A STUDY OF FEEDING STANDARDS

FOR

MILK PRODUCTION

ELMER SETH SAVAGE

THESIS

Presented to the Faculty of the Graduate School of Cornell University
for the Degree of Doctor of Philosophy

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A STUDY OF FEEDING STANDARDS FOR MILK PRODUCTION*

E. S. Savage

What may be called the science of animal nutrition began with six experiments conducted by two German scientists, Henneberg and Stohman, the results of which were published about 1860. Since that time many scientists, notably in Germany and also in America since the founding of the American experiment stations, have interested themselves in trying to calculate the definite food requirements of certain groups of animals used for such purposes as labor, meat, wool, and milk production. These food requirements have been tabulated and designated "feeding standards."

Perhaps these standards have been of greater interest to teachers and investigators than to practical stock-feeders. To the practical feeder, feeding is an art; to the investigator, feeding is an exact science. Yet the teachings of science cannot be disregarded by the practical man, and he should have an adequate knowledge of the physiological make-up of his animals, of the different constituents of feeding-stuffs, and of the various uses to which those constituents are put in order to meet the physiological requirements of the body as to growth, health, and product. In like manner the investigator must not lose sight of the fact that in the words of the old German adage, quoted by Henry, "The eye of the master fattens his cattle."

There are two distinct uses of feeding standards which cannot be denied. These uses are very important. One is as a basis from which to teach the elementary facts of animal nutrition to students in the colleges. The other is as a basis for use in economical feeding operations. In both cases, after the feeding standards are thoroughly understood they may be departed from so far as the experience of the individual may show it to be advisable.

With the purpose of learning something of the application of two of the more recent feeding standards — that of Haecker and that of Armsby — the present work was instituted at the Cornell University Agricultural Experiment Station in the winter of 1909–1910. Haecker's standard has to do with feeding dairy cows exclusively; and only that part of Armsby's standard which has to do with dairy production is considered in this paper.

*Also presented before the Faculty of the Graduate School of Cornell University, June, 1911, as a master thesis in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

HISTORY OF FEEDING STANDARDS [1]

The three volumes containing the data of Hemeberg and Stohman were known as the Weende Reports. They were published between 1860 and 1870 and were the foundation of the study of feeding standards. To the authors of these reports, more than to any other persons, belongs the credit for having started the study of animal-feeding from a scientific point of view.

The name of Justus von Liebig is also prominent in these early studies; while the Munich scientists, Bischoff and Voit, have contributed much to the laws of nutrition in their work, "On the Laws of the Nutrition of Carnivora." Boussingault, the French chemist and farmer, deserves mention in this connection. His experience dates from 1836. In England, Lawes and Gilbert of the Rothamsted Station contributed very largely to the early knowledge of nutrition.

Hay values

Thaer seems to have been the first to inaugurate a systematic scheme for feeding. He worked out the relative values of different feeding-stuffs in terms of "good" meadow hay, the value of the hay for feeding purposes being the standard unit. These hay values were in use for some time previous to 1858. They were modified by other agricultural writers and teachers, but were not changed in principle until 1858.

Grouven's feeding standards

In 1858 Grouven proposed to formulate into standards the food components as required by different animals according to their live weight. Eight standards were given for dairy cows, according to their weight from 772 to 1,543 pounds. For cows weighing about 1,000 pounds Grouven proposed the following standard, the constituents being crude protein, crude fat, and crude carbohydrates: dry matter 28.7 pounds, protein 2.76 pounds, fat .86 pound, and carbohydrates 14.55 pounds. The nutritive ratio was about 1:6.1. The components were not varied at all in the standards for production, being based entirely on live weight.

Wolff's feeding standards

The next standards proposed were those of Emil von Wolff in 1864. Digestion experiments had been conducted to some extent at this time and Wolff recognized the value of a standard in terms of digestible constituents. The Wolff standard for milch cows was as follows: for a cow weighing 1,000 pounds, organic matter 24 pounds, digestible protein 2.5 pounds, digestible carbohydrates 12.5 pounds, and digestible fat .40 pound.

[1] F. W. Woll. "On the Relation of Food to the Production of Milk and Butter Fat by Dairy Cows." Wis. Agr. Exp. Sta. Bul. 116.

This standard of Wolff's was published in the Annual Agricultural Calendar of Mentzel and von Lengerke[1] and thus became widely known and practiced by German farmers.

Julius Kuhn[2] criticises this standard of Wolff's very severely in that the standard was supposed to apply to all cases. Kuhn would have a basal ration for maintenance and then add supplementary amounts for production. He would vary the amounts fed from 20 to 23.5 pounds of dry matter, from 1.5 to 2.4 pounds of digestible albuminoids (he separates the digestible amides from the rest of the protein, saying that the digestible amides have the same effect as the carbohydrates), and from 12 to 14 pounds of digestible amides, crude fiber, and nitrogen-free extract, with a nutritive ratio of 1:5.5 to 1:8 according to the production of the cow being fed.

Wolff-Lehmann feeding standard

Next in line comes the Lehmann modification of the Wolff standard. This was published, after the death of Wolff, in the Annual Agricultural Calendar of Mentzel and von Lengerke[1] for 1897, page 107. This standard took into account the objections of Kuhn, and the Wolff standard was modified to meet the supposed requirements of cows giving different quantities of milk. They were based on 1,000 pounds live weight and were as follows:

TABLE 1

When yielding daily	Dry matter (pounds)	Digestible nutrients			
		Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Nutritive ratio
11.0 pounds milk	25	1.6	10	.3	1:6.7
16.6 pounds milk	27	2.0	11	.4	1:6.0
22.0 pounds milk	29	2.5	13	.5	1:5.7
27.5 pounds milk	32	3.3	13	.8	1:4.5

Since their first appearance these German standards, as they have been called, have been widely published both in Europe and in America. They form the basis for the computation of rations in nearly all the works on feeding. Wolff's standards are found as the basis in Armsby's "Manual of Cattle Feeding." However, Doctor Armsby has changed his basis entirely since the last edition of this book, as will be seen later. W. A.

[1] F. W. Woll. "On the Relation of Food to the Production of Milk and Butter Fat by Dairy Cows." Wis. Agr. Exp. Sta. Bul. 116.
[2] Julius Kuhn. "Feeding Standards for Domestic Animals." Exp. Sta. Record 4: 6.

Henry[1] used the Wolff-Lehmann standards as the basis of his rations. W. H. Jordan[2] also used the Wolff-Lehmann standard in his work. Besides these works, which are probably the most popular and widely read works on feeding in America, the Wolff-Lehmann standards have been published in a large number of pamphlets and bulletins of the experiment stations of the various countries.

In addition to the standards noted above, three other German investigators have published standards of more or less value: Maerker,[3] Pott,[4] and Kellner.[5] One Swedish investigator, N. Hansson,[6] has also published a set of "feeding tables."

FEEDING STANDARDS IN AMERICA

The feeding standards that have been in common use in this country up to within the last year or two, and are in use to a great extent even now, are the Wolff-Lehmann standards. In 1894 F. W. Woll[7] published a standard ration which was the average of about one hundred rations in the United States and Canada. The average ration was: dry matter 24.51 pounds, digestible protein 2.15 pounds, digestible carbohydrates and fat 14.51 pounds, nutritive ratio 1:6.9. Woll gives this as evidence that, in the experience of American farmers who are practical feeders, less protein is needed than is recommended by the Wolff-Lehmann standards. Also, the rations can have a wider nutritive ratio. Woll called his standard the "American practical feeding ration" and recommended its use by farmers in place of the German standard.

At the Connecticut (Storrs) station Atwater and Phelps[8] formulated a standard from their experience along the same lines as those followed by Woll, with a little difference in the requirements of the different constituents.

In the last two or three years a feeding standard proposed by T. L. Haecker,[9] of Minnesota, has received much attention from dairymen and has been adopted in many cases as a guide for feeding dairy cows, notably by H. R. Smith[10] and C. B. Lane,[11] and by "Hoard's Dairyman."

In January, 1909, H. P. Armsby[12] published a set of feeding standards based on the production values of feeding-stuffs as determined by Kellner at the Moeckern Experiment Station in Germany.

[1] W. A. Henry. "Feeds and Feeding."
[2] W. H. Jordan. "Feeding Farm Animals."
[3] F. W. Woll. "Our Present Relation of Food to the Production of Milk and Butter Fat by Dairy Cows." Wis. Agr. Exp. Sta. Bul. 110.
[4] Exp. Sta. Record 22: 375.
[5] O. Kellner. "The Scientific Feeding of Animals." Translation by Wilbur O. Goodwin.
[6] N. Hansson. Exp. Sta. Record 20: 475.
[7] F. W. Woll. "One Hundred American Rations for Dairy Cows." Wis. Agr. Exp. Sta. Bul. 38.
[8] W. O. Atwater and C. S. Phelps. "Nitrogenous Feeding Stuffs and Feeding Formulas for Dairy Cows." 10th Ann. Rept. Conn. (Storrs) Agr. Exp. Sta., p. 67.
[9] T. L. Haecker. "Investigations in Milk Production." Minn. Agr. Exp. Sta. Bul. 79.
[10] H. R. Smith. "Profitable Stock Feeding."
[11] C. B. Lane. "The Business of Dairying."
[12] H. P. Armsby. "The Computation of Rations for Farm Animals by the Use of Energy Values." U. S. Dept. Agr., Farmers' Bul. 340.

The study of these last two feeding standards will now be taken up in detail, since they form the basis of the experiment herein reported.

HAECKER'S FEEDING STANDARD FOR DAIRY PRODUCTION

In 1892 T. L. Haecker took up his investigations at the Minnesota Agricultural Experiment Station. He began his work by keeping careful herd records of production and the cost of feeding. For several years he published the "Dairy Herd-Records" in the several reports and bulletins of the station.[1] There is nothing that needs consideration in the earlier reports except to mention that during the winter of 1893–1894 experiments were conducted comparing the feeding value of timothy and prairie hay, and during the winter of 1894–1895 experiments were conducted comparing the feeding value of wheat, barley, and corn. These experiments are mentioned because Haecker used the data from them in later discussions in regard to his feeding standard.

In all the feeding work at Minnesota, Haecker reports the cows to have had all the feed that they would eat up clean. They were fed in as nearly a common-sense, practical way as possible. When a cow has shown a desire for more food and has shown that she would give a good return for it, it has been given to her. The aim has been to keep the cows in good working condition without any appreciable gain or loss in body weight after the first eleven weeks from calving. During the first eleven weeks it has been expected that a cow would lose in body weight, particularly if she was in good flesh at the time of calving. More will be said of this later.

The work that formed the basis of the Haecker standard was published by Haecker in bulletins 71 and 79 of the Minnesota station. All the data in these bulletins were taken from the herd records, considering mature cows in what Professor Haecker calls "good normal working condition." The results in Bulletin 71 will be taken up first.

Data in Bulletin 71 of the Minnesota station

1. Protein requirements.— In the Wolff-Lehmann standard, Doctor Lehmann calculated that .7 pound protein was required for maintenance per 1,000 pounds live weight and that .081 pound was required for the production of 1 pound of milk. These requirements were the same whether the cow was giving 11 pounds or 22 pounds of milk daily. Haecker noticed

[1] T. L. Haecker:
"Dairy Herd-Record for 1892." Minn. Agr. Exp. Sta. Rept. 1893: 313–324.
"Dairy Herd-Record for 1893; Cost of Butter Production in Winter; Comparing Prairie with Timothy Hay; Rearing Dairy Calves; Cooperative Creameries; Experiments in Sweet-curd Cheese." Minn. Agr. Exp. Sta. Bul. 35.
"Investigation in Milk Production." Minn. Agr. Exp. Sta. Bul. 67.
"Investigation in Milk Production; Protein Requirements." Minn. Agr. Exp. Sta. Bul. 71.
"Investigation in Milk Production." Minn. Agr. Exp. Sta. Bul. 79.
"The Relation of Nutriment to Product." Minn. Agr. Exp. Sta. Bul. 109.

that in the experiment in comparing timothy hay with prairie hay, less protein seemed to be required than the Wolff-Lehmann standard called for.

There were twelve cows in the experiment. The average daily production was 25.81 pounds of milk testing 4.06 per cent fat, on 24.38 pounds of dry matter containing 1.99 pound digestible protein, 12.82 pounds digestible carbohydrates, and .59 pound fat. The Wolff-Lehmann standard gives 2.5 pounds digestible protein as the amount required for 22 pounds of milk daily. The average weight of the cows during the trial was 950 pounds, and allowing them daily for maintenance .7 pound of protein per 1,000 pounds live weight there remains 1.33 pound protein daily for milk production. Since the cows gave 25.81 pounds of milk daily, they returned 1 pound of milk for .051 pound of protein, instead of for .081 pound according to the Lehmann standard. Singling out the mature cows, which made little if any gain in weight, nine remain. Using the factor .7 pound protein for maintenance and determining the amount available for product, the following average results are obtained: average weight 991 pounds, protein daily 2.09 pounds, protein for maintenance .69 pound, protein for product 1.40 pound, milk daily 29.06 pounds testing 3.9 per cent fat. From these averages, we have .0481 pound of protein required for 1 pound of milk. The amount of protein required varied all the way from .035 pound in the case of one cow giving 43.50 pounds of milk testing 2.5 per cent fat, to .057 pound as required by cows giving 25.80 and 25.99 pounds of milk containing 5.3 per cent fat. The value of the data given above is lessened when the length of the experiment is considered, since the time was only fourteen days.

However, data from the wheat, barley, and corn experiment are available on the same question. Two periods — one of eighty-four days and the other of seventy days — are considered here, so that the data have more value. The rations varied from 20.08 pounds to 31.49 pounds dry matter, and averaged 24.30 pounds dry matter containing 2.01 pounds protein, 12.03 pounds carbohydrates, and 1.53 pound fat. (In all cases in this paper the terms protein, carbohydrates, and fat have reference to the digestible constituents alone. If the crude amounts are meant, it will be so stated.) The average daily yield was 26.96 pounds milk, testing 4.01 per cent fat. The average weight of the cows was 954 pounds. Allowing .66 pound protein for maintenance, we have 1.35 pound protein for product, or .05 pound protein for 1 pound milk testing 4.01 per cent fat. These figures are the average for twelve cows for eighty-four days. One cow had aborted and another was near the close of her lactation period. Taking these out, the average requirement was .046 pound protein for 1 pound milk testing 3.9 per cent fat. During the next seventy days, twelve cows were in an

experiment that gives results on the same question. The average weight of the cows was 958 pounds. They received daily 2 pounds of protein, of which 1.33 pound was for product. The yield was 25.23 pounds milk testing 4.07 per cent fat, or .053 pound protein for 1 pound milk.

Conclusions as to protein requirements.— From the results of the two experiments reviewed above, .046 pound of protein available for product is suggested as sufficient to produce 1 pound of milk and to maintain the flow. By increasing or diminishing this allowance by .004 pound for each .5 per cent increase or decrease in the percentage of fat in the milk, Haecker estimated that the ration would be adjusted to the needs of the cows giving various grades of milk. Milk testing 3.85 per cent fat is fixed as the standard average, and a cow giving that grade of milk should receive .046 pound of protein to each pound of milk produced.

2. *Experiment in feeding dairy cows with rations containing varying amounts of protein and having various nutritive ratios.*— In this experiment it was planned to divide the herd into six groups of five cows each, to be fed during the winter on rations containing protein and having nutritive ratios as follows:

TABLE 2

Group	Protein (pounds)	Nutritive ratio
1	2.42	1:5.3
2	2.15	1:6.4
3	1.86	1:7.2
4	1.61	1:8.3
5	1.47	1:9.3

(Data for group 6 not given in bulletin cited.)

These plans were not held to exactly, since the roughage was not analyzed by the Station Chemist until later and in planning the experiment the average composition of American feeding-stuffs was used. A number of cows aborted during the winter and the records are very much disturbed because of this. In the final conclusions of the experiment, as shown by Table 6 on page 67, no results are given for groups 3 and 6. The other groups are said to be made up of four cows each. Why groups 3 and 6 were dropped and why one cow was dropped from each of the other groups is not explained.

The experiment ran through three periods. During the first period all the cows were fed the same ration, it being mixed as follows during the time noted:

TABLE 3. RATIONS IN PERIOD 1 (IN POUNDS

	Dec. 31–Jan. 6	Jan. 7–20	Jan. 21–27
Bran	5	5	5
Corn	5	5	5
Gluten meal	2	2	2
Mangels	12	12	12
Fodder corn	6	.....	6
Silage	36	36	36

During period 2, the eight weeks from January 28 to March 24, the rations for the various groups were mixed as follows:

TABLE 4. RATIONS IN PERIOD 2 (IN POUNDS)
(January 28 to March 24)

	Group 1	Group 2	Group 4	Group 5
Bran	5	.....	.....	.....
Oats	.....	5	8	4
Corn	25	25	2	4
Barley	25	25	2	4
Gluten meal	2	2	.....	.....
Fodder corn	12	12	12	12
Silage	36	36	36	36

Group 3 received the same ration as did group 4, except that bran was substituted for oats. Group 6 received the same ration as did group 5, except that bran was substituted for oats.

During period 3 all the cows were fed the following ration:

TABLE 5. RATIONS IN PERIOD 3

	Pounds
Bran	5
Corn	5
Gluten meal	2
Prairie hay	12
Silage	36

The cows were fed at all times as much as they seemed to need and all that they could use to good advantage, in the judgment of the feeder.

The results of the experiment are given in the following table:

TABLE 6

Group	Average weight (pounds)	Total protein (pounds)	Protein for maintenance (pounds)	Protein for product (pounds)	Pounds milk	Percentage fat	Pounds protein to 1 pound milk
Period 1							
1	769	1.774	.538	1.236	16.86	5.53	.0733
2	725	1.605	.507	1.098	14.86	5.17	.0739
4	881	1.845	.617	1.228	16.75	4.70	.0733
5	669	1.594	.468	1.126	17.51	4.78	.0643
Average, period 1	761	1.704	.533	1.171	16.49	5.04	.0710
Period 2							
1	794	2.037	.556	1.481	15.82	5.64	.0936
2	746	1.811	.522	1.289	15.18	5.15	.0849
4	902	1.739	.631	1.108	16.27	4.63	.0681
5	681	1.491	.477	1.014	17.66	4.56	.0574
Average, period 2	781	1.769	.547	1.222	16.23	4.98	.0753
Period 3							
1	812	1.844	.568	1.276	15.18	5.72	.0840
2	778	1.694	.545	1.149	14.29	5.02	.0804
4	938	1.937	.657	1.280	15.96	4.61	.0802
5	744	1.802	.521	1.281	17.07	4.66	.0750
Average, period 3	818	1.819	.573	1.246	15.62	4.99	.0798

Conclusions from Bulletin 71.— Haecker's conclusions from the data given in Bulletin 71 of the Minnesota station are as follows:

"1. Cows giving ordinary yields of milk and of butter-fat do not require the amount of protein called for in the standard rations.

"2. The amount of milk that a cow gives daily, and its fat content, measure the amount of protein which the animal requires over and above that needed for maintenance.

"3. There is a limit to the milk- and fat-producing power of a cow at any given time. Feeding more protein than she needs for this production and for her own support is of no advantage.

"4. The excess of protein, with the corresponding excess of other nutrients, will tend to cause a cow to lay on flesh and thereby to shrink in milk flow.

"5. Grains ordinarily grown on the farm, fed in conjunction with such roughage as fodder corn, corn silage, timothy, and prairie hay, provide ample protein for cows doing ordinary dairy work."

Data in Bulletin 79 of the Minnesota station

The investigations in regard to milk production are reported in this bulletin under four headings:

1. Maintenance requirements.
2. Nutrient requirements.
3. Protein requirements.
4. Influence of stage of lactation on nutrient requirements.

These topics will be discussed in order and the conclusions of Haecker in regard to each will be shown.

1. Maintenance requirements.— Wolff's maintenance ration for 1,000 pounds live weight is: dry matter 18 pounds, protein .7 pound, carbohydrates 8 pounds, ether extract .1 pound. In order to test the accuracy of this standard, Haecker conducted three experiments with barren cows.

As a result of the first experiment, made with two barren cows for a period of eighty-one days on a ration of 8 pounds of timothy hay and 3 pounds of barley, the cows gained an average of .36 pound daily on a ration containing daily .004 pound more protein and .209 pound less carbohydrates. Therefore the ration was in excess of the amount actually needed for maintenance.

The second experiment was conducted with two barren cows during the winter of 1896–1897 and covered a period of one hundred days. One cow received daily 18 pounds and the other 14 pounds of corn fodder. The following table shows the average weight of the cows and the nutrients consumed by them daily:

TABLE 7

Cow	Average weight (pounds)	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)
Alice	808	8.98	.297	5.45	.38
Belle	1,010	9.23	.277	5.08	.37
Average	.....	9.10	.287	5.27	.375

The cows maintained their weights during the experiment except that during the month of February Belle was down to 987 pounds; she regained her weight, however, to an average of 1,010 pounds. Yet the physical appearance of the cows showed that they had not been sufficiently nourished even though they had maintained their live weights.

During the winter of 1897–1898, in the third experiment, three cows were fed on maintenance rations of fodder corn, beets, and oil meal. The data cover the period from December 30 to April 11. Combining the results with two of these cows (the record of the third was thrown out

because it was found that she had been suffering with a broken tooth) with data obtained from feeding one cow on a maintenance ration in 1898–1899, we have the following results: material consumed per 1,000 pounds live weight, dry matter 11.38 pounds, protein .63 pound, carbohydrates 5.75 pounds, and fat .12 pound.

Conclusions in regard to maintenance requirements.— Haecker concludes from the results of the above experiments that with cows at rest in stall in comfortable quarters, a ration of 11.5 pounds of dry matter containing .06 pound protein, .6 pound carbohydrates, and .01 pound ether extract per 100 pounds live weight is ample for a maintenance ration. However, he questions whether these amounts would be sufficient for cows receiving ordinary treatment in herds if the cows are allowed a certain amount of exercise each day.

Pending further investigation on the maintenance requirements of dairy cows, Haecker suggests the following for the maintenance allowance for producing animals: 12.5 pounds dry matter, containing .7 pound protein, 7 pounds carbohydrates, and .1 pound ether extract, for each 1,000 pounds live weight.

2. *Nutrient requirements.*— In making a study of the nutrient requirements for milk production, Haecker discusses the following questions:

A. Are the Lehmann factors approximately correct?

B. Are they applicable to any and all grades or qualities of milk yielded?

C. Will they be sufficient for heifers in milk?

The results from questions A and B, only, will be discussed here, since they apply to the results of our own trial.

Question A. The herd records and records of experiments conducted in 1894–1895 are cited to throw light on this question. The records cover a period of one hundred and fifty-four days. The cows were given a fixed ration. A full flow of milk and yield was obtained without gain or loss in body weight. The following table shows the nutrients used in the production of 1 pound of milk:

TABLE 8

	Live weight (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Milk produced (pounds)
Daily average	956	2.000	12.46	.560	26.09
Daily average for maintenance	.....	.670	6.69	.095	.....
Daily average for milk	.....	1.330	5.77	.460	.....
Nutrients to 1 pound milk	.....	.051	.221	.018	.....
Lehmann for 1 pound milk (when yield is 22 pounds per day)	.....	.081	.220	.018	.....

The results as shown in the table above are not materially different from Lehmann's standard except in amount of protein.

The following winter, 1895–1896, the herd was composed of practically the same animals receiving on an average a daily allowance of 2.59 pounds of protein. Compared with 1894–1895 the performance is as follows:

TABLE 9

Year	Live weight (pounds)	Protein (pounds)	Carbo-hydrates (pounds)	Fat (pounds)	Milk produced (pounds)	Percentage of fat in milk	Pounds of fat in milk
1894–1895	956	2.00	12.46	.56	26.09	4.10	1.069
1895–1896	980	2.59	12.24	.68	25.71	3.93	1.011

This table gives strong evidence that the amount of protein prescribed in the Lehmann standard is largely in excess of the amount needed for production. The cows yielded more milk and butter-fat during the winter that they received 2 pounds of protein than they did the following winter on an allowance of 2.59 pounds of protein.

Question B. In order to answer this question, Haecker has compiled a table from the records of mature cows whose productive powers had been developed to their fullest capacity by careful feeding and handling for several years:

TABLE 10

	Percentage of fat	Protein (pounds)	Carbo-hydrates (pounds)	Ether extract (pounds)	Total nutrients (pounds)
Countess	2.5	.036	.16	.012	.208
Lou	3.7	.040	.20	.014	.254
Topsy	3.7	.042	.20	.014	.256
Olive	4.0	.044	.22	.016	.280
Sweet Briar	5.0	.052	.24	.018	.310
Houston	5.5	.057	.26	.019	.336

The figures in this table represent the average of one hundred and fifty-four consecutive days work for each cow. The table clearly indicates: first, that the amount of nutrients to 1 pound of milk increases with the improvement in quality of the milk but not in the same proportion; second, that, other things being equal, the richer the milk the more economical is the production of butter-fat. In order to show the rate of increase in nutrients required for the production of 1 pound of milk of different qualities, the records of Houston and Countess are employed:

TABLE 11

	Percentage of fat	Protein (pounds)	Carbohydrates (pounds)	Ether extract (pounds)
Houston	5.5	.057	.26	.019
Countess	2.5	.036	.16	.012
Difference	3.0	.021	.10	.007
Difference for .1 per cent fat		.0007	.0033	.00023

Taking the nutrients required for 1 pound of milk containing 2.5 per cent fat as a basis and the nutrients required in addition for each .1 per cent fat increase, we can derive a feeding table. Such a table is given in the bulletin under review, but it is not deemed necessary to reproduce it here since the one in use by Haecker at the present time is slightly different and represents his latest ideas for this standard. This table is closely in accord with the nutrients used by mature cows in the herd not gaining nor losing in body weight, except that it provides rather more than was used by cows whose milk tested between 3.5 and 4.5 per cent. From the study of question B it seems that the quality of milk is quite as important a factor in formulating a feeding standard or guide to feeding practice, as is quantity of milk yielded.

Question C. It is not deemed necessary to report here the findings in regard to question C, inasmuch as they have no bearing on the experiment in hand. It is sufficient to say that in Haecker's opinion, borne out by his own experience, heifers in milk require more nutriment per pound of milk produced than do mature cows. This is a natural consequence because heifers must provide for growth of body.

3. *Protein requirements.*— The third part of Bulletin 79 may now be studied. In the winter of 1901–1902, the feeding of the dairy herd was planned with the purpose of obtaining more data on protein requirements. The cows in the stable were naturally arranged in groups by partitions. The tables given are made up from the records produced by mature cows doing normal work. It was intended to maintain a fixed ratio between grain and roughage, but in some cases a slight deviation had to be made so as to feed each cow to her full limit. This ratio as planned was five times as much corn silage as grain and half as much hay as grain. The grain ratios were:

Group 1. Equal parts of corn, bran, and gluten meal.

Group 2. Corn and bran four parts each, gluten meal one part.

Group 3. Equal parts of corn, barley, and oats, except for one cow which received bran instead of oats.

The composition of the rations as fed was as follows:

TABLE 12

Ration	Protein (pounds)	Carbohydrates (pounds)	Ether extract (pounds)	Nutritive ratio
1	2.04	11.79	.53	1 : 6.3
2	1.68	11.75	.57	1 : 7.6
3	1.32	11.76	.50	1 : 9.7

The feeding began November 11, 1901, and continued without change until the morning of February 17, 1902, when a new supply of grain was fed and corn fodder was substituted for silage. With the exception of two cows whose records are considered for one or two weeks longer, the data given refer to this period between November 11, 1901, and February 16, 1902, inclusive. When fed as above, the yield of the three groups was as follows in terms of pounds of milk, percentage of fat, pounds of butter-fat, and pounds of total solids:

TABLE 13

Group	Ration	Milk (pounds)	Percentage of fat in milk	Pounds of fat in milk	Total solids (pounds)
1	1	27.77	4.54	1.260	3.737
2	2	30.60	3.80	1.164	3.719
3	3	26.84	4.40	1.182	3.524

Judging from yields of butter-fat and of milk, ration 3 was practically as potent as the other rations in that the product yielded bears a closer relation to total nutrients than to protein.

In order to make a better comparison, if we multiply the fat in the food by 2.4 and add the protein and carbohydrates and call this amount the total nutriment, then multiply the butter-fat by 2.5 and add the solids-not-fat and call this amount the total product, we shall have a basis on which to compare the total nutriment and the total product yielded in the three groups. Such a comparison is as follows:

TABLE 14

Group	Total nutriment daily (pounds)	Total product daily (pounds)	Net nutriment to 1 pound of product (pounds)
1	16.88	6.208	1.46
2	16.28	6.011	1.41
3	16.88	6.260	1.45

By this arrangement it is clearly shown that the three groups yielded dairy products in proportion to the nutriment available for product, and not according to the protein supply; and that the amount of nutriment required for a pound of total product depended on the ratio of butter-fat to solids-not-fat.

Comparing the rations used in studying the protein requirements for three winters (1895–1896, 1894–1895, and 1901–1902) with the Wolff-Lehmann standard, the following table is derived:

TABLE 15

Net nutrients	1895–1896 (pounds)	1894–1895 (pounds)	1901–1902 (pounds)	Standard factors (pounds)
Protein daily	2.63	2.09	1.90	2.50
Protein to 1 pound milk	.0755	.0510	.0375	.0818
Carbohydrates to 1 pound milk	.2082	.2211	.1969	.2400
Ether extract to 1 pound milk	.0224	.0177	.0156	.0180
Total net nutrients to 1 pound milk	.3061	.2898	.2500	.3398

The Wolff-Lehmann factors seem particularly faulty in the assumption that it requires .081 pound of net protein to 1 pound of milk produced, and they do not recognize the fact that the nutrient requirements vary with the quality of the milk yielded.

Reviewing the results obtained from section 3 of this bulletin, it appears:

1. That the rations having a nutritive ratio of 1:7.6 and 1:9.7, respectively, were as effective in the production of milk, butter-fat, and milk solids as was the ration having a nutritive ratio of 1:6.3.

2. That the protein required in milk production depends on the quantity and quality of the milk yield.

3. That in the production of butter-fat, actually more but relatively less protein and other nutrients were required to a pound of butter-fat with cows giving milk containing a low percentage of fat.

4. That in the production of milk solids, less nutrients were required to a pound with cows having a low percentage of butter-fat in their milk than with cows giving milk having a high percentage of butter-fat.

4. Influence of stage of lactation on nutrient requirements.— It will be sufficient to give the summary under this heading, which also includes Professor Haecker's opinions up to the publication of this work:

1. During the early stages of lactation, cows lose rapidly in body weight; of fifteen cows the average decrease per cow the first week was 49 pounds, and during fifty-six days there was a daily average loss of 2 pounds.

2. During the time that the decrease in body weight takes place, cows yield dairy products in excess of the amount provided for by the food con-

sumed. The excess yield depends on the rate of loss in weight of body; in some instances it is more than twice the amount provided for by the available nutriment.

3. The excess yield of dairy products decreases gradually until about the eleventh week, when an equilibrium generally obtains between the nutriment consumed and the dairy products yielded, although in this respect cows differ: those of a pronounced dairy temperament taking less time, while those not strong in dairy temperament decrease more slowly in weight and require more time in which to reach normal work in milk production. Before such equilibrium is reached, the body fat, and possibly other substances, contribute directly or indirectly to product.

4. The normal net nutriment required for a pound of butter-fat is approximately 6.25 pounds, with a slight increase for cows yielding milk containing a low percentage of butter-fat and less for cows giving milk containing a high percentage of butter-fat.

5. The normal net nutriment required to a pound of milk solids yielded is approximately 2.4 pounds, with a slight increase for cows yielding milk rich in butter-fat and less for cows giving milk containing a low percentage of butter-fat.

6. When the nutriment available daily for products and the products yielded daily are reduced to an approximate common value of energy, it is found that there is required about 1.75 pound of available nutriment to 1 pound of product; that is, of the available nutriment 43 per cent is expended in energy and 57 per cent is retained in the milk solids.

7. The daily yield of butter-fat in excess of the nutriment supply, by virtue of an average daily loss per cow of 2 pounds in body weight, was .283 pound, being a sacrifice of 7 pounds in body weight to 1 pound of butter-fat yielded in excess of that provided for in the ration.

8. When the normal working condition of body weight is reached, the nutriment required to a pound of butter-fat and to a pound of milk solids remains fairly constant for an indefinite time under proper management.

The above conclusions finish Haecker's published work up to date, except for deductions from the results of the breed test at St. Louis in 1904. Haecker sums up these results and applies his standard to them, and by allowing 3.2 pounds net nutriment per pound of gain in weight he accounts for the expenditure of the excess nutriment. It is not thought necessary to report this bulletin in the present paper.

Some unpublished data on Haecker's standard

The feeding table, or standard, now in use by Haecker was seen by the author of this bulletin at the Graduate School of Agriculture held at Cornell University in 1908. Professor Haecker kindly gave a copy to the

author. When this was compared with the standard as given on page 104 of Bulletin 79 of the Minnesota station, it was noticed that the requirements were slightly higher for milk low in percentage of butter-fat and slightly lower for milk ranging high in butter-fat. When a letter was sent to Professor Haecker asking the reason for this change, he kindly sent to the author the two tables given below, A and B, together with a very careful letter of explanation from which the following notes are taken:

In Table A is given the average daily summary for the Minnesota station herd for eight winters, "reduced to a daily average of dry matter consumed and digestible nutrients consumed, the total nutriment reduced to a starch equivalent, the nutriment calculated for maintenance, allowing .792 pound digestible starch equivalent for 100 pounds live weight, the amount left for product, the product yielded being the sum of the fat multiplied by 2.2 and the solids-not-fat, and the net nutriment consumed to a unit of product yielded.

"In the blank spaces following there is a double dash indicating that during the winter there was an equilibrium in the weight of the herd. If there is a plus, there is a gain; a minus sign indicates a loss. Taking an average of the eight winters work it appears that there was required 1.81 pound of net nutriment reduced to starch equivalent to produce one of product.

TABLE A (16). AVERAGE DAILY SUMMARY OF THE HERD FOR EIGHT WINTERS

	Dry matter	Protein	Carbohydrates	Ether extract	Nutriment	Nutriment		Product yielded daily	Net nutriment to 1 pound product	
					Nutriment daily (Pro. + C. H. + [fat × 2.2])	For maintenance .792 per 100 lbs. .07-.7-.01	For product B. F. × 2.2 + S. N. F.			
1894–5	24.5	2.00	12.40	.56	15.09	7.57	*8.08	4.59	1.74	=
1895–6	23.9	2.59	12.24	.67	16.30	7.70	8.54	4.39	1.95	+
1902–3	21.8	1.92	11.86	.48	14.83	6.96	7.87	4.53	1.73	=
1903–4	20.6	1.97	10.99	.36	13.74	7.19	6.55	3.29	1.53	+ Fed roots
1904–5	22.0	1.92	11.96	.56	14.98	7.09	7.89	4.38	1.70	—
1905–6	21.9	1.65	12.57	.59	15.32	6.90	8.42	4.34	1.94	+
1906–7	23.0	1.74	13.14	.63	16.27	7.40	8.87	4.50	1.94	+
1907–8	23.7	1.60	12.15	.60	15.16	6.85	8.31	4.59	1.81	—
Average	22.7	1.93	12.17	.54	15.286	7.215	8.071	4.455	1.81	

*This is probably 8.12, but is 8.08 in the original.

"Table B gives first the organic composition of milk from the number of milkings indicated in the first column, the milkings ranging from 3 to 7 per cent fat. In securing the average composition of any grade of milk, we only count .25 per cent above and no more than .25 per cent below the average; that is, the average of 3-per-cent milk was obtained from 658 different milkings, none of which went below 2.75 or above 3.25.

" Reducing the butter-fat to an equivalent of nitrogenous solids-not-fat and adding the product to the solids-not-fat, we have the following columns giving the components in one pound of milk ranging from .027 to .042 pound of protein and .112 to .202 pound of non-nitrogenous compounds.

TABLE B (17). GRAVIMETRIC ANALYSIS

Number of milkings	Organic composition of milk			Components in 1 pound milk		Feeding standard. Net nutriment to 1 pound milk		
	Milk fat	Protein, casein, and albumen	Lactose	Nitrogenous	Non-nitrogenous	Protein in milk + 50 per cent	Carbohydrates in milk + 70 per cent	13 per cent of carbohydrates as ether extract
658	3.0%	2.7	4.60	.027	.112	.04	.19	.014
770	3.5	2.8	4.75	.028	.124	.042	.21	.016
840	4.0	3.1	4.85	.031	.136	.047	.23	.018
1,638	4.5	3.3	4.97	.033	.149	.049	.25	.019
1,442	5.0	3.4	4.98	.034	.160	.051	.27	.021
1,246	5.5	3.6	4.92	.036	.170	.054	.29	.022
546	6.0	3.8	4.91	.038	.181	.057	.31	.023
336	6.5	4.1	4.90	.041	.192	.061	.33	.025
182	7.0	4.2	4.84	.042	.202	.063	.34	.026
				.310	1.426	.464	2.42	.184 ×2.2=.405
					.310		.464	
					1.736		.405	
							3.289	
				Standard provides.....			1.89	
				Amount required.....			1.81	
				Excess.....			.08	

" Now, we have in Table A that it requires 1.81 pound of net nutriment to produce one of product. Such being the case, it follows that .81 is expended in the energy required for the production of milk solids. This energy can be supplied by carbohydrates so it is not necessary to provide more protein over and above that required for the product than will provide all contingencies in waste in the process of digestion and translocation, fetal growth, and variations in the composition of both feed and milk, and increase the carbohydrates in the ration proportionately to make the total nutriment provide practically what is required in Table A."

Professor Haecker then says in his letter: " I am satisfied that any surplus ranging from 30 to 50 per cent over and above what appears in the milk will answer for ordinary milk production. This I have found by actual experiment. (See earlier results as given in this paper on pages 69 to 71.—Author.) I desire to make sure there is enough protein, so I provide protein for maintenance and protein for milk plus 50 per cent protein in the milk. Then I add enough to carbohydrates to make the amount required for milk production, seeing that the ration of carbohydrates to ether extract is about what is found in our American Feeding

Stuffs used for milk production. Adding together the total non-nitrogenous components and the various nutrients in the milk, we find there is 1.736 pound. Doing the same with the nutrients in the feeding standard, having reduced the ether extract to an equivalent of carbohydrates, we find that there are 3.289 pounds, and that the standard provides 1.89 unit to a unit of product in milk solids, while the amount used by the herd as shown by Table A is 1.81, the standard being in excess about .08 of nutriment to each pound of product."

If we refer back to the method of building the feeding tables on page 71, taken from Bulletin 79, and compare results for any one set of conditions, we will find " that the uniformity in the two methods as to results," using Haecker's words again, " are truly wonderful."

Haecker calculated the new tables of requirements to meet the objections of many investigators to the first tables on the ground that his data for the tables in Bulletin 79 were very meager.

Having now covered all the ground that serves as a basis for Haecker's arguments, his opinions and conclusions may be best summed up by giving in full his table of feeding standards as he uses them in his classroom:

TABLE 18. HAECKER'S STANDARD FOR MILK PRODUCTION

	Protein	Carbo-hydrates	Fat
For maintenance, per 100 lbs	.0700	.700	.0100
For 1 pound milk, 2.5 per cent fat	.0390	.168	.0120
For 1 pound milk, 2.6 per cent fat	.0396	.172	.0122
For 1 pound milk, 2.7 per cent fat	.0402	.176	.0124
For 1 pound milk, 2.8 per cent fat	.0408	.180	.0127
For 1 pound milk, 2.9 per cent fat	.0414	.185	.0130
For 1 pound milk, 3.0 per cent fat	.0420	.189	.0133
For 1 pound milk, 3.1 per cent fat	.0426	.193	.0136
For 1 pound milk, 3.2 per cent fat	.0432	.197	.0139
For 1 pound milk, 3.3 per cent fat	.0438	.202	.0142
For 1 pound milk, 3.4 per cent fat	.0444	.206	.0146
For 1 pound milk, 3.5 per cent fat	.0450	.211	.0149
For 1 pound milk, 3.6 per cent fat	.0456	.215	.0152
For 1 pound milk, 3.7 per cent fat	.0462	.220	.0155
For 1 pound milk, 3.8 per cent fat	.0468	.224	.0158
For 1 pound milk, 3.9 per cent fat	.0474	.228	.0161
For 1 pound milk, 4.0 per cent fat	.0480	.233	.0164
For 1 pound milk, 4.1 per cent fat	.0486	.237	.0167
For 1 pound milk, 4.2 per cent fat	.0492	.241	.0170
For 1 pound milk, 4.3 per cent fat	.0498	.245	.0173
For 1 pound milk, 4.4 per cent fat	.0504	.249	.0176
For 1 pound milk, 4.5 per cent fat	.0510	.253	.0179
For 1 pound milk, 4.6 per cent fat	.0516	.257	.0181
For 1 pound milk, 4.7 per cent fat	.0522	.260	.0184

TABLE 18 (*continued*)

	Protein	Carbo-hydrates	Fat
For maintenance, per 100 lbs	.0700	.700	.0100
For 1 pound milk, 4.8 per cent fat	.0528	.264	.0186
For 1 pound milk, 4.9 per cent fat	.0534	.267	.0189
For 1 pound milk, 5.0 per cent fat	.0540	.271	.0191
For 1 pound milk, 5.1 per cent fat	.0546	.275	.0194
For 1 pound milk, 5.2 per cent fat	.0552	.278	.0196
For 1 pound milk, 5.3 per cent fat	.0558	.282	.0199
For 1 pound milk, 5.4 per cent fat	.0564	.285	.0201
For 1 pound milk, 5.5 per cent fat	.0570	.289	.0204
For 1 pound milk, 5.6 per cent fat	.0576	.292	.0206
For 1 pound milk, 5.7 per cent fat	.0582	.296	.0209
For 1 pound milk, 5.8 per cent fat	.0588	.300	.0211
For 1 pound milk, 5.9 per cent fat	.0594	.303	.0214
For 1 pound milk, 6.0 per cent fat	.0600	.307	.0216
For 1 pound milk, 6.1 per cent fat	.0606	.310	.0219
For 1 pound milk, 6.2 per cent fat	.0612	.314	.0222
For 1 pound milk, 6.3 per cent fat	.0618	.317	.0224
For 1 pound milk, 6.4 per cent fat	.0624	.322	.0227
For 1 pound milk, 6.5 per cent fat	.0630	.325	.0229
For 1 pound milk, 6.6 per cent fat	.0636	.328	.0232
For 1 pound milk, 6.7 per cent fat	.0642	.331	.0234
For 1 pound milk, 6.8 per cent fat	.0648	.335	.0237
For 1 pound milk, 6.9 per cent fat	.0654	.339	.0239
For 1 pound milk, 7.0 per cent fat	.0660	.341	.0242

H. P. ARMSBY'S FEEDING STANDARD

Dr. H. P. Armsby has done much to further the work on animal nutrition in America, and to-day he is perhaps better known than any other nutrition expert in the country. He has become thus well known through two textbooks on animal nutrition,[1] the first a general textbook and the second a scientific treatise on the subject. Besides these two textbooks he has published a number of bulletins[2] from the Pennsylvania State College Agricultural Experiment Station, where he began work as Director of the station in 1892. Since the building of the respiration calorimeter at the Pennsylvania station, the animal nutrition work has been in cooperation with the Bureau of Animal Industry of the United States Department of Agriculture. It will not be necessary to review

[1] H. P. Armsby. "Manual of Cattle Feeding" and "Principles of Animal Nutrition."

[2] H. P. Armsby:
"Relative Values of Feeding Stuffs." Penn. State College Agr. Exp. Sta. Bul. 71.
"Feed as a Source of Energy." Penn. State College Agr. Exp. Sta. Bul. 84.
"Feeding for Meat Production." U. S. Dept. Agr., Bur. Anim. Indus. Bul. 108.
H. P. Armsby and T. Augustus Fries:
"The Available Energy of Timothy Hay." U. S. Dept. Agr., Bur. Anim. Indus. Bul. 51.
"Energy Values of Red Clover Hay and Maize Meal." U. S. Dept. Agr., Bur. Anim. Indus. Bul. 74.
"The Available Energy of Red Clover Hay." U. S. Dept. Agr., Bur. Anim. Indus. Bul. 101.

here all the bulletins that are cited in the footnote on the preceding page. In bulletins 71 and 84 of the Pennsylvania station and in Farmers' Bulletin 346 of the United States Department of Agriculture is contained subject-matter of interest in this connection. In these bulletins Armsby's attitude toward the subject of feeding as it stands to-day is explained.

The results in bulletins 71 and 84 of the Pennsylvania station and in Farmers' Bulletin 346 can now be discussed. The computation of rations, up to the work of Armsby in this country and of Kellner in Germany, has always been placed on the amount of digestible nutrients in the given fodders, as has been clearly shown in these pages. Now Armsby shows in the bulletins cited that this view is inaccurate and he proceeds to show the reasons for his opinion, taking as a basis the results on the maintenance value of red-clover hay, timothy hay, and maize meal as shown by work on these feeds with the respiration calorimeter. He wishes to place the relative value of the feeding-stuffs on the production values of the different foods. First, before comparing the different foods, we must explain what is meant by the " production value " of a food.

When a foodstuff is burned, it yields a certain amount of heat or chemical energy usually measured in calories,* or in units of 1,000 Calories called therms by Armsby. Necessarily a large part of this energy, when the foodstuff is burned in the animal, is lost in the feces and urine and in the combustible gases from the intestinal tract. When this lost energy is subtracted from the chemical energy the resulting energy is called the " fuel value " of the food. Many writers have used the fuel values of foodstuffs in showing their relative values, but since these fuel values are determined in almost exactly the same way as are the digestible nutrients they have no greater value than have the amounts of digestible nutrients in a food to show its value in nutrition.

Armsby goes a step further and defines the term " production value of a food," showing that only a part of the fuel value of a given foodstuff can go for production. He defines the " production value " of a food as that part which can really go toward the production of meat in mature fattening animals, for the production of milk, and for growth in growing animals. He shows that these production values are not in the same relation in timothy hay, clover hay, and corn meal as the fuel values and, therefore, the digestible nutrients.

Then we find also another term, namely, " maintenance value." Armsby finds that more energy can be derived from the fuel value of a food merely in maintaining the animal than in the production and storing of the energy as product; therefore the maintenance value of a food is greater

* A calorie (abbreviation small " c.") is the amount of heat energy required to raise the temperature of 1 gram of distilled water 1 degree Centigrade. 1,000 calories = 1 Calorie (abbreviation capital " C."). 1,000 Calories = 1 therm (abbreviation " T.").

than its production value but less than its fuel value. This is obvious, since extra energy would be required to store food as extra weight over that required merely to replace some body material or merely to be burned in the body in order to maintain the body without gain in weight. Tables 19 and 20, giving the comparative values of timothy hay and corn meal, will show clearly what is intended by the above explanation:

TABLE 19. DIGESTIBLE NUTRIENTS, COMPUTED FUEL VALUES, AND ACTUAL FUEL VALUES

	Nutrients per 100 pounds (pounds)	Computed fuel value (therms)	Actual fuel value (therms)
Absolute values			
Timothy hay	47.1	87.5	77.7
Corn meal	81.9	152.5	130.8
Relative values			
Timothy hay	1.00	1.00	1.00
Corn meal	1.74	1.74	1.68

The above table shows that the computed fuel values and actual fuel values are not different from each other to any extent. The next table will show the relative values as to maintenance and production in 100 pounds of timothy hay and corn meal:

TABLE 20. ACTUAL FUEL VALUES, MAINTENANCE VALUES, AND PRODUCTION VALUES PER 100 POUNDS

	Actual fuel values (therms)	Maintenance values (therms)	Production values (therms)
Absolute values			
Timothy hay	77.7	48.9	25.9
Corn meal	130.8	101.6	69.7
Relative values			
Timothy hay	1.00	1.00	1.00
Corn meal	1.68	*2.11	2.69

* From the absolute values above, this value would be 2.08. The original reference gives it as 2.11.

From this table we see that corn meal has relatively a much greater value, both for maintenance and production, than is shown by the actual fuel value (or digestible nutrients).

Not many of the production values of American feeding-stuffs have been computed, because of the amount of labor connected with

such a calculation with the respiration calorimeter. In Farmers' Bulletin 346 appears a table worked out by Armsby from data secured from Kellner at the Moeckern Experiment Station in Germany. In Armsby's opinion these production values of Kellner's, while not absolutely correct, are more nearly correct than our ordinary tables of digestible nutrients. The table is given on page 15, Farmers' Bulletin 346.

As for protein requirements, in Armsby's opinion, so far as maintenance is concerned, the total amount required is so small relatively that it is only when feeds very poor in protein are used that there is danger of its falling short. A proper supply of protein is, of course, indispensable and enough in excess of maintenance must be furnished to provide for the product when productive animals are under consideration. The amounts necessary for given purposes will be shown in the discussion of Armsby's standard (page 119).

The feeding standard for milk

In Table 21 are given Armsby's maintenance requirements for cattle, which apply to milch cows as well as to other mature cattle:

TABLE 21. MAINTENANCE REQUIREMENTS FOR CATTLE

Live weight (pounds)	Digestible protein (pounds)	Energy (therms)
150	0.15	1 70
250	0.20	2 40
500	0.30	3 80
750	0.40	4 95
1,000	0.50	6 00
1,250	0.60	7 00
1,500	0.65	7 90

These apply, for the given live weight, for one animal one day. Strict accuracy is not claimed for these figures by Armsby, but he thinks them substantially correct. Under the requirements for milk production, it is thought that .3 therm of production value in the feed is ample for 1 pound of average milk containing about 13 per cent total solids and 4 per cent butter-fat.

In regard to the protein requirements, it seems, in Armsby's opinion, that milk production can be kept up, for a time at least, on an amount of protein very slightly exceeding that found in the milk produced, added to the maintenance requirement. In the case of average milk this would

call for about .032 pound digestible protein for each pound of milk produced. For the production of a liberal supply of milk, a little more protein than this would seem advantageous. Therefore Armsby recommends .05 pound of digestible protein for each pound of milk.

Armsby suggests that the requirements of .3 therm of production value and .05 pound of digestible protein for 1 pound of milk might be increased for richer milk or decreased for poorer milk to advantage; but he does not attempt any systematic arrangement to meet the requirements for different grades of milk.

With this explanation of the standards that have been published on milk production, we may now consider the application of the two last named in the experiments at this station.

DATA OF CORNELL EXPERIMENTS. WINTERS OF 1909–1910 AND 1910–1911

The experiments in question were planned with the purpose of applying Haecker's feeding standard to milch cows. However, the data are in such form that some knowledge of the application of Armsby's standard can be gained.

Data of the winter of 1909–1910

Twelve cows were used. They were divided into three groups of four cows each, the groups being so arranged that cows of different breeds, quality of milk, and quantity of milk would be in the same group. In Table 22 is given a tabular statement of data regarding the cows in each group:

TABLE 22. COWS IN EXPERIMENT OF 1909–1910

	Breed	Age (years)	Last calf (1909)	Average live weight (pounds)
Group A				
Cornella Marvella	J	6	Oct. 6	860
Garnet Delta	J	6	Sept. 19	925
Gipsy	Gr. H	5	Sept. 19	985
Glista Eta	H	9	Oct. 17	1,175
Group B				
Glista Omicron	H	6	Nov. 9	1,150
Glista Sigma	H	6	Sept. 13	1,090
Hector's Berta	J	7	Oct. 22	815
Lady Clay	S	4	Sept. 20	1,050
Group C				
Glista Chi	H	5	Sept. 2	1,035
Glista Omega	H	5	Sept. 4	1,050
Susanna	J	10	Sept. 19	910
Taffy's Anna	J	5	Sept. 23	940

The cows were fed a ration of mixed hay (one half clover and one half mixed grasses), corn silage, mangels, and grain mixtures composed of distillers' dried grains (Ajax flakes), hominy chop, old-process linseed meal, and wheat bran. The digestible composition of the fodders, as given in Table 23, was determined from actual analysis by the application of the digestion coefficients from Experiment Station Bulletin 11 of the United States Department of Agriculture, and from "Feeds and Feeding" by W. A. Henry:

TABLE 23. COMPOSITION OF FODDERS PER 100 POUNDS. 1909–1910

	Dry matter (pounds)	Protein (pounds)	Fiber (pounds)	Nitrogen-free extract (pounds)	Fat (pounds)	Therms	Value per 100 pounds
Mixed hay	93.28	4.62	16.86	28.62	1.11	34.50	$0.60
Corn silage	25.98	1.90	3.04	11.11	0.62	16.56	0.1125
Mangels	16.68	1.32	0.55	10.63	0.03	4.62	0.20
Distillers' dried grains	93.59	19.47	6.32	39.61	9.94	79.23	1.50
Hominy	92.91	7.60	3.46	53.00	6.82	*88.84	1.125
Oil meal	91.00	32.32	4.49	28.91	4.11	78.92	1.75
Wheat bran	91.67	12.49	2.13	38.37	3.42	48.23	1.25

* The therms energy in hominy is not given by Armsby in Farmers' Bulletin 340. The therms energy in corn is used instead.

The grain mixtures used in 1909–1910 were as follows:

Mixture 1

Feeds	Constituents in mixture 1
600 lbs. hominy chop	92.50 per cent dry matter
200 lbs. wheat bran	12.24 per cent digestible protein
100 lbs. distillers' dried grains	3.59 per cent digestible fiber
100 lbs. oil meal	46.32 per cent digestible nitrogen-free extract
	6.17 per cent digestible fat
	78.77 therms energy

The cost of 100 pounds of mixture 1 was $1.25.

Mixture 2

Feeds	Constituents in mixture 2
200 lbs. hominy chop	92.80 per cent dry matter
200 lbs. wheat bran	16.99 per cent digestible protein
500 lbs. distillers' dried grains	4.73 per cent digestible fiber
100 lbs. oil meal	40.97 per cent digestible nitrogen-free extract
	7.42 per cent digestible fat
	74.92 therms energy

The cost of 100 pounds of mixture 2 was $1.10.

The rations were so constructed that the nutritive ratio would be between 1:6 and 1:7 except when group B was fed mixture 2.

Group A was fed mixture 1 all through the experiment according to the general plan of feeding practiced at the experiment station, that is, all that each individual cow would take care of and eat up clean each day. Group B was fed mixture 1 during the first and second periods, and mixture 2 during the third period. During the second period, however, it was endeavored so to arrange the feeding of group B that each cow would be fed the exact amount of nutriment called for by Haecker's standard according to her production. During the third period, group B was to be fed the same total nutriment as in the second period, but the ration was to have a narrower nutritive ratio, hence the change to mixture 2. Group C was fed mixture 1 in all three periods; but in the first period group C was to be fed nutriment in accordance with Haecker's standard, in the second period as much as each cow would eat up clean with good appetite, and in the third period all that the individual cows could possibly take without "going off feed."

Each period was six weeks in length and each followed directly after the preceding. The data from only the last five weeks of each period are taken into account, since it took the first week of each period for the cows to become adjusted to whatever change may have been made in their ration.* The quantity of food consumed by each animal during each period is shown in tables 24, 25, and 26, one table being given to each group:

TABLE 24. FEED RECORD OF GROUP A. 1909–1910

Cow	Period	Hay (pounds)	Silage (pounds)	Mangels (pounds)	Grain (pounds)	
Cornella	1	316	775	600	303	Mixture 1
	2	350	710	700	265	Mixture 1
	3	350	700	550	276	Mixture 1
Garnet Delta	1	229	700	700	315	Mixture 1
	2	280	700	700	315	Mixture 1
	3	280	700	570	315	Mixture 1
Gipsy	1	316	1,050	700	385	Mixture 1
	2	350	1,050	700	385	Mixture 1
	3	350	1,050	700	385	Mixture 1
Eta	1	316	1,070	700	420	Mixture 1
	2	350	1,125	700	420	Mixture 1
	3	350	875	580	378	Mixture 1

* These plans did not materialize, however, since the check analysis of the feeding-stuffs when the results came from the chemist showed that the silage and the mangels contained much more digestible matter than was planned for, the plans being based on the average American composition tables given in Henry's "Feeds and Feeding." Therefore, groups B and C, when they were supposed to be receiving Haecker's standard, were actually getting amounts 5 to 15 per cent in excess of that standard.

TABLE 25. FEED RECORD OF GROUP B. 1909–1910

Cow	Period	Hay (pounds)	Silage (pounds)	Mangels (pounds)	Grain (pounds)	
Omicron	1	316	1,225	700	420	Mixture 1
	2	350	1,225	700	455	Mixture 1
	3	350	840	590	319	Mixture 2
Sigma	1	316	1,225	700	420	Mixture 1
	2	350	1,225	700	420	Mixture 1
	3	350	1,225	700	385	Mixture 2
Hector's Berta	1	316	875	700	350	Mixture 1
	2	350	875	700	326	Mixture 1
	3	350	875	660	264	Mixture 2
Lady Clay	1	229	875	700	385	Mixture 1
	2	280	875	700	350	Mixture 1
	3	280	875	700	315	Mixture 2

TABLE 26. FEED RECORD OF GROUP C. 1909–1910

Cow	Period	Hay (pounds)	Silage (pounds)	Mangels (pounds)	Grain (pounds)	
Chi	1	316	1,225	700	280	Mixture 1
	2	350	1,225	700	350	Mixture 1
	3	350	1,245	700	368	Mixture 1
Omega	1	316	1,225	700	315	Mixture 1
	2	350	1,225	700	305	Mixture 1
	3	350	1,060	550	332	Mixture 1
Susanna	1	229	865	700	385	Mixture 1
	2	280	635	640	298	Mixture 1
	3	280	875	700	315	Mixture 1
Taffy's Anna	1	229	875	700	420	Mixture 1
	2	280	875	700	385	Mixture 1
	3	280	1,050	700	384	Mixture 1

The constituents in the food consumed by the cows are given in tables 27, 27a, 28, 28a, 29, and 29a; two tables to each group. Here also are shown the amounts of the different constituents provided by Haecker's and Armsby's standards in contrast with the amounts of the different constituents actually consumed by the animals. The data given in the column headed "Total nutriment" are obtained by multiplying the fat by $2\frac{1}{4}$ and adding the carbohydrates and protein.

In determining the amount of constituents required for product in Haecker's standard, the nearest .05 per cent of fat is used (Table 18); that is, 5.37 per cent fat is used as 5.35 per cent, 5.24 per cent as 5.25 per cent.

In determining the requirements for maintenance according to Armsby's standard (Table 21), the live weight is used as the nearest 25, 50, 75, or 100 pounds, and for each 25 pounds above the amount given in the table .01 pound protein and .1 therm per day and per head is added until the actual live weight coincides with the next amount given in the table.

TABLE 27. CONSTITUENTS FED GROUP A, 1909–1910, AND REQUIREMENTS ACCORDING TO STANDARDS

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Cornella, Period 1							
Amount fed	876.47	74.34	471.69	27.20	607.23	74.34	504.03
Required —			by Haecker			by Armsby	
For maintenance:							
840 lbs. weight		20.80	208.01	2.97	235.49	15.75	196.00
For product:							
849.3 lbs. milk, 5.37 per cent fat		47.65	241.20	16.99	327.08	42.47	251.79
Total		68.45	449.21	19.96	562.57	58.22	450.79
Cornella, Period 2							
Amount fed	872.83	71.34	470.16	24.85	597.41	71.34	479.63
Required —			by Haecker			by Armsby	
For maintenance:							
868 lbs. weight		21.27	212.66	3.04	240.77	15.75	196.00
For product:							
750.9 lbs. milk, 5.24 per cent fat		42.01	211.93	14.99	287.67	37.85	227.07
Total		63.28	424.59	18.03	528.44	53.60	423.07
Cornella, Period 3							
Amount fed	855.38	70.51	457.51	25.43	585.24	70.51	479.74
Required —			by Haecker			by Armsby	
For maintenance:							
879 lbs. weight		21.54	215.36	3.08	243.83	15.75	196.00
For product:							
724.1 lbs. milk, 5.31 per cent fat		40.40	204.20	14.41	277.02	36.21	217.23
Total		61.94	419.56	17.49	520.85	51.96	413.23
Garnet Delta, Period 1							
Amount fed	803.61	71.68	438.58	26.53	599.95	71.68	475.63
Required —			by Haecker			by Armsby	
For maintenance:							
913 lbs. weight		22.37	223.69	3.20	253.26	15.75	196.00
For product:							
630.6 lbs. milk, 6.19 per cent fat		38.59	198.01	14.00	268.10	31.53	189.18
Total		60.96	421.70	17.20	521.36	47.28	385.18

TABLE 27 (*continued*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Garnet Delta, Period 2							
Amount fed	851.18	74.04	461.78	27.10	596.79	74.04	493.22
Required —			by Haecker			by Armsby	
For maintenance:							
939 lbs. weight		23.01	230.06	3.29	260.47	17.50	210.00
For product:							
628.8 lbs. milk, 6.48 per cent fat		39.61	204.36	14.40	276.37	31.44	188.64
Total		62.62	434.42	17.69	536.84	48.94	398.64
Garnet Delta, Period 3							
Amount fed	829.50	72.32	447.25	27.06	580.45	72.32	487.24
Required —			by Haecker			by Armsby	
For maintenance:							
954 lbs. weight		23.37	233.73	3.34	264.62	17.50	210.00
For product:							
647.8 lbs. milk, 6.54 per cent fat		41.01	211.83	14.96	286.50	32.39	194.34
Total		64.38	445.56	18.30	551.12	49.89	404.34
Gipsy, Period 1							
Amount fed	1,040.44	90.91	562.71	33.98	730.07	90.91	618.90
Required —			by Haecker			by Armsby	
For maintenance:							
964 lbs. weight		23.62	236.18	3.37	267.38	17.50	210.00
For product:							
1,235.3 lbs. milk, 3.8 per cent fat		57.81	276.71	19.52	378.44	61.77	370.59
Total		81.43	512.89	22.89	645.82	79.27	580.59
Gipsy, Period 2							
Amount fed	1,072.16	92.48	578.17	34.36	747.96	92.48	630.63
Required —			by Haecker			by Armsby	
For maintenance:							
977 lbs. weight		23.94	239.37	3.42	271.01	17.50	210.00
For product:							
1,289.2 lbs. milk, 3.98 per cent fat		61.88	300.38	21.14	409.82	64.46	386.76
Total		85.82	539.75	24.56	680.83	81.96	596.76
Gipsy, Period 3							
Amount fed	1,072.16	92.48	578.17	34.36	747.96	92.48	630.63
Required —			by Haecker			by Armsby	
For maintenance:							
1,001 lbs. weight		24.52	245.25	3.50	277.65	17.50	210.00
For product:							
1,252.9 lbs. milk, 4.12 per cent fat		60.89	296.94	20.92	404.90	62.65	375.87
Total		85.41	542.19	24.42	682.55	80.15	585.87

TABLE 27 (*concluded*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Eta, Period 1							
Amount fed	1,078.01	95.58	583.02	36.20	760.19	95.58	649.80
Required —			by Haecker			by Armsby	
For maintenance:							
1,163 lbs. weight		28.49	284.94	4.07	322.59	19.25	227.50
For product:							
1,320.1 lbs. milk, 3.2 per cent fat		57.03	260.06	18.35	358.38	66.01	396.03
Total		85.52	545.00	22.42	680.97	85.26	623.53
Eta, Period 2							
Amount fed	1,124.02	98.20	606.25	36.99	787.68	98.20	670.66
Required —			by Haecker			by Armsby	
For maintenance:							
1,193 lbs. weight		29.23	292.29	4.17	330.90	21.00	245.00
For product:							
1,294.8 lbs. milk, 3.32 per cent fat		55.40	255.49	17.96	351.30	63.24	379.44
Total		84.63	547.78	22.13	682.20	84.24	624.44
Eta, Period 3							
Amount fed	1,000.20	86.73	536.49	32.81	697.04	86.73	590.54
Required —			by Haecker			by Armsby	
For maintenance:							
1,202 lbs. weight		29.45	294.49	4.21	333.41	21.00	245.00
For product:							
1,210.2 lbs. milk, 3.4 per cent fat		53.73	249.30	17.67	342.79	60.51	363.06
Total		83.18	543.79	21.88	676.20	81.51	608.06

TABLE 27a. AVERAGE CONSTITUENTS FED GROUP A, 1909–1910, AND REQUIREMENTS ACCORDING TO STANDARDS

	Protein (pounds)	Total nutriment (pounds)	Nutritive ratio	Percentage of total nutriment above standard		Protein (pounds)	Therms	Percentage of therms above standard
Period 1								
Amount fed	83.13	666.86	1 : 7.0	10.6		83.13	362.09	10.2
Required by Haecker	74.09	602.68	1 : 7.1		by Armsby	67.51	510.02	
Period 2								
Amount fed	84.01	682.30	1 : 7.1	12.4		84.01	368.51	11.3
Required by Haecker	74.09	607.08	1 : 7.2		by Armsby	67.18	510.73	
Period 3								
Amount fed	80.51	652.07	1 : 7.1	7.4		80.51	347.04	7.8
Required by Haecker	73.73	607.68	1 : 7.2		by Armsby	65.88	502.88	

TABLE 28. CONSTITUENTS FED GROUP B, 1909–1910, AND REQUIREMENTS ACCORDING TO STANDARDS

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Omicron, Period 1							
Amount fed	1,178.28	98.53	604.94	37.23	787.24	98.53	675.53
Required —			by Haecker			by Armsby	
For maintenance:							
1,117 lbs. weight		27.37	273.67	3.91	309.84	19.25	227.50
For product:							
1,593.4 lbs. milk, 3.35 per cent fat		70.27	325.95	22.94	419.93	70.67	478.02
Total		97.64	598.72	26.85	759.77	98.92	705.52
Omicron, Period 2							
Amount fed	1,182.38	104.38	637.87	39.77	831.73	104.38	714.84
Required —			by Haecker			by Armsby	
For maintenance:							
1,167 lbs. weight		28.59	285.92	4.08	323.69	19.25	227.50
For product:							
1,497.7 lbs. milk, 3.05 per cent fat		68.74	326.50	23.06	447.13	74.89	440.31
Total		97.33	612.42	27.14	770.82	94.14	670.81
Omicron, Period 3							
Amount fed	939.15	94.12	489.79	32.95	658.05	94.12	526.26
Required —			by Haecker			by Armsby	
For maintenance:							
1,178 lbs. weight		28.86	288.61	4.12	326.74	21.00	245.00
For product:							
1,215.1 lbs. milk, 3.84 per cent fat		57.23	274.61	19.44	375.58	60.76	364.53
Total		86.09	563.22	23.56	702.32	81.76	609.53
Sigma, Period 1							
Amount fed	1,118.28	98.53	604.94	37.23	787.24	98.53	675.53
Required —			by Haecker			by Armsby	
For maintenance:							
1,048 lbs. weight		25.68	256.76	3.67	290.70	17.50	210.00
For product:							
1,393.7 lbs. milk, 3.74 per cent fat		64.81	309.40	21.88	423.41	69.69	418.11
Total		90.49	566.16	25.55	714.11	87.19	628.11
Sigma, Period 2							
Amount fed	1,150.00	100.10	620.40	37.61	805.12	100.10	687.26
Required —			by Haecker			by Armsby	
For maintenance:							
1,091 lbs. weight		26.73	267.30	3.82	302.63	17.50	210.00
For product:							
1,344.5 lbs. milk, 3.93 per cent fat		64.13	310.58	21.92	424.03	67.23	403.35
Total		90.86	577.88	25.74	726.66	84.73	613.35

TABLE 28 (*continued*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Sigma, Period 3							
Amount fed	1,118.78	114.10	586.72	40.27	791.43	114.10	644.67
Required —			by Haecker			by Armsby	
For maintenance:							
1,110 lbs. weight		27.20	271.95	3.88	307.88	19.25	227.59
For product:							
1,270.5 lbs. milk, 4.00 per cent fat		61.75	301.11	21.22	410.61	63.53	381.15
Total		88.95	573.06	25.10	718.49	82.78	608.65
Hector's Berta, Period 1							
Amount fed	962.60	83.31	520.48	30.75	672.98	83.31	562.27
Required —			by Haecker			by Armsby	
For maintenance:							
807 lbs. weight		19.77	197.72	2.82	223.84	14.00	173.25
For product:							
1,058.3 lbs. milk, 5.46 per cent fat		60.01	303.73	21.48	412.07	52.92	317.49
Total		79.78	501.45	24.30	635.91	66.92	490.74
Hector's Berta, Period 2							
Amount fed	972.12	81.94	523.95	29.64	672.58	81.94	555.09
Required —			by Haecker			by Armsby	
For maintenance:							
818 lbs. weight		20.04	200.41	2.86	226.89	14.00	173.25
For product:							
965.2 lbs. milk, 5.71 per cent fat		56.17	285.70	20.17	387.25	48.26	289.50
Total		76.21	486.11	23.03	614.14	62.26	462.81
Hector's Berta, Period 3							
Amount fed	908.89	86.36	477.43	29.11	629.29	86.36	494.10
Required —			by Haecker			by Armsby	
For maintenance:							
812 lbs. weight		19.89	198.04	2.84	225.22	14.00	173.25
For product:							
936.0 lbs. milk, 5.43 per cent fat		53.12	268.89	19.02	364.81	46.85	281.07
Total		73.01	467.83	21.86	590.03	60.85	454.32
Lady Clay, Period 1							
Amount fed	913.83	83.57	498.37	31.03	653.78	83.57	559.84
Required —			by Haecker			by Armsby	
For maintenance:							
1,004 lbs. weight		24.60	245.98	3.51	278.48	17.50	210.00
For product:							
965.9 lbs. milk, 3.81 per cent fat		45.20	210.30	15.20	295.90	48.30	280.77
Total		69.80	462.31	18.77	574.38	65.80	490.77

TABLE 28 (*concluded*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
			Lady Clay, Period 2				
Amount fed	929.02	81.65	504.11	30.35	654.05	81.65	549.85
Required —			by Haecker			by Armsby	
For maintenance:							
1,035 lbs. weight		25.30	253.58	3.62	287.08	17.50	210.00
For product:							
899.5 lbs. milk, 4.01 per cent fat		43.18	209.58	14.75	285.95	44.98	269.85
Total		68.54	463.16	18.37	573.03	62.48	479.85
			Lady Clay, Period 3				
Amount fed	807.59	92.31	473.38	32.02	637.74	92.31	509.09
Required —			by Haecker			by Armsby	
For maintenance:							
1,080 lbs. weight		26.46	264.60	3.78	299.57	17.50	210.00
For product:							
852.1 lbs. milk, 4.13 per cent fat		41.67	203.65	14.40	277.72	42.61	255.63
Total		68.13	468.25	18.18	577.29	60.11	465.63

TABLE 28a. AVERAGE CONSTITUENTS FED GROUP B, 1909–1910, AND REQUIREMENTS ACCORDING TO STANDARDS

	Protein (pounds)	Total nutriment (pounds)	Nutritive ratio	Percentage of total nutriment above standard		Protein (pounds)	Therms	Percentage of therms above standard
Period 1								
Amount fed	90.98	725.31	1 : 7.0	8.2		90.98	618.29	6.4
Required by Haecker	84.43	670.30	1 : 6.9		by Armsby	79.71	581.04	
Period 2								
Amount fed	92.02	740.87	1 : 7.0	10.4		92.02	626.76	12.3
Required by Haecker	83.24	671.16	1 : 7.1		by Armsby	75.90	558.21	
Period 3								
Amount fed	96.72	679.13	1 : 6.0	5.0		96.72	543.75	1.7
Required by Haecker	79.04	647.03	1 : 7.2		by Armsby	71.37	534.53	

TABLE 29. CONSTITUENTS FED GROUP C, 1909–1910, AND REQUIREMENTS ACCORDING TO STANDARDS

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
			Chi, Period 1				
Amount fed	988.78	81.31	535.07	28.60	689.73	81.31	502.21
Required —			by Haecker			by Armsby	
For maintenance:							
1,025 lbs. weight		25.11	251.12	3.59	284.31	17.50	210.00
For product:							
1,160.7 lbs. milk, 3.37 per cent fat		51.18	230.78	16.71	325.56	58.04	348.21
Total		76.29	487.90	20.30	609.87	75.54	558.21

TABLE 29 (*continued*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Chi, Period 2							
Amount fed	1,085.25	91.53	585.47	33.30	751.93	91.53	632.10
Required —			by Haecker			by Armsby	
For maintenance:							
1,030 lbs. weight		25.21	252.35	3.61	285.71	17.50	210.00
For product:							
1,107.6 lbs. milk, 3.35 per cent fat		51.49	238.19	16.81	327.50	58.38	350.28
Total		76.73	490.54	20.42	613.21	75.88	560.28
Chi, Period 3							
Amount fed	1,101.90	93.73	594.45	34.41	765.60	93.73	649.60
Required —			by Haecker			by Armsby	
For maintenance:							
1,050 lbs. weight		25.73	257.25	3.68	291.26	17.50	210.00
For product:							
1,089.8 lbs. milk, 3.54 per cent fat		49.37	232.13	16.46	318.54	54.49	326.94
Total		75.10	489.38	20.14	609.80	71.99	536.94
Omega, Period 1							
Amount fed	1,021.16	85.68	552.44	30.76	707.33	85.68	592.79
Required —			by Haecker			by Armsby	
For maintenance:							
1,050 lbs. weight		25.73	257.25	3.68	291.26	17.50	210.00
For product:							
1,141.5 lbs. milk, 3.63 per cent fat		52.39	248.85	17.58	340.79	57.08	342.45
Total		78.12	506.10	21.26	632.05	74.58	552.45
Omega, Period 2							
Amount fed	1,043.63	86.02	563.01	30.52	717.70	86.02	596.64
Required —			by Haecker			by Armsby	
For maintenance:							
1,050 lbs. weight		25.73	257.25	3.68	291.26	17.50	210.00
For product:							
1,007.1 lbs. milk, 3.75 per cent fat		51.02	243.56	17.22	333.33	54.86	329.13
Total		76.75	500.81	20.90	624.59	72.36	539.13
Omega, Period 3							
Amount fed	1,000.71	84.21	536.37	31.11	690.58	84.21	583.63
Required —			by Haecker			by Armsby	
For maintenance:							
1,001 lbs. weight		25.99	259.95	3.71	294.29	17.50	210.00
For product:							
1,020.6 lbs. milk, 3.87 per cent fat		48.35	232.01	16.43	317.33	51.33	307.98
Total		74.34	491.96	20.14	611.62	68.83	517.98

TABLE 29 (*continued*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Susanna, Period 1							
Amount fed	911.23	83.38	496.96	31.86	652.02	83.38	558.18
Required —			by Haecker			by Armsby	
For maintenance:							
900 lbs. weight		22.05	220.50	3.15	249.64	15.75	196.00
For product:							
785.8 lbs. milk, 5.11 per cent fat		42.90	216.09	15.25	293.30	39.29	235.74
Total		64.95	436.59	18.40	542.94	55.04	431.74
Susanna, Period 2							
Amount fed	808.55	69.94	437.48	25.63	565.09	69.94	466.27
Required —			by Haecker			by Armsby	
For maintenance:							
900 lbs. weight		22.27	222.71	3.18	252.13	15.75	196.00
For product:							
649.9 lbs. milk, 5.41 per cent fat		36.65	185.22	13.06	251.26	32.50	194.97
Total		58.92	407.93	16.24	503.39	48.25	390.97
Susanna, Period 3							
Amount fed	896.65	77.37	486.54	28.19	627.34	77.37	522.27
Required —			by Haecker			by Armsby	
For maintenance:							
919 lbs. weight		22.52	225.16	3.22	254.92	15.75	196.00
For product:							
627.3 lbs. milk, 5.35 per cent fat		35.19	178.15	12.55	241.58	31.37	188.19
Total		57.71	403.31	15.77	496.50	47.12	384.19
Taffy's Anna, Period 1							
Amount fed	946.20	87.86	515.84	34.09	680.40	87.86	587.42
Required —			by Haecker			by Armsby	
For maintenance:							
898 lbs. weight		22.00	220.01	3.14	249.08	15.75	196.00
For product:							
878.6 lbs. milk, 6.07 per cent fat		52.98	271.49	19.15	367.56	43.93	263.58
Total		74.98	491.50	22.29	616.64	59.68	459.58
Taffy's Anna, Period 2							
Amount fed	961.40	85.93	521.57	32.50	680.63	85.93	577.43
Required —			by Haecker			by Armsby	
For maintenance:							
927 lbs. weight		22.71	227.12	3.24	257.12	15.75	196.00
For product:							
828.2 lbs. milk, 6.37 per cent fat		51.43	265.02	18.72	358.57	41.41	248.46
Total		74.14	492.14	21.96	615.69	57.16	444.46

TABLE 29 (*concluded*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Taffy's Anna, Period 3							
Amount fed	1,005.93	89.13	545.85	33.52	719.40	89.13	605.69
Required —		by Haecker				by Armsby	
For maintenance: 969 lbs. weight		23.74	237.41	3.39	268.78	17.50	210.00
For product: 804.2 lbs. milk, 6.61 per cent fat		51.15	263.78	18.66	356.91	40.21	241.26
Total		74.89	501.19	22.05	625.69	57.71	451.26

TABLE 29a. AVERAGE CONSTITUENTS FED GROUP C, 1909–1910, AND REQUIREMENTS ACCORDING TO STANDARDS

	Protein (pounds)	Total nutriment (pounds)	Nutritive ratio	Percentage of total nutriment above standard		Protein (pounds)	Therms	Percentage of therms above standard
Period 1								
Amount fed	84.56	680.14	1 : 7.0	13.3		84.56	575.15	14.9
Required by Haecker	73.59	600.37	1 : 7.2		by Armsby	66.21	500.49	
Period 2								
Amount fed	83.35	678.84	1 : 7.1	15.2		83.35	568.11	17.4
Required by Haecker	71.63	589.22	1 : 7.2		by Armsby	63.41	483.71	
Period 3								
Amount fed	86.11	698.48	1 : 7.1	19.2		86.11	590.30	24.9
Required by Haecker	70.51	585.90	1 : 7.3		by Armsby	61.41	472.59	

The records of production in 1909–1910 used in the study of the application of Haecker's standard are given in tables 30, 31, and 32. For the study of the application of Armsby's standard, tables 33, 34, and 35 are drawn from tables 30, 31, and 32. In tables 30, 31, and 32, the data in the column headed "Pounds total product" are derived by multiplying the butter-fat by $2\frac{1}{4}$ and adding the solids-not-fat.

TABLE 30. RECORD OF PRODUCTION. GROUP A, 1909–1910

Cow	Period	Pounds milk	Percentage fat	Pounds fat	Percentage solids-not-fat	Pounds solids-not-fat	Pounds total product
Cornelia	1	849.3	5.37	45.647	9.37	79.625	182.331
	2	750.9	5.24	39.692	9.21	69.741	159.048
	3	724.1	5.31	38.456	9.31	67.408	153.934
Garnet Delta	1	630.6	6.10	39.028	9.93	62.611	150.424
	2	628.8	6.48	40.769	9.87	62.082	153.812
	3	647.8	6.54	42.353	9.82	63.601	158.895

TABLE 30 (*concluded*)

Cow	Period	Pounds milk	Percentage fat	Pounds fat	Percentage solids-not-fat	Pounds solids-not-fat	Pounds total product
Gipsy	1	1,235.3	3.80	46.918	8.93	110.331	215.897
	2	1,289.2	3.98	51.351	8.92	114.971	230.511
	3	1,252.9	4.12	51.653	9.03	113.115	229.334
Eta	1	1,320.1	3.20	42.203	8.77	115.770	210.727
	2	1,264.8	3.32	42.014	8.91	112.746	207.278
	3	1,210.2	3.40	41.128	8.91	107.783	200.321
Average, group A	1	1,008.8	4.31	43.449	.....	.....	189.845
	2	984.9	4.41	43.456	.....	.....	187.662
	3	958.7	4.53	43.397	.....	.....	185.621

TABLE 31. RECORD OF PRODUCTION. GROUP B, 1909–1910

Cow	Period	Pounds milk	Percentage fat	Pounds fat	Percentage solids-not-fat	Pounds solids-not-fat	Pounds total product
Omicron	1	1,593.4	3.35	53.403	8.72	138.910	259.067
	2	1,497.7	3.65	54.645	8.71	130.382	253.333
	3	1,215.1	3.84	46.669	8.70	105.746	210.751
Sigma	1	1,393.7	3.74	52.127	8.95	124.677	241.063
	2	1,344.5	3.93	52.822	8.99	120.871	239.724
	3	1,270.5	4.09	51.969	9.01	114.486	231.416
Hector's Berta	1	1,058.3	5.46	57.791	9.34	98.888	228.918
	2	965.2	5.71	55.126	9.27	89.518	213.552
	3	936.9	5.43	50.849	9.41	88.174	202.584
Lady Clay	1	965.9	3.81	36.840	9.01	87.032	169.922
	2	899.5	4.01	36.054	9.06	81.512	162.634
	3	852.1	4.13	35.172	9.10	77.571	156.708
Average, group B	1	1,252.8	3.99	50.040	.....	.....	224.967
	2	1,176.7	4.32	49.662	.....	.....	217.311
	3	1,068.7	4.32	46.165	.....	.....	200.305

TABLE 32. RECORD OF PRODUCTION. GROUP C, 1909–1910

Cow	Period	Pounds milk	Percentage fat	Pounds fat	Percentage solids-not-fat	Pounds solids-not-fat	Pounds total product
Chi	1	1,160.7	3.37	39.117	8.95	103.845	191.858
	2	1,167.6	3.35	39.093	8.90	103.930	191.889
	3	1,089.8	3.54	38.590	8.82	96.108	182.996
Omega	1	1,141.5	3.63	41.401	9.12	104.093	197.245
	2	1,097.1	3.75	41.130	8.95	98.229	190.772
	3	1,026.6	3.87	39.742	8.99	92.270	181.696
Susanna	1	785.8	5.11	40.191	9.50	74.684	165.114
	2	649.9	5.41	35.168	9.00	58.401	137.589
	3	627.3	5.35	33.570	9.09	57.047	134.563
Taffy's Anna	1	878.6	6.07	53.330	9.83	86.362	206.355
	2	828.2	6.37	52.739	9.77	80.955	199.040
	3	804.2	6.61	53.135	9.81	78.931	198.480
Average, group C	1	991.7	4.39	43.510	.....	.....	190.138
	2	935.7	4.49	42.035	.....	.....	179.972
	3	887.0	4.65	41.269	.....	.....	173.934

The factors 4.218 therms per pound of butter-fat and 1.860 therm per pound of ash-free solids-not-fat are used in computing the energy value of the product in tables 33, 34, and 35.[1] In determining the ash, .7 per cent was used as the average percentage of ash in milk.

TABLE 33. ENERGY VALUE OF PRODUCT. GROUP A, 1909–1910

Cow	Period	Pounds solids-not-fat —.7 per cent ash	Therms in fat	Therms in ash-free solids-not-fat	Total therms
Cornella	1	73.680	192.539	137.045	329.584
	2	64.443	167.421	119.864	287.285
	3	62.339	162.207	115.951	278.158
Garnet Delta	1	58.197	164.620	108.246	272.866
	2	57.680	171.964	107.285	279.249
	3	59.066	178.645	109.863	288.508
Gipsy	1	101.684	197.900	189.132	387.032
	2	105.947	216.599	197.061	413.660
	3	104.345	217.872	194.082	411.954
Eta	1	106.529	178.012	198.144	376.156
	2	103.892	177.215	193.239	370.454
	3	99.312	173.478	184.720	358.198
Average, group A	1	.....	.....	.....	341.409
	2	.....	.....	.....	337.662
	3	.....	.....	.....	334.204

TABLE 34. ENERGY VALUE OF PRODUCT. GROUP B, 1909–1910

Cow	Period	Pounds solids-not-fat —.7 per cent ash	Therms in fat	Therms in ash-free solids-not-fat	Total therms
Omicron	1	127.756	225.254	237.626	462.880
	2	119.898	230.493	223.010	453.503
	3	97.240	196.850	180.866	377.716
Sigma	1	114.921	219.872	213.753	433.625
	2	111.462	222.803	207.319	430.122
	3	105.592	219.205	196.401	415.606
Hector's Berta	1	91.480	243.762	170.153	413.915
	2	82.762	232.521	153.937	386.458
	3	81.616	214.481	151.806	366.287
Lady Clay	1	80.271	155.391	149.304	304.695
	2	75.215	152.076	139.900	291.976
	3	71.606	148.355	133 187	281.542
Average, group B	1	.....	.....	.....	403.779
	2	.....	.....	.....	390 515
	3	.....	.....	.....	360 288

[1] H. P. Armsby. "Principles of Animal Nutrition," page 279.

TABLE 35. ENERGY VALUE OF PRODUCT. GROUP C, 1909–1910

Cow	Period	Pounds solids-not-fat —.7 per cent ash	Therms in fat	Therms in ash-free solids-not-fat	Total therms
Chi	1	95.720	164.996	178.039	343.035
	2	95.757	164.894	178.108	343.002
	3	88.539	162.773	164.683	327.456
Omega	1	96.102	174.629	178.750	353.379
	2	90.549	173.486	168.421	341.907
	3	85.090	167.632	158.267	325.899
Susanna	1	69.183	169.526	128.680	298.206
	2	53.912	148.339	100.276	248.615
	3	52.626	141.624	97.884	239.508
Taffy's Anna	1	80.212	224.946	149.194	374.140
	2	75.158	222.495	139.794	362.289
	3	73.302	224.115	136.342	360.457
Average, group C	1	.....	.....	.....	342.190
	2	.....	.....	.....	323.953
	3	.....	.....	.....	313.330

TABLE 36. RECORD OF LIVE WEIGHT (IN POUNDS). GROUP A, 1909–1910 *

	Average at beginning	Average at end	Gain + Loss —	Average for period
Period 1				
Cornella	858	840	—18	849
Garnet Delta	887	940	+53	913
Gipsy	934	994	+60	964
Eta	1,138	1,187	+49	1,163
Period 2				
Cornella	861	876	+15	868
Garnet Delta	925	953	+28	939
Gipsy	974	980	+ 6	977
Eta	1,199	1,188	—11	1,193
Period 3				
Cornella	891	868	—23	879
Garnet Delta	962	947	—15	954
Gipsy	995	1,007	+12	1,001
Eta	1,205	1,199	— 6	1,202
Average for group A, period 1	.....	.....	.....	972
2	.....	.....	.....	994
3	.....	.....	.....	1,009

* The method of computing tables 36, 37, and 38 is given on page 98.

TABLE 37. RECORD OF LIVE WEIGHT (IN POUNDS). GROUP B, 1909–1910

	Average at beginning	Average at end	Gain + Loss —	Average for period
Period 1				
Omieron	1,093	1,142	+49	1,117
Sigma	1,029	1,067	+38	1,048
Hector's Berta	793	821	+28	807
Lady Clay	987	1,021	+34	1,004
Period 2				
Omieron	1,152	1,183	+31	1,167
Sigma	1,077	1,106	+29	1,091
Hector's Berta	816	821	+ 5	818
Lady Clay	1,016	1,053	+37	1,035
Period 3				
Omieron	1,184	1,171	—13	1,178
Sigma	1,109	1,111	+ 2	1,110
Hector's Berta	828	796	—32	812
Lady Clay	1,067	1,093	+26	1,080
Average for group B, period 1				994
2				1,028
3				1,045

TABLE 38. RECORD OF LIVE WEIGHT (IN POUNDS). GROUP C, 1909–1910

	Average at beginning	Average at end	Gain + Loss —	Average for period
Period 1				
Chi	1,003	1,046	+43	1,025
Omega	1,049	1,051	+ 2	1,050
Susanna	881	919	+38	900
Taffy's Anna	881	914	+33	898
Period 2				
Chi	1,018	1,042	+24	1,030
Omega	1,050	1,050		1,050
Susanna	908	910	+ 2	909
Taffy's Anna	912	941	+29	927
Period 3				
Chi	1,040	1,061	+21	1,050
Omega	1,061	1,062	+ 1	1,061
Susanna	913	926	+13	919
Taffy's Anna	960	977	+17	969
Average for group C, period 1				968
2				979
3				1,000

The record of the live weight of the cows in 1909–1910 is given in tables 36, 37, and 38. The cows were weighed for three successive mornings at

the beginning and the end of each period. The average of these three weights is taken as the weight at the beginning and at the end of each period, in determining the loss or gain during the period. The average of all six weights is given in the fifth column of these tables. This average weight is the weight used to determine the requirement for maintenance for each period.

Data of the winter of 1910–1911

It was considered best to give the detailed records for 1910–1911 in the same way and to draw conclusions from the data of both years considered together.

In 1910–1911 the experiment was started with twelve cows. They were divided into groups A, B, and C, four cows to a group. At about the middle of the experiment, a cow in group B died from a cause that could not be determined by a thorough post-mortem examination. Therefore group B is shown to be made up of three cows. The data regarding the cows are given in Table 39:

TABLE 39. COWS IN EXPERIMENT OF 1910–1911

	Breed	Age (years)	Last calf (1910)	Average live weight (pounds)
Group A				
Glenwood Queen	G	4	Nov. 16	1,072
Cornella Marvella	J	7	Sept. 16	865
Glista Eta	H	10	Oct. 2	1,184
Glista Tau	H	6	Sept. 12	1,341
Group B				
Glista Omicron	H	7	Oct. 5	1,239
Glista Sigma	H	7	Oct. 3	1,053
Charity	Gr. H	4	Oct. 9	990
Group C				
Glista Chi	H	6	Sept. 13	1,073
Glista Psi	H	5	July 21	1,179
Effie	Gr. G	4	Sept. 29	846
Glista Carlotta	H	4	Oct. 17	1,253

In 1910–1911 the cows were fed a ration of clover hay, corn silage, mangels, and grain mixtures composed of hominy chop, wheat bran, gluten feed, and distillers' dried grains (Ajax flakes). The composition of the fodders, as given in Table 40, was determined from actual chemical analysis by the use of the digestible coefficients given in the tenth edition of "Feeds and Feeding" by W. A. Henry:

TABLE 40. COMPOSITION OF FODDERS PER 100 POUNDS. 1910–1911

	Dry matter (pounds)	Protein (pounds)	Fiber (pounds)	Nitrogen-free extract (pounds)	Fat (pounds)	Therms	Value per 100 pounds
Clover hay	86.85	5.35	16.31	24.44	11.09	34.74	$0.60
Corn silage	31.09	1.42	4.15	13.38	.84	16.56	0.1125
Mangels	12.26	1.09	.29	8.41	.06	4.62	0.20
Distillers' dried grains	95.08	23.54	9.08	30.94	12.11	79.23	1.50
Hominy	90.68	6.74	2.35	57.90	8.23	*88.84	1.125
Gluten feed	90.78	21.46	4.94	46.87	1.93	79.32	1.25
Wheat bran	92.68	11.97	3.79	40.45	2.84	48.23	1.25

*The therms energy in hominy is not given by Armsby in Farmers' Bulletin 346. The therms energy in corn is used instead.

The grain mixtures used in 1910–1911 were as follows:

Mixture 1

Feeds	Constituents in mixture 1
200 lbs. hominy chop	92.02 per cent dry matter
200 lbs. wheat bran	12.94 per cent digestible protein
75 lbs. gluten feed	4.15 per cent digestible fiber
75 lbs. distillers' dried grains	46.37 per cent digestible nitrogen-free extract
	5.94 per cent digestible fat
	71.46 therms energy

The cost of 100 pounds of mixture 1 was $1.239.

Mixture 2

Feeds	Constituents in mixture 2
50 lbs. hominy chop	92.53 per cent dry matter
75 lbs. wheat bran	17.65 per cent digestible protein
100 lbs. gluten feed	5.55 per cent digestible fiber
100 lbs. distillers' dried grains	42.18 per cent digestible nitrogen-free extract
	6.24 per cent digestible fat
	73.58 therms energy

The cost of 100 pounds of mixture 2 was $1.308.

The rations were so constructed that the nutritive ratio would be about 1:7 except when groups B and C were fed mixture 2.

The groups were fed practically the same as in 1909–1910. Group A received mixture 1 all through the experiment, getting about all the roughage and grain that the cows would eat up clean each day. Group B was fed mixture 1 during the first and second periods, and mixture 2 during the third period. During the second period, however, it was

intended that group B be fed the exact amounts of nutriment called for by Haecker's standard according to its production. During the third period, group B was fed the same amount of total nutriment as in the second period, but the relative amount of protein was increased so that the nutritive ratio was 1:6.3. Group C was fed mixture 1 during the first and second periods. It was intended that this group be fed according to Haecker's standard in the first period, all that they would eat up clean during the second period, and in the third period all that they would eat of mixture 2, so that the nutritive ratio of their ration in period 3 was 1:6.2.

As in 1909–1910, each period was six weeks in length, the data from only the last five weeks of each period being considered. The detailed records of quantity of food consumed are given in tables 41, 42, and 43:

TABLE 41. FEED RECORD OF GROUP A. 1910–1911

Cow	Period	Hay (pounds)	Silage (pounds)	Mangels (pounds)	Grain (pounds)	
Glenwood	1	280	1,050	700	318	Mixture 1
	2	224	1,050	700	350	Mixture 1
	3	272	1,050	700	350	Mixture 1
Cornella	1	280	970	650	318	Mixture 1
	2	224	875	700	316	Mixture 1
	3	268	970	535	312	Mixture 1
Eta	1	350	1,400	700	420	Mixture 1
	2	350	1,400	700	420	Mixture 1
	3	350	1,380	700	420	Mixture 1
Tau	1	350	1,225	700	420	Mixture 1
	2	350	1,195	690	361	Mixture 1
	3	350	1,165	685	338	Mixture 1

TABLE 42. FEED RECORD OF GROUP B. 1910–1911

Cow	Period	Hay (pounds)	Silage (pounds)	Mangels (pounds)	Grain (pounds)	
Omicron	1	350	1,400	700	420	Mixture 1
	2	350	1,400	700	385	Mixture 1
	3	350	1,375	700	372	Mixture 2
Sigma	1	350	1,225	700	420	Mixture 1
	2	350	1,225	700	385	Mixture 1
	3	350	1,225	700	375	Mixture 2
Charity	1	350	1,150	700	385	Mixture 1
	2	342	1,050	700	350	Mixture 1
	3	350	1,050	700	340.5	Mixture 2

TABLE 43. FEED RECORD OF GROUP C. 1910–1911

Cow	Period	Hay (pounds)	Silage (pounds)	Mangels (pounds)	Grain (pounds)	
Chi	1	350	1,225	700	245	Mixture 1
	2	350	1,225	700	309	Mixture 1
	3	350	1,225	700	350	Mixture 2
Psi	1	350	1,225	700	298	Mixture 1
	2	350	1,400	700	365	Mixture 1
	3	350	1,400	700	399	Mixture 2
Effie	1	280	875	700	228	Mixture 1
	2	224	930	560	273	Mixture 1
	3	268	875	210	280	Mixture 2
Carlotta	1	350	1,225	700	332	Mixture 1
	2	350	1,400	700	400	Mixture 1
	3	350	1,400	700	420	Mixture 2

The constituents in the food are tabulated as in the records for 1909 1910, as described on page 85. This tabulation makes up tables 44, 44a, 45, 45a, 46, and 46a. These are followed by tables 47, 48, and 49, giving the record of production of each group in 1910–1911. The energy value of the product is given in tables 50, 51, and 52. The record of live weight in 1910–1911 is given in tables 53, 54, and 55.

TABLE 44. CONSTITUENTS FED GROUP A, 1910–1911, AND REQUIREMENTS ACCORDING TO STANDARDS

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Glenwood, Period 1							
Amount fed	948.07	78.67	519.73	31.18	668.55	78.67	530.73
Required —			by Haecker			by Armsby	
For maintenance: 1,055 lbs. weight		25.85	258.48	3.69	292.63	18.20	217.00
For product: 1,118 lbs. milk, 5.33 per cent fat		62.73	317.51	22.36	430.55	55.90	335.40
Total		88.58	575.99	26.05	723.18	74.10	552.40
Glenwood, Period 2							
Amount fed	928.88	79.81	513.08	32.47	665.95	79.81	534.15
Required —			by Haecker			by Armsby	
For maintenance: 1,098 lbs. weight		26.17	261.66	3.74	296.25	18.20	217.00
For product: 889.7 lbs. milk, 5.69 per cent fat		51.34	260.69	18.11	353.52	44.34	266.01
Total		77.51	522.35	22.18	649.77	62.54	483.01

TABLE 44 (*continued*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Glenwood, Period 3							
Amount fed	970.57	82.38	532.64	32.99	689.25	82.38	550.82
Required —			by Haecker			by Armsby	
For maintenance:							
1,093 lbs. weight	.....	26.78	267.79	3.83	303.19	18.90	224.00
For product:							
777 lbs. milk, 5.82 per cent fat	.....	45.69	233.10	16.39	315.67	38.85	233.10
Total	.....	72.47	500.89	20.22	618.86	57.75	457.10
Cornella, Period 1							
Amount fed	917.06	76.99	501.37	30.48	646.94	76.99	515.17
Required —			by Haecker			by Armsby	
For maintenance:							
874 lbs. weight	.....	21.41	214.13	3.06	242.42	15.75	192.50
For product:							
1,074.9 lbs. milk, 5.15 per cent fat	.....	59.01	297.75	20.96	403.92	53.75	322.47
Total	.....	80.42	511.88	24.02	646.34	69.50	514.97
Cornella, Period 2							
Amount fed	843.18	72.93	465.21	28.98	603.35	72.93	480.87
Required —			by Haecker			by Armsby	
For maintenance:							
857 lbs. weight	.....	21.00	209.97	3.00	237.72	15.40	189.00
For product:							
1,011.8 lbs. milk, 5.22 per cent fat	.....	55.85	281.28	19.83	381.75	50.59	303.54
Total	.....	76.85	491.25	22.83	619.47	65.99	492.54
Cornella, Period 3							
Amount fed	887.02	74.31	483.42	29.02	625.05	74.31	501.41
Required —			by Haecker			by Armsby	
For maintenance:							
864 lbs. weight	.....	21.17	211.68	3.02	239.64	15.40	189.00
For product:							
952.1 lbs. milk, 5.46 per cent fat	.....	53.98	273.25	19.23	370.50	47.61	285.63
Total	.....	75.15	484.93	22.25	610.14	63.01	474.63
Eta, Period 1							
Amount fed	1,211.54	100.59	661.13	40.95	853.86	100.59	685.90
Required —			by Haecker			by Armsby	
For maintenance:							
1,176 lbs. weight	.....	28.81	288.12	4.12	326.20	19.95	234.50
For product:							
1,584.6 lbs. milk, 3.46 per cent fat	.....	70.83	331.18	23.15	454.77	79.23	475.38
Total	.....	99.64	619.30	27.27	780.97	99.18	709.88

TABLE 44 (*concluded*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Eta, Period 2							
Amount fed	1,211.54	100.59	661.13	40.95	853.86	100.59	685.90
Required —			by Haecker			by Armsby	
For maintenance:							
1,185 lbs. weight		29.03	290.33	4.15	328.70	19.95	234.50
For product:							
1,550.8 lbs. milk, 3.42 per cent fat		69.26	321.32	22.77	441.81	77.99	467.94
Total		98.29	611.65	26.92	770.51	97.94	702.44
Eta, Period 3							
Amount fed	1,205.32	100.31	657.62	40.78	849.68	100.31	682.59
Required —			by Haecker			by Armsby	
For maintenance:							
1,192 lbs. weight		29.20	292.04	4.17	330.62	20.30	238.00
For product:							
1,423.8 lbs. milk, 3.79 per cent fat		66.63	318.93	22.50	436.19	71.19	427.14
Total		95.83	610.97	26.67	766.81	91.49	665.14
Tau, Period 1							
Amount fed	1,157.13	98.11	639.40	39.48	817.40	98.11	656.92
Required —			by Haecker			by Armsby	
For maintenance:							
1,327 lbs. weight		32.51	325.12	4.64	368.07	22.05	255.50
For product:							
1,097.5 lbs. milk, 3.93 per cent fat		52.35	253.52	17.89	346.12	54.88	329.25
Total		84.86	578.64	22.53	714.19	76.93	584.75
Tau, Period 2							
Amount fed	1,092.29	89.93	594.92	35.71	765.20	89.93	699.33
Required —			by Haecker			by Armsby	
For maintenance:							
1,336 lbs. weight		32.73	327.32	4.68	370.58	22.05	255.50
For product:							
1,040.2 lbs. milk, 4.17 per cent fat		50.87	248.61	17.58	339.04	52.01	312.06
Total		83.60	575.93	22.26	709.62	74.06	567.56
Tau, Period 3							
Amount fed	1,061.09	86.48	577.22	34.10	740.43	86.48	587.69
Required —			by Haecker			by Armsby	
For maintenance:							
1,350 lbs. weight		33.30	332.99	4.76	376.97	22.40	259.00
For product:							
967.6 lbs. milk, 4.29 per cent fat		48.19	237.06	16.71	322.02	48.38	290.28
Total		81.49	570.02	21.50	699.89	70.78	549.28

TABLE 44a. AVERAGE CONSTITUENTS FED GROUP A, 1910–1911, AND REQUIREMENTS ACCORDING TO STANDARDS

	Protein (pounds)	Total nutriment (pounds)	Nutritive ratio	Percentage of total nutriment above standard		Protein (pounds)	Therms	Percentage of therms above standard
Period 1								
Amount fed	88.59	746.69	1:7.4	4.3		88.59	597.18	1.1
Required by Haecker	88.38	716.17	1:7.1	.....	by Armsby	79.93	590.50	.....
Period 2								
Amount fed	85.82	721.99	1:7.4	5.0		85.82	577.56	2.9
Required by Haecker	84.06	687.34	1:7.2	.....	by Armsby	75.13	561.39	.....
Period 3								
Amount fed	85.87	726.10	1:7.5	7.7		85.87	580.63	8.2
Required by Haecker	81.24	673.92	1:7.3	.....	by Armsby	70.76	536.54	.....

TABLE 45. CONSTITUENTS FED GROUP B, 1910–1911, AND REQUIREMENTS ACCORDING TO STANDARDS

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Omicron, Period 1							
Amount fed	1,211.54	100.59	661.13	40.95	853.86	100.59	685.90
Required —			by Haecker			by Armsby	
For maintenance:							
1,224 lbs. weight	.....	29.99	299.88	4.28	339.50	20.65	241.50
For product:							
1,500 lbs. milk, 3.79 per cent fat	.....	70.20	336.00	23.70	459.53	75.00	450.00
Total	.....	100.19	635.88	27.98	799.03	95.65	691.50
Omicron, Period 2							
Amount fed	1,179.34	96.06	643.45	38.87	826.97	96.06	660.89
Required —			by Haecker			by Armsby	
For maintenance:							
1,236 lbs. weight	.....	30.28	302.82	4.33	342.84	20.65	241.50
For product:							
1,405.4 lbs. milk, 3.91 per cent fat	.....	66.62	320.43	22.63	437.97	70.27	421.62
Total	.....	96.90	623.25	26.96	780.81	90.92	663.12
Omicron, Period 3							
Amount fed	1,161.50	111.55	622.13	39.00	821.43	111.55	655.35
Required —			by Haecker			by Armsby	
For maintenance:							
1,258 lbs. weight	.....	30.82	308.21	4.40	348.93	21.00	245.00
For product:							
1,377.5 lbs. milk, 4 per cent fat	.....	66.12	320.96	22.59	437.01	68.88	413.25
Total	.....	96.94	629.17	26.99	780.84	89.88	658.25

TABLE 45 (*continued*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Sigma, Period 1							
Amount fed	1,157.13	98.11	630.46	39.48	817.40	98.11	656.92
Required —			by Haecker			by Armsby	
For maintenance:							
1,043 lbs. weight		25.55	255.54	3.65	289.30	18.20	217.00
For product:							
1,518.0 lbs. milk, 3.83 per cent fat		71.54	343.27	24.30	469.49	75.05	455.67
Total		97.09	598.81	27.95	758.79	94.15	672.67
Sigma, Period 2							
Amount fed	1,124.93	93.58	612.78	37.40	790.51	93.58	631.91
Required —			by Haecker			by Armsby	
For maintenance:							
1,053 lbs. weight		25.80	257.09	3.69	292.09	18.20	217.00
For product:							
1,500.6 lbs. milk, 3.87 per cent fat		70.68	339.14	24.01	463.84	75.03	450.18
Total		96.48	597.13	27.70	755.93	93.23	667.18
Sigma, Period 3							
Amount fed	1,117.64	100.95	597.27	37.93	792.56	100.95	632.72
Required —			by Haecker			by Armsby	
For maintenance:							
1,004 lbs. weight		26.07	260.68	3.72	295.12	18.20	217.00
For product:							
1,492.6 lbs. milk, 4.1 per cent fat		72.54	353.75	24.93	482.38	74.63	447.78
Total		98.61	614.43	28.65	777.50	92.83	664.78
Charity, Period 1							
Amount fed	1,001.62	92.51	509.63	36.77	774.87	92.51	619.49
Required —			by Haecker			by Armsby	
For maintenance:							
987 lbs. weight		24.18	241.82	3.45	273.76	17.50	210.00
For product:							
1,451.9 lbs. milk, 3.8 per cent fat		67.95	325.23	22.94	444.79	72.60	435.57
Total		92.13	567.05	26.39	718.55	90.10	645.57
Charity, Period 2							
Amount fed	1,031.37	86.13	561.16	33.76	723.25	86.13	575.14
Required —			by Haecker			by Armsby	
For maintenance:							
987 lbs. weight		24.18	241.82	3.45	273.76	17.50	210.00
For product:							
1,340.3 lbs. milk, 3.72 per cent fat		60.54	288.27	20.31	394.51	65.52	393.00
Total		84.72	530.09	23.76	668.27	83.02	603.00

TABLE 45 (*concluded*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
			Charity, Period 3				
Amount fed	1,031.31	101.37	550.12	34.31	728.69	101.37	578.35
Required —			by Haecker			by Armsby	
For maintenance:							
995 lbs. weight		24.38	243.78	3.48	275.99	17.50	210.00
For product:							
1,247.2 lbs. milk, 3.78 per cent fat		58.37	279.37	19.71	382.09	62.36	374.16
Total		82.75	523.15	23.19	658.08	79.86	584.16

TABLE 45a. AVERAGE CONSTITUENTS FED GROUP B, 1910–1911, AND REQUIREMENTS ACCORDING TO STANDARDS

	Protein (pounds)	Total nutriment (pounds)	Nutritive ratio	Percentage of total nutriment above standard		Protein (pounds)	Therms	Percentage of therms above standard
Period 1								
Amount fed	97.07	815.38	1:7.4	7.5		97.07	654.10	—2.4
Required by Haecker	90.47	758.79	1:6.9	.....	by Armsby	93.30	669.91	.....
Period 2								
Amount fed	91.02	780.24	1:7.5	6.2		91.02	622.65	—3.4
Required by Haecker	92.70	735.00	1:6.9	.....	by Armsby	89.06	644.46	.....
Period 3								
Amount fed	107.62	780.89	1:6.3	5.4		107.62	622.14	—2.1
Required by Haecker	92.77	740.81	1:7.0	.....	by Armsby	87.52	635.73	.....

TABLE 46. CONSTITUENTS FED GROUP C, 1910–1911, AND REQUIREMENTS ACCORDING TO STANDARDS

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
			Chi, Period 1				
Amount fed	996.10	75.46	542.06	20.08	682.95	75.46	531.87
Required —			by Haecker			by Armsby	
For maintenance:							
1,067 lbs. weight		20.14	261.42	3.73	295.95	18.20	217.00
For product:							
1,172.1 lbs. milk, 3.47 per cent fat		52.39	244.97	17.35	330.40	58.61	351.03
Total		78.53	506.39	21.08	632.35	76.81	568.03
			Chi, Period 2				
Amount fed	1,054.99	83.74	574.38	32.88	732.10	83.74	577.00
Required —			by Haecker			by Armsby	
For maintenance:							
1,073 lbs. weight		20.29	262.89	3.76	297.04	18.55	220.50
For product:							
1,177.6 lbs. milk, 3.38 per cent fat		52.20	242.59	17.19	333.50	58.88	353.28
Total		78.58	505.38	20.95	631.20	77.33	573.78

TABLE 46 *(continued)*

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pounds)	Therms
Chi, Period 3							
Amount fed	1,094.51	105.51	585.34	36.37	772.71	105.51	614.32
Required —			by Haecker			by Armsby	
For maintenance:							
1,080 lbs. weight		26.46	264.60	3.78	299.57	18.55	220.50
For product:							
1,130.3 lbs. milk, 3.46 per cent fat		50.79	237.40	16.82	326.12	56.82	340.89
Total		77.25	502.00	20.60	625.69	75.37	561.39
Psi, Period 1							
Amount fed	1,044.87	82.32	568.83	32.23	723.67	82.32	569.74
Required —			by Haecker			by Armsby	
For maintenance:							
1,181 lbs. weight		28.93	289.35	4.13	327.57	19.95	234.50
For product:							
1,404.8 lbs. milk, 3.37 per cent fat		61.95	286.58	20.23	394.05	70.24	421.44
Total		90.88	575.93	24.36	721.62	90.19	655.94
Psi, Period 2							
Amount fed	1,160.93	93.47	633.35	37.68	811.60	93.47	646.60
Required —			by Haecker			by Armsby	
For maintenance:							
1,175 lbs. weight		28.79	287.88	4.11	325.92	19.95	234.50
For product:							
1,458.2 lbs. milk, 3.43 per cent fat		65.18	304.76	21.58	418.49	72.91	437.46
Total		93.97	592.64	25.69	744.41	92.86	671.96
Psi, Period 3							
Amount fed	1,194.25	110.66	639.39	40.91	848.08	110.66	679.35
Required —			by Haecker			by Armsby	
For maintenance:							
1,180 lbs. weight		28.91	289.10	4.13	327.30	19.95	234.50
For product:							
1,410.4 lbs. milk, 3.58 per cent fat		64.72	305.17	21.57	418.42	70.97	425.82
Total		93.63	594.27	25.70	745.72	90.92	660.32
Effie, Period 1							
Amount fed	810.85	64.54	443.57	24.36	562.92	64.54	437.44
Required —			by Haecker			by Armsby	
For maintenance:							
842 lbs. weight		20.63	206.29	2.95	233.59	15.30	180.00
For product:							
890.3 lbs. milk, 4.24 per cent fat		41.59	204.19	14.35	278.29	42.02	252.09
Total		62.22	410.48	17.30	511.85	57.32	432.09

TABLE 46 (*Concluded*)

	Dry matter (pounds)	Protein (pounds)	Carbohydrates (pounds)	Fat (pounds)	Total nutriment (pounds)	Protein (pound	Therms
Effie, Period 2							
Amount fed	803.55	66.62	440.95	26.81	567.89	66.62	452.79
Required —			by Haecker			by Armsby	
For maintenance:							
814 lbs. weight		20.68	206.78	2.95	234.10	15.40	189.00
For product:							
781.1 lbs. milk, 4.71 per cent fat		40.77	203.09	14.37	276.19	39.06	234.33
Total		61.45	409.87	17.32	510.29	54.46	423.33
Effie, Period 3							
Amount fed	789.63	78.48	414.51	27.87	555.70	78.48	453.72
Required —			by Haecker			by Armsby	
For maintenance:							
852 lbs. weight		20.87	208.74	2.98	236.32	15.40	189.00
For product:							
719.5 lbs. milk, 5.02 per cent fat		38.85	194.98	13.74	264.74	35.98	215.85
Total		59.72	403.72	16.72	501.06	51.38	404.85
Carlotta, Period 1							
Amount fed	1,076.16	86.72	586.01	34.25	749.79	86.72	594.04
Required —			by Haecker			by Armsby	
For maintenance:							
1,225 lbs. weight		30.01	300.13	4.29	339.79	20.65	241.50
For product:							
1,368.1 lbs. milk, 3.37 per cent fat		60.33	279.09	19.70	383.75	68.41	410.43
Total		90.34	579.22	23.99	723.54	89.06	651.93
Carlotta, Period 2							
Amount fed	1,193.14	98.00	651.03	39.76	838.49	98.00	671.61
Required —			by Haecker			by Armsby	
For maintenance:							
1,250 lbs. weight		30.77	307.72	4.40	348.39	21.00	245.00
For product:							
1,492.5 lbs. milk, 3.42 per cent fat		66.27	307.46	21.79	422.76	74.03	447.75
Total		97.04	615.18	26.19	771.15	95.03	692.75
Carlotta, Period 3							
Amount fed	1,213.09	120.37	649.42	42.21	864.76	120.37	694.81
Required —			by Haecker			by Armsby	
For maintenance:							
1,278 lbs. weight		31.31	313.11	4.47	354.48	21.35	248.50
For product:							
1,537.6 lbs. milk, 3.46 per cent fat		68.73	321.36	22.76	411.30	76.88	491.28
Total		100.04	634.47	27.23	795.78	98.23	709.78

TABLE 46a. AVERAGE CONSTITUENTS FED GROUP C, 1910–1911, AND REQUIREMENTS ACCORDING TO STANDARDS

	Protein (pounds)	Total nutriment (pounds)	Nutritive ratio	Percentage of total nutriment above standard		Protein (pounds)	Therms	Percentage of therms above standard
Period 1								
Amount fed	77.26	679.83	1:7.7	5.0		77.26	533.27	—8.0
Required by Haecker	80.49	647.34	1:7.0	.....	by Armsby	78.37	579.49	.....
Period 2								
Amount fed	85.46	737.52	1:7.6	11.0		85.46	587.15	—0.6
Required by Haecker	82.76	664.26	1:7.0	.....	by Armsby	80.10	590.46	.....
Period 3								
Amount fed	105.26	760.31	1:6.2	14.0		105.26	610.55	4.5
Required by Haecker	82.66	667.06	1:7.1	.....	by Armsby	78.98	584.09	.....

TABLE 47. RECORD OF PRODUCTION. GROUP A, 1910–1911

Cow	Period	Pounds milk	Percentage fat	Pounds fat	Percentage solids-not-fat	Pounds solids-not-fat	Pounds total product
Glenwood	1	1,118.0	5.33	59.606	9.28	103.767	237.881
	2	886.7	5.66	50.204	9.34	82.785	195.744
	3	777.0	5.82	45.203	9.49	73.734	175.441
Cornella	1	1,074.9	5.15	55.325	9.35	100.519	225.000
	2	1,011.8	5.22	52.780	9.30	94.134	212.889
	3	952.1	5.46	51.993	9.48	90.250	207.234
Eta	1	1,584.6	3.46	54.776	8.99	142.397	265.643
	2	1,559.8	3.42	53.415	9.08	141.573	261.757
	3	1,423.8	3.79	53.911	9.19	130.851	252.151
Tau	1	1,097.5	3.93	43.186	9.27	101.789	198.958
	2	1,040.2	4.17	43.375	9.40	97.766	195.360
	3	967.6	4.29	41.473	9.52	92.091	185.405
Average, group A	1	1,218.8	4.37	53.223			231.871
	2	1,124.6	4.44	49.944			216.438
	3	1,030.1	4.67	48.145			205.058

TABLE 48. RECORD OF PRODUCTION. GROUP B, 1910–1911

Cow	Period	Pounds milk	Percentage fat	Pounds fat	Percentage solids-not-fat	Pounds solids-not-fat	Pounds total product
Omicron	1	1,500.0	3.79	56.887	9.00	135.880	263.876
	2	1,405.4	3.91	54.948	9.04	127.045	250.678
	3	1,377.5	4.00	55.025	9.19	126.552	250.358
Sigma	1	1,518.9	3.83	58.202	8.91	135.378	266.333
	2	1,500.6	3.87	58.072	8.98	134.789	265.451
	3	1,492.6	4.10	61.148	9.21	137.539	275.122
Charity	1	1,451.9	3.80	55.158	9.32	135.273	259.378
	2	1,310.3	3.72	48.775	9.30	121.909	231.053
	3	1,247.2	3.78	47.202	9.39	117.087	223.292
Average, group B	1	1,490.3	3.81	56.749			263.196
	2	1,405.4	3.84	53.932			249.201
	3	1,372.4	3.97	54.458			249.591

TABLE 49. RECORD OF PRODUCTION. GROUP C, 1910–1911

Cow	Period	Pounds milk	Percentage fat	Pounds fat	Percentage solids-not-fat	Pounds solids-not-fat	Pounds total product
Chi	1	1,172.1	3.47	40.648	8.92	104.540	195.998
	2	1,177.6	3.38	39.817	8.95	105.356	194.944
	3	1,136.3	3.46	39.310	9.09	103.254	191.701
Psi	1	1,404.8	3.37	47.342	8.92	125.348	231.867
	2	1,458.2	3.43	49.959	9.04	131.819	244.227
	3	1,419.4	3.58	50.843	9.13	129.526	243.923
Effie	1	840.3	4.24	35.618	9.46	79.521	159.662
	2	781.1	4.71	36.792	9.50	74.200	156.982
	3	719.5	5.02	36.123	9.67	69.561	150.838
Carlotta	1	1,368.1	3.37	46.114	8.94	122.338	226.094
	2	1,492.5	3.42	51.027	9.08	135.474	250.285
	3	1,537.6	3.46	53.276	9.14	140.493	260.364
Average, group C	1	1,196.3	3.55	42.431	.....	.....	203.405
	2	1,227.4	3.62	44.399	.....	.....	211.610
	3	1,203.2	3.73	44.888	.....	.....	211.707

TABLE 50. ENERGY VALUE OF PRODUCT. GROUP A, 1910–1911

Cow	Period	Pounds solids-not-fat —.7 per cent ash	Therms in fat	Therms in ash-free solids-not-fat	Total therms
Glenwood	1	95.941	251.418	178.450	429.868
	2	76.778	211.760	142.807	354.567
	3	68.295	190.666	127.029	317.695
Cornella	1	92.995	233.361	172.971	406.332
	2	87.051	222.626	161.915	384.541
	3	83.585	219.306	155.468	374.774
Eta	1	131.305	231.045	244.227	475.272
	2	130.654	225.304	243.016	468.320
	3	120.884	227.397	224.844	452.241
Tau	1	94.107	182.159	175.039	357.198
	2	90.485	182.956	168.302	351.258
	3	85.318	174.933	158.691	333.624
Average, group A	1	.....	.....	.....	417.168
	2	.....	.....	.....	389.672
	3	.....	.....	.....	369.584

TABLE 51. ENERGY VALUE OF PRODUCT. GROUP B, 1910–1911

Cow	Period	Pounds solids-not-fat —.7 per cent ash	Therms in fat	Therms in ash-free solids-not-fat	Total therms
Omicron	1	125.380	239.949	233.207	473.156
	2	117.207	231.771	218.005	449.776
	3	116.910	232.095	217.453	449.548
Sigma	1	124.746	245.496	232.028	477.524
	2	124.285	244.948	231.170	476.118
	3	127.091	257.922	236.379	494.301
Charity	1	125.110	232.656	232.705	465.361
	2	112.738	205.733	209.693	415.426
	3	108.357	199.098	201.544	400.642
Average, group B	1	.....	.....	.....	472.014
	2	.....	.....	.....	447.107
	3	.....	.....	.....	448.164

TABLE 52. ENERGY VALUE OF PRODUCT. GROUP C, 1910–1911

Cow	Period	Pounds solids-not-fat —.7 per cent ash	Therms in fat	Therms in ash-free solids-not-fat	Total therms
Chi	1	96.335	171.453	179.183	350.636
	2	97.113	167.948	180.630	348.578
	3	95.300	165.810	177.258	343.068
Psi	1	115.604	199.689	215.023	414.712
	2	121.612	210.727	226.198	436.925
	3	119.590	214.456	222.437	436.893
Effie	1	73.639	150.237	136.969	287.206
	2	68.732	155.189	127.842	283.031
	3	64.525	152.367	120.017	272.384
Carlotta	1	112.761	194.509	209.735	404.244
	2	125.027	215.232	232.550	447.782
	3	129.730	224.718	241.298	466.016
Average, group C	1	.....	.....	.....	364.200
	2	.....	.....	.....	379.079
	3	.....	.....	.....	379.590

TABLE 53. RECORD OF LIVE WEIGHT (IN POUNDS). GROUP A, 1910–1911

	Average at beginning	Average at end	Gain + Loss —	Average for period
Period 1				
Glenwood	1,052	1,057	+ 5	1,055
Cornella	894	854	—40	874
Eta	1,172	1,180	+ 8	1,176
Tau	1,328	1,326	— 2	1,327
Period 2				
Glenwood	1,057	1,079	+22	1,068
Cornella	854	859	+ 5	857
Eta	1,180	1,190	+10	1,185
Tau	1,326	1,345	+19	1,336
Period 3				
Glenwood	1,079	1,106	+27	1,093
Cornella	859	868	+ 9	864
Eta	1,190	1,194	+ 4	1,192
Tau	1,345	1,373	+28	1,359
Average for group A, period 1	.....	.....	.....	1,108
2	.....	.....	.....	1,112
3	.....	.....	.....	1,127

TABLE 54. RECORD OF LIVE WEIGHT (IN POUNDS). GROUP B, 1910–1911

	Average at beginning	Average at end	Gain + Loss —	Average for period
Period 1				
Omicron	1,224	1,224	.....	1,224
Sigma	1,038	1,047	+ 9	1,043
Charity	991	984	— 7	987
Period 2				
Omicron	1,224	1,248	+24	1,236
Sigma	1,047	1,059	+12	1,053
Charity	984	990	+ 6	987
Period 3				
Omicron	1,248	1,268	+20	1,258
Sigma	1,059	1,069	+10	1,064
Charity	990	1,000	+10	995
Average for group B period 1	.....	.....	.....	1,085
2	.....	.....	.....	1,092
3	.....	.....	.....	1,106

TABLE 55. RECORD OF LIVE WEIGHT (IN POUNDS). GROUP C, 1910–1911

	Average at beginning	Average at end	Gain + Loss −	Average for period
Period 1				
Chi	1,066	1,068	+ 2	1,067
Psi	1,184	1,177	− 7	1,181
Effie	839	844	+ 5	842
Carlotta	1,208	1,242	+34	1,225
Period 2				
Chi	1,068	1,077	+ 9	1,073
Psi	1,177	1,173	− 4	1,175
Effie	844	843	− 1	844
Carlotta	1,242	1,269	+27	1,256
Period 3				
Chi	1,077	1,083	+ 6	1,080
Psi	1,173	1,186	+13	1,180
Effie	843	860	+17	852
Carlotta	1,269	1,287	+18	1,278
Average for group C, period 1				1,079
2				1,087
3				1,098

DISCUSSION OF DATA

The correctness of the application of Haecker's standard

In the discussion of the data as to the correctness of Haecker's standard as a guide in the practice of feeding dairy cows, the two questions to be considered are:

1. Does this feeding standard furnish sufficient protein?
2. Does this feeding standard furnish sufficient total nutriment?

Protein requirements.— In answer to question 1, the feeding and production records for periods 2 and 3 of group B in both 1909–1910 and 1910–1911, and of group C in 1910–1911, may be studied.

1. Group B, 1909–1910. In period 2 of this year, the average ration fed group B contained 92.02 pounds of protein and 740.87 pounds of total nutriment, with a nutritive ratio of 1:7; in period 3 of the same year, the average ration of group B contained 96.72 pounds of protein and 679.13 pounds of total nutriment, with a nutritive ratio of 1:6. (Table 28a.) In period 2, group B produced an average of 1,176.7 pounds of milk, containing 49.662 pounds of fat (4.22 per cent) and 217.311 pounds of total product; in period 3, group B produced 1,068.7 pounds of milk, containing 46.165 pounds of fat (4.32 per cent) and 200.365 pounds of total product. (Table 31.) In period 3, then, group B received 4.70 pounds more protein per cow and 61.74 pounds less total nutriment. From tables 25 and 23,

the computed cost of the ration for each cow is found to have been $1.121 less in period 3 than in period 2. The production of fat for each cow was 3.497 pounds less in period 3 than in period 2. This fat was worth 40 cents per pound, or a total of $1.398. Thus the average amount realized per cow for group B was 27.7 cents less in period 3 than in period 2. A study of these data indicates that the increased amount of protein did no good. However, the value of the data is much lessened by two facts: that the cows were reduced in the amount of their ration, and that the cow Omicron was "off feed" in this period.

The amount of total nutriment allowed by Haecker for group B in period 2, 1909–1910, averaged 671.16 pounds per cow, or 10.4 per cent below the amount fed. In period 3 the amount allowed averaged 647.03 pounds, or 5 per cent below the amount fed. While the amount of fat yielded was greater in period 2 than in period 3, it may have been that the cows were fed too highly, causing one to go "off feed" and making it advisable to reduce somewhat the feed of the others. The amount of fat produced by check group A was slightly less in period 3 than in period 2. The amount of total product also was a little less. The feed of the check group was reduced from 12.4 per cent above the standard to 7.4 per cent above the standard. The nutritive ratio of the ration fed the check group was practically identical with that of the standard.

2. Group B, 1910–1911. In periods 2 and 3, group B offers in this year a much better set of data from which to judge of the value of more protein than is allowed by Haecker's standard. All the cows seemed to be normal during both these periods in 1910-1911. In period 2, group B averaged 91.92 pounds of protein and 780.24 pounds of total nutriment, with a nutritive ratio of 1:7.5; in period 3, 107.62 pounds of protein and 780.89 pounds of total nutriment, nutritive ratio 1:6.3. (Table 45a.) In period 2, group B produced 1,405.4 pounds of milk, 53.932 pounds of fat (3.84 per cent), and 249.261 pounds of total product; in period 3, group B produced 1,372.4 pounds of milk, 54.458 pounds of fat (3.97 per cent), and 249.591 pounds of total product. (Table 48.) Since there was an increase of but .65 pound of total nutriment fed per cow, whatever gain there was in product must have been due to the increase of 15.70 pounds of protein per cow. Calculating the average per-cow from tables 42 and 40, it is found that the average amount of feed cost 13.5 cents less per cow in period 3 than in period 2. If the value of the increase of fat is added, .526 pound at 40 cents, the total gain per cow in period 3 over period 2 was 34.5 cents. The amount of total nutriment in period 2 was 6.2 per cent above Haecker's standard, while in period 3 it was 5.4 per cent above the standard. Because the amount of total nutriment was practically the same in both periods, the gain shown by group B would indicate that

the nutritive ratio of 1:6.3 was more advantageous. The average amount per cow of total nutriment fed check group A in period 3 was 4.11 pounds more than in period 2. (Table 44a.) The fat produced was 1.799 pounds less per cow in period 3. Calculating the gain or loss as for group B above, the total loss for group A in period 3 was 65.8 cents per cow.

3. Group C, 1910–1911. In period 2, group C averaged 85.46 pounds of protein and 737.52 pounds of total nutriment, with a nutritive ratio of 1:7.6; in period 3, group C averaged 105.26 pounds of protein and 760.31 pounds of total nutriment, with a nutritive ratio of 1:6.2. (Table 46a.) In period 2, the average production of group C was 1,227.4 pounds of milk, 44.309 pounds of fat (3.62 per cent), and 211.610 pounds of total product; in period 3, the average production of group C was 1,203.2 pounds of milk, 44.888 pounds of fat (3.73 per cent), and 211.707 pounds of total product. (Table 49.) There was fed to group C, then, in period 3, 22.70 pounds more total nutriment and 19.80 pounds more protein than in period 2. The increase in fat production was .489 pound of fat, worth 40 cents per pound, or 19.6 cents. The increased nutriment cost 20.9 cents, showing an average loss of 1.3 cent in period 3 over period 2. In period 2, the ration fed group C was 11 per cent above Haecker's standard; in period 3 it was 14 per cent above Haecker's standard.

This comparison would tend to show that, while it may have been well to increase the protein, 14 per cent of total nutriment above the standard was not economical.

Total nutriment requirements.— The data of 1909–1910 give no conclusions as to the amount of total nutriment required except in a general way, which will be discussed later. In 1910–1911, the data admit of two direct comparisons in periods 1 and 2; group B was fed nearer Haecker's standard in period 2 than in period 1, and group C was fed nearer the standard in period 1 than in period 2.

1. Group B, 1910–1911. In period 1, group B was fed an average of 97.07 pounds of protein and 815.38 pounds of total nutriment, nutritive ratio 1:7.4; in period 2, group B averaged 91.92 pounds of protein and 780.24 pounds of total nutriment, nutritive ratio 1:7.5. The amount of total nutriment was 7.5 per cent above Haecker's allowance in period 1 and 6.2 per cent above Haecker's standard in period 2. (Table 45a.) In period 1, group B produced an average of 1,490.3 pounds of milk, 56.749 pounds of fat (3.81 per cent), and 263.196 pounds of total product; in period 2, group B produced 1,405.4 pounds of milk, 53.932 pounds of fat (3.84 per cent), and 249.261 pounds of total product. (Table 48.) There was, then, 35.14 pounds less total nutriment fed in period 2 than in period 1. This was an average saving of 48.8 cents per cow. The amount of fat produced per cow was 2.817 pounds less in period 2, worth $1.126

at 40 cents per pound. Giving the cow credit for the saving of feed, the loss would still be 63.8 cents per cow. This would indicate that the feed should not have been reduced.

No definite comparison can be made with the check group A in this case, because one cow, Glenwood, was fed much less than Haecker's standard in period 1, since, in the opinion of the herdsman, she would not consume feed equal in quantity to that recommended by Haecker. (Table 44.) Another cow, Cornella, was fed practically the standard requirement in period 1 and somewhat below the standard in period 2. A study of the feeding of these cows (Table 44) and of their production (Table 47) will show that they produced relatively much less in period 2 than in period 1, while a very small loss was shown by the cow Eta and a slight gain by the cow Tau in this check group A. Eta was fed exactly the same in both periods; Tau was fed a little less in period 2, but nevertheless she kept up her production.

2. Group C, 1910–1911. Group C was fed nearer to Haecker's standard during period 1 and then allowed more food during period 2. In period 1, group C averaged 77.26 pounds of protein and 679.83 pounds of total nutriment, nutritive ratio 1:7.7; in period 2, group C averaged 85.46 pounds of protein and 737.52 pounds of total nutriment, with a nutritive ratio of 1:7.6. (Table 46a.) The average production in period 1 was 1,196.3 pounds of milk, 42.431 pounds of fat (3.55 per cent), and 203.405 pounds of total product; in period 2, the production was 1,227.4 pounds of milk, 44.399 pounds of fat (3.62 per cent), and 211.610 pounds of total product. (Table 49.)

The increase in food in period 2 was 57.69 pounds of total nutriment per cow, costing 71.6 cents. The increase in fat production averaged 1.968 pounds, worth 78.7 cents at 40 cents per pound. Therefore the increase in food up to 11 per cent above the standard was more economical than feeding at 5 per cent above the standard as in period 1. (Table 46a.)

In 1909–1910, group A for all three periods, group B for periods 1 and 2, and group C for all three periods were fed a ration with a nutritive ratio close to that recommended by Haecker and were fed all that they would eat up clean. The same is true of group A for all three periods in 1910–1911, group B for period 1, and group C for period 2. Therefore, if the amount of protein and total nutriment be averaged for these periods, and the amounts allowed by Haecker for the same periods, an idea may be derived as to the amount of nutriment that a cow will use for product if her appetite is given free range, and a comparison may be made with the nutriment that Haecker recommends. (Tables 27a, 28a, 29a, 30, 31, 32, 36, 37, 38; 44a, 45a, 46a, 47, 48, 49, 53, 54, 55.)

From these averages it is seen that .0558 pound of net protein was used per pound of milk containing 4.26 per cent fat. Haecker's standard

provides .0496 pound of net protein for 1 pound of milk containing 4.20 per cent fat. For 1 pound of this same quality of milk an average of .388 pound of net nutriment was used, while the standard provides .329 pound of net nutriment, or 15 per cent less. (Table 56.) From this it would seem that, if the cows were allowed to satisfy their appetites in a normal way, Haecker's standard would not provide sufficient nutriment. Furthermore, wherever comparisons have been possible, it has been shown that the greater amount of nutriment was the more economical.

TABLE 56. AVERAGE FOOD CONSUMED COMPARED WITH HAECKER'S STANDARD (IN POUNDS)

Group	Period	Fed		Haecker		Product			Live weight
		Protein	Total nutriment	Protein	Total nutriment	Milk	Fat	Total product	
1909–1910									
A	1	83.13	666.86	74.09	602.68	1,008.8	43.119	189.845	972
A	2	84.01	682.36	74.09	607.08	984.9	43.156	187.662	991
A	3	80.51	652.07	73.73	607.68	958.7	43.397	185.624	1,009
B	1	99.98	725.31	84.43	670.30	1,252.8	50.030	224.967	991
B	2	92.02	710.87	83.24	671.16	1,176.7	49.662	217.311	1,028
C	1	84.56	680.11	73.59	600.37	991.7	43.519	190.138	968
C	2	83.35	678.84	71.63	589.22	935.7	42.935	179.972	979
C	3	89.11	698.48	70.51	585.09	887.0	41.260	173.934	1,000
1910–1911									
A	1	88.59	716.69	88.38	716.17	1,218.8	53.223	231.871	1,108
A	2	85.82	721.99	84.07	687.34	1,124.6	49.044	216.438	1,112
A	3	85.87	726.10	84.24	673.92	1,039.1	48.115	205.058	1,127
B	1	97.07	815.38	95.47	758.79	1,490.3	56.749	263.166	1,085
C	2	85.46	737.52	82.76	664.26	1,227.4	44.300	211.610	1,087
Total		1,127.48	9,273.31	1,038.22	8,434.87	14,287.5	600.260	2,677.623	13,403
Average		86.73	713.33	79.86	648.84	1,099.0	46.867	205.971	1,030
For maintenance		25.38	287.30	25.38	287.30	...	...	...	...
Net for product		61.35	425.97	54.48	361.48	.....	.....	.....	.....
Nutritive ratio		1:7.2		1:7.1		.....	.....	.....	.....

Average percentage of fat in milk, 4.26.
Average net protein fed for 1 pound milk .0558 pound; standard .0496 pound.
Average net protein fed for 1 pound product .298 pound; standard .264 pound.
Average net nutriment fed for 1 pound milk .388 pound; standard .329 pound.
Average net nutriment fed for 1 pound product 2.068 pounds; standard — 1.755 pound.

The writer is fully aware of the limitations of the data submitted. However, questions 1 and 2 on page 114 are answered in some degree as follows:

1. The data indicate that a nutritive ratio of 1:6 will stimulate a greater production of butter-fat than will wider nutritive ratios as proposed in Haecker's standard.

2. The data indicate that an increase of at least 10 per cent in the amount of total nutriment above that allowed by Haecker, would stimulate butter-fat production to an extent great enough to pay for the increased feed.

The correctness of the application of Armsby's standard

Essentially the same questions may be asked in regard to Armsby's feeding standard as were asked concerning Haecker's standard:

1. Does this feeding standard furnish sufficient protein?

2. Does this standard furnish sufficient energy for milk production?

Protein requirements.— For a study of the question whether sufficient protein and energy is provided by Armsby's standard, Table 57, similar to Table 56, has been prepared. Armsby's standard, page 82, provides .05 pound of digestible protein per pound of milk. In Table 56 it was shown that the rations there averaged had a nutritive ratio of 1:7.2. In Table 57, after the amount of protein considered by Armsby to be sufficient for maintenance has been subtracted, the protein left for product provides .0623 pound of protein for 1 pound of milk containing 4.26 per cent fat. The data indicate that when the rations were narrowed, more butter-fat was secreted by group B, 1910–1911, in period 3 as compared with period 2 even though no more nutriment was provided (page 115). The average protein fed during period 3 to group B, after deducting protein for maintenance, was 89.07 pounds. Dividing by the average amount of milk produced by group B during this period, 1,372.4 pounds, it is found that .065 pound of protein was used per pound of milk. This milk tested 3.97 per cent fat. In Table 57 the amount of protein fed per pound of milk is .0623 pound, instead of .0558 pound, as shown in Table 56, because Armsby provides .50 pound of protein to maintain a 1,000-pound animal while Haecker provides .70 pound of protein.

TABLE 57. AVERAGE FOOD CONSUMED COMPARED WITH ARMSBY'S STANDARD

Group	Period	Fed		Armsby		Product			Pounds live weight
		Pounds protein	Therms	Pounds protein	Therms	Pounds milk	Pounds fat	Therms in product	
1909–1910									
A	1	83.13	562.09	67.51	510.02	1,008.8	43.439	341.409	972
A	2	84.01	568.54	67.18	510.73	984.9	43.450	337.602	994
A	3	80.51	547.04	65.88	502.88	958.7	43.397	331.204	1,009
B	1	90.98	618.29	79.71	581.04	1,252.8	50.030	403.779	994
B	2	92.02	626.76	75.99	558.21	1,176.7	49.662	390.515	1,028
C	1	84.56	575.15	66.21	500.49	991.7	43.519	342.199	968
C	2	83.35	568.11	63.41	483.71	935.7	42.935	323.953	979
C	3	86.11	590.30	61.41	472.50	887.0	41.260	313.333	1,000
1910–1911									
A	1	88.59	597.18	79.93	590.50	1,218.8	53.223	417.168	1,108
A	2	85.82	577.50	75.13	561.39	1,121.6	49.944	389.672	1,112
A	3	85.87	580.03	70.76	536.54	1,030.1	48.145	369.583	1,127
B	1	97.07	654.40	93.30	669.93	1,399.3	59.749	472.015	1,085
C	2	85.46	587.15	80.19	599.30	1,227.4	54.399	429.959	1,087
Total		1,127.48	7,652.90	940.43	7,067.47	14,227.5	609.269	4,814.550	13,363
Average		80.73	588.68	72.80	543.75	1,099.0	46.867	379.350	1,030
For maintenance		18.20	217.00	18.20	217.00				
Net for product		68.53	371.68	54.60	326.75				

Average percentage of fat in milk, 4.26.
Average net protein fed for 1 pound of milk .0623 pound; standard .05 pound.
Average net therms fed for 1 pound of milk .338; standard .297.

Therefore, if only .50 pound of protein is to be provided for the maintenance of a 1,000-pound animal, it would seem clear that more than .05 pound of protein must be provided for the production of 1 pound of 4-per-cent milk. In the discussion of Haecker's standard, it will be remembered that the data give a basis for the assumption that a nutritive ratio of 1:6 is probably better than a wider nutritive ratio. An allowance of .05 pound of protein per pound of 4-per-cent milk, with .50 pound of protein for the maintenance of a 1,000-pound animal, will provide a ration much wider than 1:6.

Total energy requirements.— It is not possible to make direct comparisons in studying the data on this point. It is seen in Table 57 that, when allowed, the cows would average for 1 pound of 4.26-per-cent milk .338 therm energy. The standard provides .3 therm for 1 pound of 4-per-cent milk. If Tables 27a, 28a, and 29a are examined, it is found that in 1909–1910 the energy consumed by the cows was in excess of that provided by the standard. However, it will also be found that the milk averaged somewhat higher than 4 per cent fat. (Tables 30, 31, and 32.) In Table 44a it is shown that in 1910–1911 group A was fed a little higher than is provided by the standard. In Tables 45a and 46a it is seen that the cows were fed practically the same as called for by the standard. Group A produced milk averaging somewhat above 4 per cent fat, while groups B and C produced milk averaging lower than 4 per cent fat, in all periods.

In Table 57 it is seen that in the standard there is left for product 326.73 therms after the energy for maintenance is deducted. There was an average of 370.350 therms in the product as calculated by the method described on page 96. Therefore, for this amount and quality of product, the standard of .3 therm per pound of milk appears to be too low. In the light of the data submitted, the following seems to be indicated:

1. An allowance of at least .06 pound of protein for 1 pound of 4-per-cent milk will probably lead to a greater production of butter-fat than will .05 pound of protein if only .50 pound of protein is allowed daily for the maintenance of a 1,000-pound animal.

2. While .3 therm energy seems to be sufficient for 1 pound of 4-per-cent milk, more than that must be allowed for better grades of milk.

3. While the production values suggested by Armsby from his own and Kellner's work are probably nearer the true relative values of different feeding-stuffs, it does not seem to the writer that they represent enough difference in practice to recommend a change to this system at present, particularly in teaching a feeding standard for milk. Furthermore, the standard does not make any definite recommendations for varying the amount of nutriment for cows giving milk of different percentages of fat.

SUMMARY

The principal need for a feeding standard is for teaching purposes. Any standard can be used only as a guide and must be departed from at times to suit the individuality of different animals or to meet existing conditions such as would preclude the use of high-protein foods — for example, when the cost of such foods is too high.

In New York State, where the prices of such protein foods as gluten feed and distillers' dried grains are relatively no higher than many carbohydrate foods, the question of the cost of protein is not so important as in States farther west. Therefore, rations with nutritive ratios not wider than 1:6 are recommended in New York and in the Eastern States in general.

Good feeders who have had long experience make a practice of starting their animals on large rations soon after calving. They say that as long as they can keep their cows and heifers in good flesh, the production of butter-fat will hold up longer. Animals in good flesh and perhaps gaining slightly in weight will grow stronger calves and will be in better condition for the next lactation if in good flesh at the end of the present lactation. By consulting tables 36, 37, 38, 53, 54, and 55, it is seen that under the system of feeding practiced in 1909–1910 and 1910–1911 the cows averaged a slight gain in live weight from period to period, but not a gain that caused any animal to appear too fat for economical production at any time.

Therefore, from what has been learned from practical experience together with the results of the two years investigation summed up in the foregoing pages, the writer would suggest the standard for milk production given in Table 58. This standard is a modification of Haecker's standard, pages 77–78. The amounts of nutriment and protein for maintenance recommended by Haecker have been left the same. The protein for product has been increased 35 per cent. This amount has been added in order that a cow weighing 1,000 pounds and giving about 30 pounds of milk testing either 3, 4, or 5 per cent fat, shall have a ration with a nutritive ratio of approximately 1:6. The amount of total nutriment for product has been increased 10 per cent. The standard has been given in terms of digestible protein and total nutriment instead of in terms of digestible protein, digestible carbohydrates, and digestible fat, because with varying feeds in the ration it is impossible to construct rations from different sorts of feeds and meet these three different requirements of protein, carbohydrates, and fat, while it is perfectly feasible to meet a requirement of digestible protein and total digestible nutriment.

TABLE 58. SUGGESTED MODIFICATION OF HAECKER'S FEEDING STANDARD FOR MILK PRODUCTION

	Protein	Total nutriment
For maintenance, per 100 lbs.	.0700	.7925
For 1 pound milk, 2.5 per cent fat	.0527	.2574
For 1 pound milk, 2.6 per cent fat	.0535	.2629
For 1 pound milk, 2.7 per cent fat	.0543	.2685
For 1 pound milk, 2.8 per cent fat	.0551	.2743
For 1 pound milk, 2.9 per cent fat	.0559	.2812
For 1 pound milk, 3.0 per cent fat	.0567	.2870
For 1 pound milk, 3.1 per cent fat	.0575	.2928
For 1 pound milk, 3.2 per cent fat	.0583	.2987
For 1 pound milk, 3.3 per cent fat	.0591	.3055
For 1 pound milk, 3.4 per cent fat	.0599	.3115
For 1 pound milk, 3.5 per cent fat	.0608	.3185
For 1 pound milk, 3.6 per cent fat	.0616	.3243
For 1 pound milk, 3.7 per cent fat	.0624	.3312
For 1 pound milk, 3.8 per cent fat	.0632	.3369
For 1 pound milk, 3.9 per cent fat	.0640	.3428
For 1 pound milk, 4.0 per cent fat	.0648	.3497
For 1 pound milk, 4.1 per cent fat	.0656	.3555
For 1 pound milk, 4.2 per cent fat	.0664	.3612
For 1 pound milk, 4.3 per cent fat	.0672	.3671
For 1 pound milk, 4.4 per cent fat	.0680	.3729
For 1 pound milk, 4.5 per cent fat	.0689	.3787
For 1 pound milk, 4.6 per cent fat	.0697	.3842
For 1 pound milk, 4.7 per cent fat	.0705	.3900
For 1 pound milk, 4.8 per cent fat	.0713	.3945
For 1 pound milk, 4.9 per cent fat	.0721	.3992
For 1 pound milk, 5.0 per cent fat	.0729	.4048
For 1 pound milk, 5.1 per cent fat	.0737	.4105
For 1 pound milk, 5.2 per cent fat	.0745	.4150
For 1 pound milk, 5.3 per cent fat	.0753	.4209
For 1 pound milk, 5.4 per cent fat	.0761	.4253
For 1 pound milk, 5.5 per cent fat	.0770	.4311
For 1 pound milk, 5.6 per cent fat	.0778	.4355
For 1 pound milk, 5.7 per cent fat	.0786	.4413
For 1 pound milk, 5.8 per cent fat	.0794	.4469
For 1 pound milk, 5.9 per cent fat	.0802	.4517
For 1 pound milk, 6.0 per cent fat	.0810	.4572
For 1 pound milk, 6.1 per cent fat	.0818	.4619
For 1 pound milk, 6.2 per cent fat	.0826	.4676
For 1 pound milk, 6.3 per cent fat	.0834	.4721
For 1 pound milk, 6.4 per cent fat	.0842	.4791
For 1 pound milk, 6.5 per cent fat	.0851	.4835
For 1 pound milk, 6.6 per cent fat	.0859	.4882
For 1 pound milk, 6.7 per cent fat	.0867	.4926
For 1 pound milk, 6.8 per cent fat	.0875	.4984
For 1 pound milk, 6.9 per cent fat	.0883	.5040
For 1 pound milk, 7.0 per cent fat	.0891	.5075

The writer would further recommend that a cow be fed according to this standard when her condition has become normal after calving. Then the grain ration should be increased 1 pound per day and the cow watched

closely for one week, a careful record being kept of her milk and fat production. If at the end of the week the cow's health is good and she has increased in fat or milk production sufficiently to pay for the increase in feed, another pound per day should be added to the grain ration as before; and so on until the cow is getting all the feed that she will eat up clean, if she shows in her product that she will pay for the increase each time. In case the cows are not valuable and in case the amount of money received for product is small, this standard as recommended may be too high to be economical; but it is doubtful whether any plan of dairy husbandry that would not permit feeding cows as high as recommended would be a profitable business. In pure-bred herds, particularly, yearly records of which are of much importance, it is thought that the above system of feeding can be used to the greatest advantage.

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