal grain feeding *per se* had no significant effect on cow losses during the 3 lactations of this experiment, because the cows in control group 1 and in liberal grain groups 2 and 3 responded to treatment with similar degrees of complications that caused death to the cows in group 4. The effect of corn silage as the sole source of forage over successive lactations needs further evaluation, and an experiment is now in progress to re-evaluate this problem. It can be stated that an all-corn-silage ration can be fed for a period as long as a year, but for a longer period about 5 or 6 pounds of hay or possibly hay-crop silage should be fed daily until more is known about an all-corn-silage ration.

The results of the experiment show that the *ad lib.* feeding of high-quality forage with liberal grain is a sound practice for high-producing cows. We concluded also that feeding moderately liberal amounts of grain is a good practice, but it may be advisable to establish a top limit of 25 to 35 pounds and to give careful attention to the individual cow and to the feeding level. Cows went off-feed easily during the first 6 to 8 weeks of lactation when their appetites were not keen. At this time it is better to avoid "off-feed" periods from excessive grain, especially during early lactation, even though body weight losses are high during this initial period.

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Appendix table 1. *Grain allowance table, group 1 — control ration, moderate grain (forage: hay ad lib., 36 pounds corn silage*)

| Milk yield | Fat test (%)* | | | | | |
|---|---|---|---|---|---|---|
| | 3.6 | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 |
| (lb./day) | (pounds per feeding 2 x daily) | | | | | |
| 19 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| 20 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 |
| 21 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.9 |
| 22 | 0.9 | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 |
| 23 | 1.1 | 1.2 | 1.2 | 1.2 | 1.3 | 1.3 |
| 24 | 1.2 | 1.3 | 1.3 | 1.3 | 1.4 | 1.4 |
| 25 | 1.4 | 1.5 | 1.5 | 1.5 | 1.6 | 1.6 |
| 26 | 1.6 | 1.7 | 1.7 | 1.7 | 1.8 | 1.8 |
| 27 | 1.7 | 1.8 | 1.8 | 1.8 | 1.9 | 1.9 |
| 28 | 1.9 | 1.9 | 2.0 | 2.0 | 2.1 | 2.2 |
| 29 | 2.1 | 2.1 | 2.2 | 2.3 | 2.3 | 2.5 |
| 30 | 2.2 | 2.2 | 2.3 | 2.4 | 2.4 | 2.5 |
| 31 | 2.4 | 2.4 | 2.5 | 2.6 | 2.6 | 2.7 |
| 32 | 2.6 | 2.6 | 2.7 | 2.8 | 2.8 | 2.9 |
| 33 | 2.7 | 2.7 | 2.8 | 2.9 | 2.9 | 3.0 |
| 34 | 2.8 | 2.9 | 3.0 | 3.1 | 3.2 | 3.2 |
| 35 | 3.0 | 3.1 | 3.2 | 3.3 | 3.4 | 3.4 |
| 36 | 3.1 | 3.2 | 3.3 | 3.4 | 3.5 | 3.6 |
| 37 | 3.3 | 3.4 | 3.5 | 3.6 | 3.7 | 3.8 |
| 38 | 3.5 | 3.6 | 3.7 | 3.8 | 3.9 | 4.0 |
| 39 | 3.6 | 3.7 | 3.8 | 3.9 | 4.0 | 4.1 |
| 40 | 3.8 | 3.9 | 4.0 | 4.1 | 4.2 | 4.3 |
| 41 | 4.0 | 4.1 | 4.2 | 4.3 | 4.5 | 4.5 |
| 42 | 4.1 | 4.2 | 4.3 | 4.4 | 4.5 | 4.8 |
| 43 | 4.3 | 4.4 | 4.5 | 4.6 | 4.7 | 4.9 |
| 44 | 4.5 | 4.6 | 4.7 | 4.8 | 4.9 | 5.1 |
| 45 | 4.6 | 4.7 | 4.8 | 4.9 | 5.0 | 5.2 |
| 46 | 4.7 | 4.9 | 5.0 | 5.1 | 5.3 | 5.4 |
| 47 | 4.9 | 5.1 | 5.2 | 5.3 | 5.5 | 5.6 |
| 48 | 5.0 | 5.2 | 5.3 | 5.4 | 5.6 | 5.7 |
| 49 | 5.2 | 5.4 | 5.5 | 5.6 | 5.8 | 5.9 |
| 50 | 5.4 | 5.6 | 5.7 | 5.8 | 6.0 | 6.1 |
| 51 | 5.5 | 5.6 | 5.8 | 6.0 | 6.1 | 6.3 |
| 52 | 5.7 | 5.8 | 6.0 | 6.2 | 6.3 | 6.5 |
| 53 | 5.9 | 6.0 | 6.2 | 6.4 | 6.5 | 6.7 |
| 54 | 6.0 | 6.1 | 6.3 | 6.5 | 6.6 | 6.8 |
| 55 | 6.2 | 6.3 | 6.5 | 6.7 | 6.8 | 7.0 |
| 56 | 6.4 | 6.5 | 6.7 | 7.0 | 7.0 | 7.2 |
| 57 | 6.4 | 6.6 | 6.8 | 7.0 | 7.0 | 7.3 |
| 58 | 6.6 | 6.8 | 7.0 | 7.2 | 7.4 | 7.5 |
| 59 | 6.8 | 7.0 | 7.2 | 7.4 | 7.6 | 7.8 |

Appendix table 1. *(concluded)*

| Milk yield | Fat test(%)* | | | | | |
|---|---|---|---|---|---|---|
| | 3.6 | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 |
| (lb./day) | (pounds per feeding 2 x daily) | | | | | |
| 60 | 6.9 | 7.1 | 7.3 | 7.5 | 7.7 | 7.9 |
| 61 | 7.1 | 7.3 | 7.5 | 7.7 | 7.9 | 8.1 |
| 62 | 7.3 | 7.5 | 7.7 | 8.0 | 8.1 | 8.3 |
| 63 | 7.4 | 7.6 | 7.8 | 8.0 | 8.2 | 8.4 |
| 64 | 7.6 | 7.8 | 8.0 | 8.2 | 8.4 | 8.6 |
| 65 | 7.8 | 8.0 | 8.2 | 8.4 | 8.6 | 8.8 |
| 66 | 7.9 | 8.1 | 8.3 | 8.5 | 8.7 | 8.9 |
| 67 | 8.1 | 8.3 | 8.5 | 8.7 | 8.9 | 9.2 |
| 68 | 8.2 | 8.5 | 8.7 | 8.9 | 9.2 | 9.4 |
| 69 | 8.3 | 8.6 | 8.8 | 9.0 | 9.3 | 9.5 |
| 70 | 8.5 | 8.8 | 9.0 | 9.2 | 9.5 | 9.7 |
| 71 | 8.7 | 9.0 | 9.2 | 9.4 | 9.7 | 9.9 |
| 72 | 8.8 | 9.1 | 9.3 | 9.5 | 9.8 | 10.0 |
| 73 | 9.0 | 9.3 | 9.5 | 9.7 | 10.0 | 10.0 |
| 74 | 9.2 | 9.4 | 9.7 | 10.0 | 10.0 | 10.0 |
| 75 | 9.3 | 9.5 | 9.8 | 10.0 | 10.0 | 10.0 |
| 76 | 9.5 | 9.7 | 10.0 | 10.0 | 10.0 | 10.0 |
| 77 | 9.7 | 9.9 | 10.0 | 10.0 | 10.0 | 10.0 |
| 78 | 9.8 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 79 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 80 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 81 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 82 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 83 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 84 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 85 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 86 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 87 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 88 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 89 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 90 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 91 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 92 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 93 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 94 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 95 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 96 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 97 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 98 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 99 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 100 or more | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |

*For odd-numbered fat tests, use values for next highest even-numbered fat test. Use values for 3.6% fat test for all fat tests lower than 3.6%. Use values for 4.6% fat test for all fat tests higher than 4.6%.

Appendix table 2. *Grain allowances, group 2 — liberal grain (forage: hay ad lib., 36 pounds corn silage)*

| Milk yield | Fat test (%)* | | | | | |
|---|---|---|---|---|---|---|
| | 3.6 or less | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 or above |
| (lb./day) | (pounds per feeding 2 x daily) | | | | | |
| 10 or less | 2.0 | 2.2 | 2.5 | 2.8 | 3.0 | 3.2 |
| 11 | 2.2 | 2.4 | 2.7 | 3.0 | 3.2 | 3.4 |
| 12 | 2.4 | 2.6 | 2.9 | 3.2 | 3.4 | 3.6 |
| 13 | 2.6 | 2.8 | 3.1 | 3.4 | 3.6 | 3.8 |
| 14 | 2.8 | 3.0 | 3.3 | 3.6 | 3.8 | 4.0 |
| 15 | 3.0 | 3.2 | 3.5 | 3.8 | 4.0 | 4.2 |
| 16 | 3.2 | 3.4 | 3.7 | 4.0 | 4.2 | 4.4 |
| 17 | 3.4 | 3.6 | 3.9 | 4.2 | 4.4 | 4.6 |
| 18 | 3.6 | 3.8 | 4.1 | 4.4 | 4.6 | 4.8 |
| 19 | 3.8 | 4.0 | 4.3 | 4.6 | 4.8 | 5.0 |
| 20 | 4.0 | 4.2 | 4.5 | 4.8 | 5.0 | 5.2 |
| 21 | 4.2 | 4.4 | 4.7 | 5.0 | 5.2 | 5.4 |
| 22 | 4.4 | 4.6 | 4.9 | 5.2 | 5.4 | 5.6 |
| 23 | 4.6 | 4.8 | 5.1 | 5.4 | 5.6 | 5.8 |
| 24 | 4.8 | 5.0 | 5.3 | 5.6 | 5.8 | 6.0 |
| 25 | 5.0 | 5.2 | 5.5 | 5.8 | 6.0 | 6.2 |
| 26 | 5.2 | 5.4 | 5.7 | 6.0 | 6.2 | 6.4 |
| 27 | 5.4 | 5.6 | 5.9 | 6.2 | 6.4 | 6.6 |
| 28 | 5.6 | 5.8 | 6.1 | 6.4 | 6.6 | 6.8 |
| 29 | 5.8 | 6.0 | 6.3 | 6.6 | 6.8 | 7.0 |
| 30 | 6.0 | 6.2 | 6.5 | 6.8 | 7.0 | 7.2 |
| 31 | 6.2 | 6.4 | 6.7 | 7.0 | 7.2 | 7.4 |
| 32 | 6.4 | 6.6 | 6.9 | 7.2 | 7.4 | 7.6 |
| 33 | 6.6 | 6.8 | 7.1 | 7.4 | 7.6 | 7.8 |
| 34 | 6.8 | 7.0 | 7.3 | 7.6 | 7.8 | 8.0 |
| 35 | 7.0 | 7.2 | 7.5 | 7.8 | 8.0 | 8.2 |
| 36 | 7.2 | 7.4 | 7.7 | 8.0 | 8.2 | 8.4 |
| 37 | 7.4 | 7.6 | 7.9 | 8.2 | 8.4 | 8.6 |
| 38 | 7.6 | 7.8 | 8.1 | 8.4 | 8.6 | 8.8 |
| 39 | 7.8 | 8.0 | 8.3 | 8.6 | 8.8 | 9.0 |
| 40 | 8.0 | 8.3 | 8.5 | 8.7 | 9.0 | 9.2 |
| 41 | 8.2 | 8.5 | 8.7 | 8.9 | 9.2 | 9.4 |
| 42 | 8.4 | 8.7 | 8.9 | 9.1 | 9.4 | 9.6 |
| 43 | 8.6 | 8.9 | 9.1 | 9.3 | 9.6 | 9.8 |
| 44 | 8.8 | 9.1 | 9.3 | 9.5 | 9.8 | 10.0 |
| 45 | 9.0 | 9.3 | 9.5 | 9.7 | 10.0 | 10.2 |
| 46 | 9.2 | 9.5 | 9.7 | 9.9 | 10.2 | 10.4 |
| 47 | 9.4 | 9.7 | 9.9 | 10.1 | 10.4 | 10.6 |
| 48 | 9.6 | 9.9 | 10.1 | 10.3 | 10.6 | 10.8 |
| 49 | 9.8 | 10.1 | 10.3 | 10.6 | 10.8 | 11.0 |
| 50 | 10.0 | 10.3 | 10.6 | 10.9 | 11.1 | 11.3 |

Appendix table 2. *(concluded)*

| Milk yield | Fat test (%)* | | | | | |
|---|---|---|---|---|---|---|
| | 3.6 or less | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 or above |
| (lb./day) | (pounds per feeding 2 x daily) | | | | | |
| 51 | 10.2 | 10.5 | 10.8 | 11.1 | 11.3 | 11.5 |
| 52 | 10.4 | 10.7 | 11.0 | 11.3 | 11.5 | 11.8 |
| 53 | 10.6 | 10.9 | 11.2 | 11.5 | 11.7 | 12.0 |
| 54 | 10.8 | 11.1 | 11.4 | 11.7 | 11.9 | 12.3 |
| 55 | 11.0 | 11.3 | 11.6 | 11.9 | 12.1 | 12.5 |
| 56 | 11.2 | 11.5 | 11.8 | 12.1 | 12.3 | 12.8 |
| 57 | 11.4 | 11.7 | 12.0 | 12.3 | 12.5 | 13.0 |
| 58 | 11.6 | 11.9 | 12.2 | 12.5 | 12.7 | 13.2 |
| 59 | 11.8 | 12.1 | 12.4 | 12.8 | 13.0 | 13.5 |
| 60 | 12.0 | 12.3 | 12.7 | 13.1 | 13.3 | 13.8 |
| 61 | 12.3 | 12.6 | 12.9 | 13.3 | 13.5 | 14.0 |
| 62 | 12.6 | 12.9 | 13.2 | 13.5 | 13.8 | 14.2 |
| 63 | 12.9 | 13.2 | 13.5 | 13.8 | 14.1 | 14.4 |
| 64 | 13.2 | 13.5 | 13.8 | 14.1 | 14.4 | 14.7 |
| 65 | 13.5 | 13.8 | 14.1 | 14.4 | 14.7 | 10.0 |
| 66 | 13.8 | 14.1 | 14.4 | 14.7 | 10.0 | 10.2 |
| 67 | 14.1 | 14.4 | 14.7 | 10.0 | 10.2 | 10.5 |
| 68 | 14.4 | 14.7 | 10.0 | 10.2 | 10.5 | 10.7 |
| 69 | 14.7 | 10.0 | 10.2 | 10.5 | 10.7 | 11.0 |
| 70 | 10.0 | 10.2 | 10.5 | 10.7 | 11.0 | 11.2 |
| 71 | 10.2 | 10.5 | 10.8 | 11.0 | 11.3 | 11.5 |
| 72 | 10.5 | 10.7 | 11.1 | 11.3 | 11.6 | 11.8 |
| 73 | 10.7 | 11.0 | 11.3 | 11.6 | 11.9 | 12.1 |
| 74 | 11.0 | 11.2 | 11.6 | 11.9 | 12.2 | 12.4 |
| 75 | 11.2 | 11.5 | 11.8 | 12.2 | 12.5 | 12.7 |
| 76 | 11.5 | 11.7 | 12.1 | 12.4 | 12.8 | 13.0 |
| 77 | 11.7 | 12.0 | 12.3 | 12.6 | 13.1 | 13.3 |
| 78 | 12.0 | 12.2 | 12.6 | 12.9 | 13.4 | 13.6 |
| 79 | 12.2 | 12.5 | 12.8 | 13.2 | 13.7 | 13.9 |
| 80 | 12.5 | 12.8 | 13.1 | 13.5 | 13.9 | 14.2 |
| 81 | 12.7 | 13.0 | 13.4 | 13.8 | 14.2 | 14.5 |
| 82 | 13.0 | 13.3 | 13.7 | 14.1 | 14.5 | 14.8 |
| 83 | 13.2 | 13.5 | 14.0 | 14.4 | 14.8 | 15.1 |
| 84 | 13.5 | 13.8 | 14.3 | 14.7 | 15.1 | 15.4 |
| 85 | 13.7 | 14.0 | 14.6 | 15.0 | 15.4 | 15.7 |
| 86 | 14.0 | 14.3 | 14.9 | 15.3 | 15.7 | 16.0 |
| 87 | 14.2 | 14.5 | 15.2 | 15.6 | 16.0 | 16.3 |
| 88 | 14.5 | 14.8 | 15.5 | 15.9 | 16.3 | 16.6 |
| 89 | 14.7 | 15.0 | 15.8 | 16.1 | 16.6 | 16.9 |
| 90 | 15.0 | 15.4 | 16.0 | 16.4 | 16.9 | 17.3 |
| 91 | 15.3 | 15.7 | 16.3 | 16.7 | 17.2 | 17.6 |
| 92 | 15.6 | 16.0 | 16.6 | 17.0 | 17.5 | 17.9 |
| 93 | 15.9 | 16.3 | 16.9 | 17.3 | 17.8 | 18.2 |
| 94 | 16.2 | 16.6 | 17.2 | 17.6 | 18.1 | 18.5 |
| 95 | 16.5 | 16.9 | 17.5 | 17.9 | 18.4 | 18.8 |
| 96 | 16.8 | 17.2 | 17.8 | 18.2 | 18.7 | 19.1 |
| 97 | 17.1 | 17.5 | 18.1 | 18.5 | 19.0 | 19.4 |
| 98 | 17.4 | 17.8 | 18.4 | 18.8 | 19.3 | 19.6 |
| 99 | 17.7 | 18.1 | 18.7 | 19.1 | 19.6 | 19.8 |
| 100+ | 18.0 | 18.5 | 19.0 | 19.5 | 20.0 | 20.0 |

*Fat test for previous week and milk yield for 3 successive days of previous week. For odd-numbered fat test use intermediate values.

Shaded area represents pounds per feeding 3 times daily for grain allowance of 30 pounds or above.

Appendix table 3. *Grain allowance table, group 3 — restricted forage, liberal grain (forage: 8 pounds hay and 12 pounds corn silage)*

| Milk yield | Fat test (%)* | | | | | |
|---|---|---|---|---|---|---|
| | 3.6 or less | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 or above |
| (lb./day) | (pounds per feeding 2 x daily) | | | | | |
| Dry (3 or more weeks before freshening) | 7.5 for all cows | | | | | |
| 0-10 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 | 8.5 |
| 10-20 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 | 9.0 |
| 20-30 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 | 9.6 |
| 31 | 9.6 | 9.7 | 9.7 | 9.7 | 9.7 | 9.8 |
| 32 | 9.7 | 9.7 | 9.8 | 9.8 | 9.9 | 9.9 |
| 33 | 9.8 | 9.8 | 9.9 | 10.0 | 10.0 | 10.1 |
| 34 | 9.8 | 9.9 | 10.0 | 10.1 | 10.2 | 10.3 |
| 35 | 9.8 | 10.0 | 10.0 | 10.2 | 10.3 | 10.4 |
| 36 | 9.9 | 10.0 | 10.1 | 10.3 | 10.4 | 10.6 |
| 37 | 10.0 | 10.1 | 10.2 | 10.5 | 10.6 | 10.8 |
| 38 | 10.0 | 10.2 | 10.3 | 10.6 | 10.7 | 11.0 |
| 39 | 10.0 | 10.2 | 10.4 | 10.7 | 10.9 | 11.1 |
| 40 | 10.1 | 10.3 | 10.5 | 10.8 | 11.0 | 11.3 |
| 41 | 10.4 | 10.6 | 10.8 | 11.1 | 11.3 | 11.6 |
| 42 | 10.6 | 10.8 | 11.0 | 11.3 | 11.6 | 11.9 |
| 43 | 10.8 | 11.0 | 11.3 | 11.6 | 11.8 | 12.1 |
| 44 | 11.1 | 11.3 | 11.6 | 11.9 | 12.1 | 12.4 |
| 45 | 11.4 | 11.6 | 11.8 | 12.2 | 12.4 | 12.7 |
| 46 | 11.6 | 11.8 | 12.1 | 12.4 | 12.7 | 13.0 |
| 47 | 11.8 | 12.0 | 12.4 | 12.7 | 13.0 | 13.3 |
| 48 | 12.1 | 12.3 | 12.7 | 13.0 | 13.2 | 13.5 |
| 49 | 12.4 | 12.6 | 12.9 | 13.2 | 13.5 | 13.8 |
| 50 | 12.6 | 12.8 | 13.2 | 13.5 | 13.8 | 14.1 |
| 51 | 12.9 | 13.1 | 13.5 | 13.8 | 14.1 | 14.4 |
| 52 | 13.1 | 13.3 | 13.7 | 14.1 | 14.4 | 14.7 |
| 53 | 13.4 | 13.6 | 14.0 | 14.3 | 14.7 | 15.0 |
| 54 | 13.6 | 13.8 | 14.3 | 14.6 | 15.0 | 10.2 |
| 55 | 13.9 | 14.1 | 14.6 | 14.9 | 10.2 | 10.4 |
| 56 | 14.2 | 14.4 | 14.8 | 10.1 | 10.3 | 10.5 |
| 57 | 14.4 | 14.6 | 10.1 | 10.3 | 10.5 | 10.7 |
| 58 | 14.7 | 14.9 | 10.2 | 10.5 | 10.7 | 10.9 |
| 59 | 14.9 | 10.2 | 10.4 | 10.7 | 10.9 | 11.1 |
| 60 | 10.1 | 10.4 | 10.6 | 10.9 | 11.1 | 11.3 |
| 61 | 10.3 | 10.6 | 10.8 | 11.1 | 11.3 | 11.5 |
| 62 | 10.5 | 10.8 | 11.0 | 11.3 | 11.5 | 11.7 |
| 63 | 10.7 | 11.0 | 11.2 | 11.5 | 11.7 | 12.0 |
| 64 | 10.9 | 11.2 | 11.4 | 11.7 | 11.9 | 12.2 |
| 65 | 11.1 | 11.4 | 11.6 | 11.9 | 12.2 | 12.4 |

Appendix table 3 *(concluded)*

| Milk yield | Fat test (%)* | | | | | |
|---|---|---|---|---|---|---|
| | 3.6 or less | 3.8 | 4.0 | 4.2 | 4.4 | 4.6 or above |
| (lb./day) | (pounds per feeding 2 x daily) | | | | | |
| 66 | 11.2 | 11.5 | 11.8 | 12.1 | 12.4 | 12.6 |
| 67 | 11.4 | 11.7 | 12.0 | 12.3 | 12.6 | 12.8 |
| 68 | 11.6 | 11.9 | 12.2 | 12.5 | 12.8 | 13.1 |
| 69 | 11.8 | 12.1 | 12.4 | 12.7 | 13.0 | 13.3 |
| 70 | 12.0 | 12.3 | 12.6 | 12.9 | 13.2 | 13.5 |
| 71 | 12.2 | 12.5 | 12.8 | 13.1 | 13.4 | 13.7 |
| 72 | 12.4 | 12.7 | 13.0 | 13.3 | 13.6 | 14.0 |
| 73 | 12.6 | 12.9 | 13.2 | 13.6 | 13.8 | 14.2 |
| 74 | 12.8 | 13.1 | 13.4 | 13.8 | 14.1 | 14.4 |
| 75 | 13.0 | 13.4 | 13.6 | 14.0 | 14.3 | 14.6 |
| 76 | 13.2 | 13.5 | 13.8 | 14.2 | 14.5 | 14.9 |
| 77 | 13.4 | 13.7 | 14.0 | 14.3 | 14.7 | 15.1 |
| 78 | 13.6 | 13.9 | 14.2 | 14.6 | 15.0 | 15.3 |
| 79 | 13.8 | 14.1 | 14.4 | 14.8 | 15.2 | 15.6 |
| 80 | 14.0 | 14.4 | 14.7 | 15.1 | 15.4 | 15.8 |
| 81 | 14.2 | 14.6 | 14.9 | 15.3 | 15.6 | 16.0 |
| 82 | 14.4 | 14.9 | 15.2 | 15.6 | 15.9 | 16.3 |
| 83 | 14.7 | 15.1 | 15.4 | 15.8 | 16.2 | 16.6 |
| 84 | 14.9 | 15.3 | 15.6 | 16.1 | 16.4 | 16.8 |
| 85 | 15.1 | 15.6 | 15.8 | 16.3 | 16.6 | 17.0 |
| 86 | 15.3 | 15.8 | 16.1 | 16.5 | 16.9 | 17.3 |
| 87 | 15.5 | 16.0 | 16.3 | 16.8 | 17.2 | 17.6 |
| 88 | 15.8 | 16.2 | 16.5 | 17.0 | 17.4 | 17.8 |
| 89 | 16.0 | 16.5 | 16.8 | 17.3 | 17.6 | 18.0 |
| 90 | 16.2 | 16.7 | 17.0 | 17.5 | 17.9 | 18.3 |
| 91 | 16.4 | 17.0 | 17.3 | 17.8 | 18.2 | 18.6 |
| 92 | 16.7 | 17.2 | 17.5 | 18.0 | 18.5 | 18.9 |
| 93 | 17.0 | 17.4 | 17.8 | 18.3 | 18.7 | 19.2 |
| 94 | 17.2 | 17.7 | 18.1 | 18.6 | 19.0 | 19.5 |
| 95 | 17.4 | 18.0 | 18.4 | 18.8 | 19.3 | 19.8 |
| 96 | 17.7 | 18.2 | 18.6 | 19.1 | 19.6 | 20.0 |
| 97 | 18.0 | 18.5 | 18.9 | 19.4 | 19.9 | 20.3 |
| 98 | 18.2 | 18.7 | 19.2 | 19.7 | 20.1 | 20.6 |
| 99 | 18.4 | 19.0 | 19.4 | 19.9 | 20.4 | 20.9 |
| 100 or more | 18.7 | 19.2 | 19.7 | 20.2 | 20.7 | 21.2 |

*For odd-numbered fat test percentages, use values of next highest even-numbered fat test. For fat tests below 3.6%, use values for 3.6%. For fat tests above 4.6%, use values for 4.6%.

Shaded area represents pounds per feeding 3 times daily for grain allowance of 30 pounds or above.

Appendix table 4. *Protein substitution and grain allowance adjustment, group 4 — all silage, liberal grain (forage: corn silage ad lib.)**

| Corn silage intake | 44% protein soybean meal | 16% protein grain replaced Subtract lbs./feeding | Subtract lbs./feeding |
|---|---|---|---|
| (lb./day) | (lb./day) | (2 x a day feeding) | (3 x a day feeding) |
| 0- 39† | 0 | 0 | 0 |
| 40 - 49 | 0.5 | 0.2 | 0.1 |
| 50 - 59 | 1.0 | 0.4 | 0.3 |
| 60 - 69 | 1.5 | 0.6 | 0.4 |
| 70 - 79 | 2.0 | 0.9 | 0.6 |
| 80 - 89 | 2.5 | 1.1 | 0.7 |
| 90 - 99 | 3.0 | 1.3 | 0.9 |
| 100- 109 | 3.5 | 1.5 | 1.0 |
| 110-119 | 4.0 | 1.8 | 1.2 |
| 120-129 | 4.5 | 1.9 | 1.2 |
| 130- 139 | 5.0 | 2.2 | 1.5 |
| 140 - 149 | 5.5 | 2.4 | 1.6 |

*See appendix table 2 for basic grain allowances.

†Protein substitution applies only to the corn silage above the 36-pound level allowed to group 1 and 2.

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