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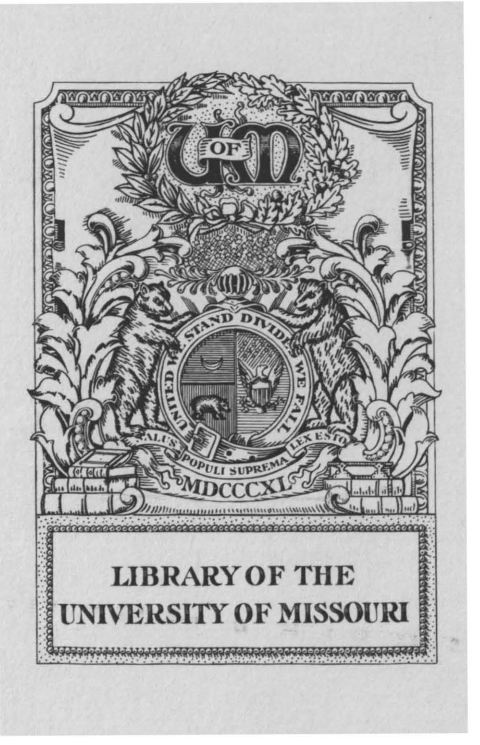

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NUTRIENTS REQUIRED FOR MILK PRODUCTION.

Thesis submitted by

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in partial fulfillment of the requirements for
the degree of

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This work was done under the direction of Professor C. H. Eckles of the Dairy Department. The chemical analyses of the milk were made in the laboratory which is maintained jointly by the Missouri Experiment Station and the Dairy Division of the U. S. Department of Agriculture; Dr. Matthew Steel has charge of this laboratory. The remainder of the chemical analyses were made in the laboratories of the Agricultural Chemistry Department of which Professor P. F. Trowbridge has charge.

CONTENTS.

Some time before this investigation began a paper was prepared containing a discussion of the subject and the plan of investigation. This paper is reproduced here.

NUTRIENTS REQUIRED FOR MILK PRODUCTION.

There are three essentials to high yields of milk---proper kind of cows, proper care and management and proper feeding. This investigation will deal only with the last. No matter what the inherent dairy qualities of the cow may be nor how well she is cared for she may be rendered profitless by feeding too much or too little or by giving the wrong kind of feed. The proper feeding of cows is of great economic importance to dairymen everywhere. Feeding standards have been in use over 40 years and while modifications and improvements have been made in them none are as yet perfect. Investigators have realized the importance of proper feeding and have done considerable work at the various stations. It is quite surprising, however, after reviewing the literature on feeding to find out how very little we know of this subject. One trouble has been that all of the disturbing factors have not been eliminated from the investigations, and with comparatively few it is possible to attribute the results with any degree of definiteness to any one certain thing. Some work in the feeding of dairy cows has been done at this Station and accurate records have been kept; it is with the hope of furthering our knowledge concerning the nutrients required for milk production that this investigation is taken up. In addition to the data which is available at present from five Jersey cows it is planned to secure more from cows yielding normally a poorer grade of milk in order that information may be obtained on the nutrients required for milk varying in quality. No

attempt will be made to determine the amount of protein required.

Bases for judging the nutritive value of feeds and the nutrient requirements of cattle. The first attempt to assign to different feeding-stuffs their true value for feeding purposes is shown in the so-called hay equivalents or hay values which were quite commonly advocated in Europe prior to the year 1860. Good meadow hay was taken as the unit and all other feeds given relative values. These values were based upon the results of practical experiments. This method of judging the nutritive values of feeds did not prove entirely satisfactory, probably because of the limited amount of experimental work upon which it was based and because the unit for comparison, meadow hay, was too variable. A modification of this system is being used at present in some of the north European countries. Each foodstuff is given a value of a certain number of units, which represents approximately the relative nutritive values as determined by the carefully conducted feeding experiments of Fjord, a Danish investigator. These "food units" are very convenient to use when buying food or when estimating the economy of production for herds or individual cows, dealing as they do entirely with the nutritive values, not the market values. (1) Grouven in 1859 is said to be the first man to suggest compounding rations with reference to the actual amounts of the different nutrients they contain--crude protein, carbohydrates, and ether extract. Henneberg and Stohmann at Weende later showed that these constituents were not digested in the same proportions for all feeds, so it was suggested that only the digestible nutrients be used in the calculation of rations. As a result

(1 Exp. Station Record 4 - Translation from J. Kuhn.)

of Henneberg and Stohmann's work Wolff, who was the first director of the first experiment station in Germany, constructed feeding standards based on the amounts of digestible nutrients contained in feeding stuffs. This method of determining the nutritive values of feeds is the one in most common use at the present time, although somewhat inaccurate as has been shown by Armsby in experiments with the calorimeter. Digestible nutrients in themselves show merely the amounts of the feed or ration which are absorbed thru the walls of the alimentary tract. They make no allowance for the energy required for digestion and assimilation. Consequently those feeds which are difficult to digest, ordinarily classed as roughness, when compared with concentrates show a greater efficiency than they really possess. That this is the case has been demonstrated by Armsby in his work with a respiration calorimeter and also by Kellner. (2) Armsby has found that timothy hay with 57% as much digestible material as corn meal was worth for flesh or fat production only 37% as much as the corn meal. This evidence alone is sufficient to condemn the prevailing system of estimating the nutritive value of a feed or ration.

The question then arises, how may this system be modified so as to accurately represent the true feeding value of the different foodstuffs? To determine this point Kellner planned and executed some extensive investigations.(3) He first took some of the pure nutrients such as protein, carbohydrates and fat and found out by actually feeding them the nutritive value of each. These values he expressed in the form of energy. The assumption thruout is that the digested energy value of

(2. Bul. 84 Pa.)
(3. Bul. 71 Pa.)

the nutrients minus the energy required to prepare the food for use represents the true nutritive value, or production value. He found with fattening cattle that the production values of the different nutrients per 100 pounds were as follows:

Digestible proteids	101.6	Therms (1 Therm =1000 Cal)
" starch or crude fibre	107.1	"
" cane sugar	81.2	"
" fat		
in coarse fodders and roots	204.1	Therms
in grains and by products	227.3	"
in feeds with over 5% fat	258.5	"

The next step was to apply the values so obtained to the digestible nutrients of the different feeds and compare the computed value of each feed with the real value as determined by actual feeding trials. It was found possible to estimate fairly accurately the production value of the concentrated feeds by means of these factors. However, with those feeds containing a higher proportion of fiber this method was not reliable on account of the fact that a larger amount of energy was required for digestion. It was found that the energy expended in digestion was directly proportional to the amount of crude fiber present, so by deducting 61.7 Therms for each 100 pounds crude fiber the computed value was brought very close to the real value. This method consists then of multiplying the digestible nutrients by the calorific value of each nutrient and then making a deduction for the crude fiber.

(4) Armsby has formulated from his own and Kellner's work a system of expressing the nutrients of feeding-stuffs which may in time

4. Farmers' Bul. 346

entirely supplant the system now in vogue. The protein is expressed as albuminoids and the energy value as a single figure. The assumption is that the amides, which with the albuminoids go to make up the total protein, are not so valuable as the albuminoids for feeding purposes and that all the food may be classified under two heads--that which goes toward the formation of nitrogenous substances and that used for heat, fat and energy. The amount of albuminoids is the measure for the one purpose and the energy value for the other. Two figures, therefore, are sufficient to show the nutritive value of a food.

The food of the dairy cow may be used in four ways:

1. For maintenance.
2. For milk production.
3. For development of the foetus.
4. For growth or gain in weight.

Each of these will be discussed separately.

REQUIREMENTS FOR MAINTENANCE:

Since it is impossible to determine the nutrients required for milk without first knowing those required for maintenance, it naturally follows that an accurate knowledge of the food used for maintenance is of as much importance as a knowledge of the total food used. These questions suggest themselves. Can we calculate accurately the maintenance requirements or will it be necessary to carry on separate maintenance experiments? If calculations will answer our purposes, how are they to be made; if experiments are required, what precautions must be observed in order to secure reliable results? The following discussion will have for its object the answering of these questions.

The amount of food to be used for maintenance will depend upon several factors: The extent of the radiating surface of the animal, the outside temperature, the disposition and weight of the animal.

The main function of the maintenance ration is to supply heat to replace the constant loss that takes place. (5) Armsby says, "Henneberg has long ago shown that in round numbers, over 90% of this heat is removed by radiation and evaporation. Consequently we should expect the demands of the organism for heat (i. e. for maintenance) to be proportional to its surface (including lung surface)

rather than to its weight, and the more recent researches of Rubner have confirmed this theoretical conclusion." He also says that in the absence of surface measurements of the animals experimented on it may be assumed that they are geometrically "similar figures" and therefore that their surfaces are proportional to the two-thirds powers of their live weights.

Since the temperature of warm-blooded animals is fairly constant it is evident that the metabolism of the body must change with the different outside temperatures in order to keep the body temperature uniform. More heat must be produced in cold weather than in warmer weather, consequently more food is required other conditions being identical. It seems, also, that very warm weather causes an increase in metabolism. In other words energy is required to get rid of an excess of heat as well as to produce a sufficiency. We find, therefore, that an animal's maintenance requirements are highest in the coldest part of winter and the hottest part of summer. Humidity of the air increases the conductivity of the animal's coat and in this way brings about the same effect as a colder temperature, that is, when the outside temperature is below that at which the minimum metabolism of the animal takes place. When the outside temperature is above this point humidity exerts the same influence as a still higher temperature on account of the lessened power of the air to evaporate water from the body and so reduce temperature. Wind increases heat radiation and water evaporation, consequently, it tends to reduce the heat of the body no matter what the outside temperature. Wind, therefore, during the hottest days of summer may lower the maintenance requirement and during the colder days of the other seasons increase the maintenance requirements.

(2) Armsby has found with his calorimeter that a steer when standing produces from 30 to 50% more heat than when lying down. It is thought that the disposition of an animal may affect the maintenance requirement in this way. An animal with a nervous temperament will move around more than an animal with a sluggish disposition even when both are at rest in a stall. Perhaps also the nervous animal will not lie down so much as the sluggish one although this has not been demonstrated experimentally.

The food required for maintenance will vary also with the weight of the animal independent of the surface exposed, although generally but not always the heavier the animal the greater the radiating surface. Two cows might expose an equal amount of surface but on account of a difference in conformation or condition or both one might weigh considerably more than the other. If conditions are otherwise identical the heavier cow will require more food for maintenance. Every muscular activity such as standing, walking, etc., calls for more energy due to the greater weight which must be moved or supported.

It must be evident from the foregoing discussion that since the amount of food required for maintenance depends upon several factors, some of which cannot be measured nor accurately estimated, the only way to obtain thoroughly reliable figures is to carry on a separate maintenance experiment. In ordinary feeding practices the food of maintenance may be estimated with a sufficient degree of accuracy by assuming that the requirement is proportional to the two-thirds powers of the live weights; in this investigation, however, an attempt will be made to eliminate every source of error and to make the results as accurate as is possible.

(2.Bul. 84 Pa.)

An examination of some of the maintenance experiments which have been conducted will serve to emphasize the impossibility of calculating accurately the maintenance requirements of a cow from her live weight. (6) At this Station four dry, farrow cows were fed a ration similar in composition and in such amounts as to keep the body weights uniform. The length of time the cows were fed varied from 120 to 180 days. Following is a table showing the approximate relation which exists between the body weight and the food of maintenance as found in these experiments.

Number of cow	Weight of cow	Nutrients daily Therms
4	792	5.79
63	888	4.91
27	891	5.53
62	914	4.79

It will be seen from this that the maintenance requirements do not vary directly with the weight in all cases. The heaviest cow has the lowest requirement; the lightest cow has the greatest. The conclusion to be drawn from this table is that the weight of a cow in itself is not an accurate indication of the amount of nutriment required for maintenance.

(7) Haecker has attempted to determine the maintenance requirements of some cows, but his results will not be considered here for three reasons: The weights of the cows were not controlled as closely as they should have been; the rations were not uniform for all; no records are available to show what quantities of feeds were fed.

(6. Research Bul. 2 Mo.)

7. Bul. 79 Minn.

Following are some of the points which should be observed in carrying on a maintenance experiment; It should extend over a period of at least six months in order to represent a fair average for the year. A cow requires the most food in the hottest part of summer and the coldest part of winter. A period of six months, then, will include a portion of the year when the requirements are the greatest and also a portion when they are the lowest. One year would be still better than six months. The cows should be at the same weight when on maintenance as when milking. The principal difficulty encountered in an investigation of this kind is the great fluctuation in live weight from day to day even when every precaution is exercised to have conditions entirely uniform. This is undoubtedly due in large part to a change in the contents of the alimentary tract although part may be due to a variation in the water content of the blood and solid tissues. It has been observed that when a heavy feed like silage is added to the ration the live weight decreases. It is important therefore to change the ration as little as possible and to have it similar in bulk and weight at the close of the experiment to what it was in the beginning. On account of the difficulty in determining the true weight of an animal at any given time it becomes necessary to carry on maintenance trials for a considerable period of time.

REQUIREMENTS FOR MILK:

The second division of this subject has to do with the nutrients required for milk production. The amounts of nutrients required will depend upon the quantity of milk yielded; but, as a matter of convenience, it has been thought best to discuss this subject under the two heads--total nutrient requirements and protein requirements.

The first feeding standard for milk cows was published in 1864 by Wolff. This standard was deduced from the results of a large number of experiments at different times by different observers. It calls for 24.0 lbs. dry matter and digestible nutrients to the extent of 2.5 lbs. protein, 12.50 lbs. carbohydrates, and .4 lbs. ether extract for a cow weighing 1000 pounds. While this seems to meet the requirements of a good average dairy cow fairly well it is criticised for not making any allowance for a very heavy producer or a light producer. (1) Prof. Julius Kuhn of the Halle Experiment Station in 1861 was the first scientist of prominence to question the advisability of feeding all cows the same irrespective of production or of kind or quality of feed. Later he proposed a standard which is somewhat more flexible than Wolff's and has the nutrients arranged a little differently. He objected to the classifying of all nitrogen compounds under the head of protein and considering them as having the same nutritive value. His standard follows:

Dry Matter	Digestible albuminoids	Digestible carbohydrates and amides
20 to 23.5 lbs.	1.5 to 2.4 lbs.	12 to 14 lbs.

While Kuhn apparently had good reasons for dividing the protein

(1. Exp. Sta., Rec. 4--Translation from J. Kuhn.)

in this way his classification did not prove popular.

(8) In 1892-3 Woll of the Wisconsin Station secured reports from 128 dairymen in different parts of the United States and Canada and from these together with reports from two or three experiment stations he formulated the so-called American ration. This calls for dry matter 24.5 lbs. and digestible nutrients to the extent of 2.15 lbs. protein, 13.27 lbs. carbohydrates and .74 lbs. other extract and is o open to the same objection as the Wolff standard. Regarding this ration an (9) editorial in the Experiment Station Record Vol. 6 has this to say in part: "A feeding standard is an expression of the amount and proportion of the several nutrients best adapted to the purpose for which the animal is kept, as determined by continued and systematic feeding experiments conducted on scientific principles. Its value depends upon the extent and accuracy of the observations on which it is based. A feeding standard cannot be established by a study of feeding practice. If practice were sufficiently perfect the necessity for experiments would be at an end."

(10) Woods and Phelps studied the rations of 16 Connecticut dairy herds in 1893-94. They do not consider their findings as final; but pending further investigations they tentatively suggest a ration composed of 25 lbs. organic matter 2.5 lbs. of which are to be digestible protein with enough fat and carbohydrates to bring the fuel value up to 31,000 Calories. This ration has the same objections as Wolff's and Woll's in not being adaptable to a cow yielding either a very large or small quantity of milk. It seems to the writer,

(8. Bul. 38 Wis.)
(9. Page 538)
(10. Bul. 13 Conn.)

however, that they have made a step in the right direction in doing away with separate requirements for carbohydrates and fat and in dealing with the energy value of the nutrients.

In 1897 Dr. C. Lehmann of the Berlin Agricultural College modified the Wolff standard to meet the criticism of Kuhn and formulated what is known as the Wolff-Lehmann standard. In this the kinds and amounts of nutrients vary with the quantity of milk produced.

	Dry Matter	Digestible Nutrients Protein	Carbohydrates	Ether extract
11 lbs. milk require	25.0	1.6	10.0	.3
16½ " " "	27.0	2.0	11.0	.4
22 " " "	29.0	2.5	13.0	.5
27½ " " "	32.0	3.3	13.0	.8

This standard is very likely an improvement on the original still as Haecker has pointed out (7) it is not clear why the nutrients should not increase in the same proportion as the milk yield. For example the same amount of carbohydrates is prescribed for a cow giving 27½ pounds milk as to the one giving 22 pounds milk. In the last column, why should not the figures run 3, 4, 5, 6 instead of 3, 4, 5, 8?

(11) (7) During the winter of 1894-5 Haecker fed 12 cows a fixed ration for 154 days during which time a full flow of milk and yield of butter fat is said to have been secured. From this record he attempts to determine whether or not the Wolff-Lehmann standard calls for an excess of nutrients. The gain in weight for this period was about 29 pounds per cow or about .3 pounds per head a day. 4 of the 12

(7. Bul. 79 Minn.)

(11. Bul. 67 Minn.)

were 2 or 3 year old heifers. All the cows were bred during the experiment the times varying from 6 weeks to 4 months before its conclusion, so probably all or nearly all the cows were carrying calves. The cows were fed an average of about 12 pounds concentrates each per day along with all the timothy hay 16 parts and roots 10 parts or timothy hay 18 parts, and silage 14 parts that they would take. The roughage consumed amounted to about 24 pounds per head daily. The daily yield of milk was 26 pounds testing 4.1 % fat. The average weight of the cows was 956 lbs. and the digestible nutrients consumed daily 2.00lbs. protein, 12.46 pounds carbonydrates and .67 pounds fat or calculated on the basis of 1000 lbs. live weight.

2.03 protein 12.77 carbohydrates .565 fat.

The Wolff-Lehmann standard under similar conditions prescribes

3.08 protein 13.00 carbohydrates .472 fat

It will be seen that Haecker's cows used a smaller amount of these nutrients all the way through than is provided for by the standard, the greatest difference being in the protein. Under ordinary dairy conditions in this country he is apparently justified in his assumption that the Wolff-Lehmann standard prescribes an excess of nutrients. When we take into consideration that Haecker's cows were heavily fed on concentrates and the fact that the digestible nutrients contained therein are worth considerably more than those from roughage as has been pointed out before it is very doubtful whether he has proved the Wolff-Lehmann figures to be too high as regards total nutrients under all conditions of feeding.

In this investigation we shall attempt to determine the nutrients required for milk production alone. Haecker's figures have no accurate

bearing on this point for two reasons: first his cows were using a part of their food for the development of the foetuses, second they were gaining in weight. With our present knowledge we are unable to make the proper correction for these two factors.

(4) In Farmers' Bulletin 346 Armsby describes a system for computing the rations of dairy cows by the use of energy values. He tentatively suggests in the absence of definite experimental data that the total energy necessary for the production of 1 lb. of average milk -- 4 % fat and 13 % solids-- be placed at .3 therm of production value of the food. Included in this ration there should be digestible amide-free protein to the extent of .05 lb. for each pound of milk. Besides this there are figures given in the same way for the food of maintenance, which vary with the weight of the animal but not proportionally so. It is our opinion that these are the proper terms in which to express the nutrients required for dairy cows. The greatest objections are, first that insufficient high-grade work has been done to permit of an accurate estimate of the nutrients required, second there is no definite allowance made for variations in the quality of the milk.

(7) Haecker raises the question as to whether the Lehmann factors are applicable to any and all grades or qualities of milk yielded, and to settle this point he studied the records of six cows fed for 154 days as has been mentioned before. The Wolff-Lehmann feeding factors reduced to terms of carbohydrates for the production of one pound of milk are as follows:

(4. Farmers' Bul. 346.)
(7. Bul. 79 Minn.)

	Nutrients to 1 lb milk Deducting .7-8.-.1 for maintenance (Wolff's figures)	Nutrients to 1 lb milk. Deducting .7-7.-.1 for maintenance Haecker's figures
11 lbs. milk	.301	.392
16½ " "	.298	.359
22 " "	.341	.386
27½ " "	.330	.366

The figures which Haecker secures from cows yielding milk varying in composition reduced to the same basis are:

	Per cent fat	Nutrients to lb. milk. Deducting .7-7.-1. for maintenance
Countess	2.5	.223
Lou	3.7	.271
Topsy	3.7	.273
Olive	4.0	.300
Sweet Briar	5.0	.332
Houston	5.5	.360

It will be seen from this that the Wolff-Lehmann standard prescribes more nutrients than Haecker fed to his cows with good results. When cows are heavily fed on grain as Haecker's cows were, it seems that only those producing very rich milk require as much total nutriment per pound of milk as called for by the Wolff-Lehmann standard.

(12) Woll of the Wisconsin Station in order to throw some light on this question compiled data from several years records with the Station herd. It seems that the cows as in Haecker's work had not been fed with the express purpose of determining the effect of quality of milk upon the nutrient requirements, so the records were merely such as

(12. Bul. 116 Wis.)

are kept at any other experiment station. No mention is made as to whether the cows were mature or not, whether they were pregnant, or whether they gained or lost in body weight. He found that each increase of .1 % fat in the milk called for an increase per pound of milk of .0075 pounds protein and .0063 pounds carbohydrates and fat, the fat being multiplied by 2.25. Haecker's figures reduced to the same basis are .0007 lbs. protein and .0038 lb. carbohydrates and fat. These figures do not mean much to us because there are too many sources of error. We have no assurance that the cows were fed in the best possible way. The discrepancy also between Woll's and Haecker's results serves to emphasize the need for further work along this line.

Protein Requirements---Since it is not the purpose of this investigation to determine the amount of protein best adapted to the production of milk the matter of protein requirements will be discussed here merely to show first, that moderate variations in the protein content of a ration have no very marked influence upon milk production, providing the allowance is above the minimum requirement of the animal; second, that the ration which we propose using contains ample protein for all purposes for which it is intended.

The Wolff-Lehmann standard prescribes 1.6 to 3.3 pounds of digestible protein for a 1000 pound cow yielding 11 to 27½ pounds of milk per day. It is with respect to the protein requirement especially that this standard calls for an excess of nutrients. (7) Haecker has demonstrated by feeding twelve cows 154 days on two-thirds the amount of protein prescribed by this standard with very good results, that under the conditions which obtain in the Northwest, at least, if not in the

(7. Bul. 79 Minn.)

whole country, this standard calls for more protein than is actually needed. Some of the work done at the various experiment stations along the line of protein requirements will be mentioned only briefly.

(13) Carlyle and Woll in 1903 write as follows: "According to our present knowledge, we bel ieve that only cows of a large capacity will give economical returns for a supply of more than 2.0 pounds of digestible protein per day under the conditions present in the Northwest."

(14) Humphrey and Woll in a later report suggest that the digestible protein may profitably range from 2.0 to 2.4 lbs. per day.

(15) A Danish investigator concludes that the minimum protein content of rations for milk cows will range between 1.70 and 2.06 pounds digestible protein per day.

(16) At the Virginia Station four groups of four cows each were fed 140 days. The authors conclude that rations supply less digestible protein and less dry matter than called for by the Lehmann standard may be fed to dairy cows, while maintaining satisfactory yields of milk and butter and keeping the cows in good health.

(17) Lindsey of Mass. fed 1½, 2, and 2½ pounds digestible protein to three lots of cows, the total amount of digestible nutrients remaining the same in each case. He is of the opinion that animals weighing 800 to 1000 lbs. and producing 10 to 15 quarts per day should receive about 2.5 lbs. digestible protein and 15 to 16 pounds total nutrients daily.

(18) At Cornell Station in 1895-96 Anderson fed three lots of three cows for 22 weeks each the same amounts of digestible nutrients

13. Bul. 102 Wis.
14. Wis. Sta. Rpt. 1904
15. Exp. Sta. Rec.
16. Bul. 169 Va.
17. Mass. Sta. Rpt. 1901-2
18. Bul. 173 Cornell.

but with nutritive ratios of 1 : 4.5, 1 : 6.0, and 1 :9.0. This was repeated the next year with nutritive ratios of 1:4. 3, 1:5.7 and 1:9.3. The narrow ration contained 2.99 pounds digestible protein, the medium 2.31 pounds and the wide 1.58. The first year the narrow ration gave the highest returns per unit of dry matter; the second year it gave the lowest. If any conclusions are to be drawn they would be to the effect that the nutritive ratio in this case had little or nothing to do with the economy of production per unit of dry matter consumed.

(19) As a result of three feeding experiments with cows from the years 1896 to 1899 Hayward of Pa. concludes: "The nutritive ratio between the limite of 1:3.4 and 1:11.3 had no effect upon the quantity of quality of milk production. 1.3 pounds of computed digestible protein was sufficient for a 1000 pound cow in full milk, the other conditions necessary to her welfare being met. Within certain limits, the quantity, digestibility and palatability of the food and its effect upon the animal's general system was of more importance than the relative amount of digestible protein and carbohydrates the ration contained."

(20) Wheeler of the Geneva Station studied the immediate effect of milk production of changes in the ration using the data from nearly 1000 records of feeding trials with milch cows at the New York Experiment Station. He found that moderate changes in the nutritive ratio within the ordinary limits had considerably less effect on the milk flow than did the changes in the amount of total digestible

19. Pa. Sta. Rpt. 1901-2

20. Bul. 210 Geneva.

organic matter, but that, in general, a narrowing of the ration had a favorable effect on milk production, while a widening of the ratio tended toward the reverse.

(7) Haecker fed 3 lots of 6 cows each for eight consecutive weeks on rations containing different amount of protein. One lot received 2.04 lbs. protein daily, another 1.68 lbs. and the other 1.32 lbs. The carbohydrates and ether extract were about the same for each lot. After deducting for maintenance it was found that one lot produced fat and total solids as economically as the other.

If any conclusion is to be drawn from this motley aggregation of experimental results, the one most justified is that moderate variations in the protein content of a ration have not been proved to exert any marked influence upon the production of milk.

The ration which we propose using in this investigation consists of 1 part of a grain mixture (corn meal 4 parts, bran 2 parts, oilmeal 1 part) 1 part alfalfa hay and 4 parts corn silage. In general it contains less protein than is prescribed by the Wolff-Lehmann standard, more than is called for by Haecker's standard, and about the same as is suggested by Armsby. The following table shows how closely these feeds, mixed in the proportions mentioned, will meet the requirements of both a heavy and light producer computed according to Armsby. The weight of the cow is taken as 1250 pounds, the per cent of fat as 4, and the daily yield of milk as 40 pounds in the first instance and 15 pounds in the second.

7. Bul. 79 Minn.

	Digestible amide-free protein	Therms
Required for 40 lbs. milk	2.6	19.00
Supplied in 11 pounds grain, 11 lbs. hay and 44 lbs. silage	2.5	19.35
Required for 15 lbs. milk	1.35	11.50
Supplied in 6.5 lbs. grain, 6.5 lbs. hay, and 26 lbs. silage	1.47	11.44

With our present knowledge of the protein requirements for milk production there can be no serious objection to the above ration on this score.

REQUIREMENT FOR FOETUS:--

As to the food cost of the development of the foetus there is no data on record which would permit us to make even a rough approximation of nutriment required. We do not even know the chemical composition of a calf at birth so we cannot figure with any degree of accuracy how much milk would be required to contain the same amount of solids as are found in the new-born calf. Jordan in his book "Principles of Feeding", gives the composition of a fat calf as

Water	Ash	Protein	Fat
64.6	4.8	16.5	14.1

The composition of calves of four breeds figured on this basis is in pounds:

Breed	Birth Weight	Water	Ash	Protein	Fat
Jersey	53	34.24	2.54	8.74	7.47
Holstein	90	58.14	4.32	14.85	12.69
Shorthorn	76	49.10	3.65	12.54	10.71
Ayrshire	64	41.34	3.07	10.56	9.02

The equivalent in milk on basis of total solids is:

Breed	Solids in calf lbs.	Solids in milk per cent	Milk equivalent lbs.
Jersey	18.75	14.50	129.
Holstein	31.86	12.00	265.
Shorthorn	26.90	13.00	207.
Ayrshire	22.65	12.50	181.

It will be seen from this table that the amount of milk required to contain the same amount of solids as are contained in the calf at birth can be yielded by a good average dairy cow of any of the breeds mentioned in six or eight days. It is safe to say, however, that

the production of a pound of solids in the foetus takes a great deal more food than the production of a pound of solids in the milk. Besides the calf, the amniotic fluid and the foetal membranes must be provided for.

REQUIREMENTS FOR GROWTH:--

It is a well known fact that a heifer requires more nutriment for product yielded than does a mature cow. The reason for this is not merely becasue of the heifer's lack of dairy capacity but also because a part of the food consumed must be used for the growth which takes place. The extent of growth will depend upon how near the heifer has reached maturity. Ordinarily a heifer 18 months old at time of parturition will grow more than one 36 months old; also a heifer that has been stinted with feed will grow more than a well-fed heifer of the same age because the more liberal the feeding the quicker the animal reaches maturity. The amount of nutriment then to be supplied in addition to that used for maintenance, milk production and development of the foetus will depend upon the age and previous handling of the heifer. Such being the case it is very obvious that no certain amount of feed will answer the purposes for all heifers. Any one standard for the feeding of all heifers must at best be nothing but a rough approximation.

From the much discussed feeding record of 1894-95 carried on for 154 days Haecker selected the records of 5 animals--2 two year olds, 2 three year olds, and 1 five year old and proceeded to calculate the amount of nutriment required. All of the heifers freshened soon before or soon after this 154 days began so the record for this time represents the earlier part of the lactation periods. Now it has been learned that heifers do most of their growing in the latter part of their lactation periods. It naturally follows, therefore, that a standard of feeding on the basis of milk produced applicable to a heifer when fresh does not answer the purposes when

she is nearly dry. A table with the ages of the heifers and nutrients available for each pound of milk is taken from Minn. Bulletin 79:

	Age	Per cent fat	Protein	Carbo-hydrates	Ether extract
Lydia	5	3.5	.052	.25	.018
Ouidee	3	3.5	.049	.24	.016
Tricksey	2	5.1	.068	.33	.023
Beckley	3	5.6	.079	.37	.027
Reddy	2	5.2	.079	.38	.029

When a cow has reached the age of five years she is ordinarily considered as mature and why she is included in this group seems to be explainable only thru the fact that there are no 4 year olds. In order to get at the rate of increase for each. .1 per cent increase in butterfat the nutrients for the two heifers yielding 3.5 per cent milk are compared with the other three yielding milk testing more than 5.0 per cent. It will be noticed also that two animals with an average of four years are compared with three heifers between two and three years of age. Even if the quality of milk were the same for all of these we should expect the older heifers to require less nutriment per pound of product than do the younger. Formulating a standard from this data is open to the objection that the figures can be juggled so as to secure almost any rate of increase for quality. They show the futility of attempting to lay down any set of feeding rules for all heifers expecially from such a meager amount of data. Besides we have no evidence that all the heifers were properly nourished; the chances are that they were not. It appears to the

writer that for the present at least the feeder must rely upon his judgment as to the proper amount to feed a heifer.

It was mentioned at the beginning of this paper that a mature cow at certain times normally uses a part of her food for gain in weight. Since the body weight of a cow is not constant it must necessarily follow that at certain times she puts on flesh. This matter has been referred to several times throughout this paper and it will be discussed only briefly here. The amount of food used for flesh or fat production depends primarily on how much food the animal takes in excess of that needed for maintenance, milk and foetus. Immediately after parturition a cow produces milk in such quantities that it is impossible for her to take enough food to prevent a loss in weight; after a few weeks an equilibrium is attained between the cow's capacity for food and the food needed for maintenance and production, consequently she ceases to lose in weight; later her milk flow milk flow diminishes and she is enabled to take, if permitted, enough food for a gain in weight as well as for maintenance and milk. If carrying a foetus at the same time her capacity is sufficient to provide for the foetus as well as gain in weight and for the other purposes. By taking away some of her feed, however, she stops gaining in weight herself but still contributes to the growth of the foetus. This is exemplified by the fact that thin cows give birth to calves of about average weight for the breed. It is evident therefore that it is impossible to prevent a loss of weight immediately after calving but that it is possible to prevent a gain in weight after equilibrium is restored by restricting the supply of food.

In feeding experiments to determine the amounts of nutrients used for milk it would be advisable to eliminate one source of error by keeping the body weights constant.

PLAN OF EXPERIMENT:--

Some work has been done at this Station (6) upon the amount of nutrients required for milk production with Jersey cows. In order that the results obtained with these cows may be comparable with work to be done in the future it is planned to feed and handle the cows in the same way as has been done with the Jerseys. If possible two Holsteins and two cows of either the Ayrshire or Shorthorn breed will be selected for this work. It is thought that the data obtained from these together with that already available from five Jerseys will furnish sufficient material so that we may secure reliable information as to the amount of nutriment necessary for the production of milk. All cows selected are to be of mature age, healthy and fresh. They are to be kept farrow throughout the experiment. No effort will be made to select either good, medium, or inferior producers for this work as previous (6) investigations at this Station have shown that one cow uses food available for milk as economically as another.

The cows are all to be fed the same kind of ration, that is, it is to be composed of the same kind and quality of feeds mixed in exactly the same proportions. The concentrated part of the ration is to consist of a mixture of cornmeal 4 parts, bran 2 parts, and oilmeal 1 part. The roughage will be alfalfa hay and corn silage, and the ratio between the concentrates, hay and silage will be about 1:1:4. During the summer green feed will take the place of silage. All feeds will be analyzed. Enough of the hay and grain which has been analyzed will be reserved to run the cows for some time so as to make unnecessary the frequent sampling and analyzing of the feeds. The cows are to be fed

such amounts as are required to support the milk flow without gain or loss in body weight. Any heavy milkers which are selected will undoubtedly lose weight immediately after calving but this loss is to be restored before the end of the experiment. The experiment is to last for a year, and the aim shall be to have the cows at the same weight at the close as at the beginning.

Accurate records are to be kept of all feed consumed and any which may be refused. All cows are to be handled, fed and milked in exactly the same way and by the same man if possible. Care will be exercised that the cows get all the feed meant for them but no more. Careful notes will be taken on the health of the cows, their feeding characteristics and any condition or happenings out of the ordinary.

Method of stating results---The results of this work will be expressed in digestible, amide-free protein and energy values according to the method given by Armsby in Farmers' Bulletin No. 346. From the chemical analyses of the feeds and the coefficients of digestion of the nutrients contained therein as determined by the digestion trial, the energy values will be calculated as described on page 4.

Sampling and analyzing the milk---The milk is to be weighed at the barn immediately after being drawn and the weight recorded upon the regular dairy milk sheet just as is done with the other cows. The milker shall then mix the milk with a dipper and fill at once a pint milk jar about two-thirds full, place on it a paper cap to prevent evaporation or spilling, and mark the number of pounds of milk yielded weighed to tenths on the cap along with the number of the cow. The milk is to be then taken to the Dairy

Laboratory where a ten-day composite sample is to be prepared by taking an aliquot part from each milking and preserving it with formaldehyde. This composite is to be analyzed for fat, nitrogen, sugar and ash.

Digestion experiment---In order to make our records as complete as possible it is planned to carry on a digestion experiment for ten days at some time when all the cows are giving a good flow of milk. About two weeks previous to the time of this experiment the cows are to be kept inside during the day and are to be watered in the stable so that conditions will have time to become entirely normal. It is also important that the cows shall have been fed upon their regular milking ration for sometime before this trial.

Maintenance experiment---Cows differ markedly in their maintenance requirements and with our present knowledge of this subject it is impossible to make an accurate correction for the difference. It becomes necessary therefore to carry on a maintenance trial for each cow. At the end of the year the cows are to be dried off if they are not already dry and fed a ration similar to that given when they were milking, the only difference being in the amount. Just enough will be fed to maintain their weights without gain or loss. The weights will be taken in exactly the same way as in the previous experiment. It is planned to keep the cows on a maintenance ration for at least six months.

In the discussion of this experiment we mentioned four ways in which a cow might use her food; they are (a) for maintenance, (b) for milk, (c) for development of the foetus, (d) for growth or gain in weight. As the purpose of this investigation is

to get information on the nutrients used for milk production it has been thought best to eliminate the last two and measure the first since it is impossible to eliminate it. These three sources of error are guarded against in the following ways:

a. By separate maintenance experiment

c. By keeping the cows farrow

d. By selecting mature cows and keeping their weights uniform.

Description of Cows.

The cows used in this investigation are all of pure breeding. The five cows having numbers less than 100 are Jerseys, 206 is a Holstein, 304 is an Ayrshire and 400 a Shorthorn. A detailed set of data has been or is being collected for these eight animals. In addition to these cows another Ayrshire No. 303, has been used for a few months, and it is quite probable that before the investigation ends at least one more Holstein will be employed in the same way as No. 303.

Tabulated below are the butterfat records by lactation periods of these nine animals together with the date of birth of each and the date at which the last calf was dropped. The last figure of each column indicates the production while under experiment. The object in introducing these records is to show that the cows were mature and that, since their records under experiment were equal to or better than at any previous time, they were properly nourished.

TABLE--1:.

Number of cow:	27	62	4	63	43	206	400	304	303
Date of birth:	9-4-02	5-11-03	6-12-00	3-26-03	9-3-02	5-10-02	5-20-03	7-10-02	8-13-06
Date of last calving	10-7-07	10-4-07	10-5-07	9-28-07	9-20-07	11-5-10	12-20-10	12-28-10	1-4-11
Lactation period	Fat	Fat	Fat	Fat	Fat	Fat	Fat	Fat	Fat
1.	239	44	303	219	306	287	223	209	265
2.	478	115	360	360	376	285	195	228	265
3.	470	169	344	368	388	275	141	145 c.	114 d.
4.			291			292	109 b.		
5.			373			312			
6.						224 a.			

a. 155 days
b. 123 days
c. 110 days
d. 98 days

All of the cows remained in good health thruout the investigation and so far as we know nothing occurred which would vitiate the results obtained. Occasionally some of the cows failed to clean up their feed entirely, but it is thought that this was due to the fact that they were receiving at that particular time more feed than they could handle rather than to any pathological condition. No. 304 had a sore teat for a few weeks which seemed to affect to some extent her milk production, but since the trouble did not extend to the secreting part of her udder she was retained in the experiment.

The cows were handled and fed precisely as described in the original plan except that the ratio between the grain and roughness was not kept constant for all of the animals. An inferior producer will take a greater proportion of her food in the form of roughness than will a high producer. It was not thought that this deviation from the original plan would affect the reliability of the data since the nutrients were to be calculated by Armsby's method.

Complete data is available only from the five Jersey cows. The other four are still on experiment so that the data concerning them is merely tentative and for this reason it is presented separately and in an abbreviated form.

Tables 2, 3, 4, 5, and 6 show the feed consumed and the average weights of the cows by ten-day periods thruout the whole year or so long as the animals were producing milk--in the case of No. 62 for 320 days only.

Nutrients for Maintenance and Milk.

TABLE 2.

Cow No. 27.

SUMMARY OF FEED CONSUMED.

(Weights in Pounds.)

Period No.	Date. 1907.	Grain	Alfalfa Hay.	Silage.	Green Feed.	Average Weight of Cow.
1	10-10--10-15:	44	54	180	...	924
2	10-16--10-25:	72	91	125	...	857
3	10-26--11- 4:	75	90	265	...	846
4	11- 5--11-14:	105	90	350	...	861
5	11-15--11-24:	110	90	350	...	890
6	11-25--12- 4:	110	90	350	...	879
7	12- 5--12-14:	110	90	350	...	872
8	12-15--12-24:	110	90	350	...	861
9	12-25-- 1- 3:	110	90	350	...	873
10	1- 4-- 1-13:	110	90	365	...	865
11	1-14-- 1-23:	110	88.5	370.5	...	882
12	1-24-- 2- 2:	110	90	326.7	...	865
13	2- 3-- 2-12:	110	83	338	...	875
14	2-13-- 2-22:	110	90	331	...	872
15	2-23-- 3- 3:	110	90	328	...	885
16	3- 4-- 3-13:	110	89	350	...	883
17	3-14-- 3-23:	110	90	325	...	897
18	3-24-- 4- 2:	101	90	300.5	...	888
19	4- 3-- 4-12:	100	90	320	...	900
20	4-13-- 4-22:	94	86	310	12	902
21	4-23-- 5- 2:	90	56	269	135	899
22	5- 3-- 5-12:	90	50	220	268	902
23	5-13-- 5-22:	90	79	191	314	914
24	5-23-- 6- 1:	90	56	233	300	924
25	6- 2-- 6-11:	83	50	219.8	260.8	925
26	6-12-- 6-21:	80	50	234.4	274.4	929
27	6-22-- 7- 1:	80	45.6	168.3	184.3	926
28	7- 2-- 7-11:	80	50	120.1	297.4	932
29	7-12-- 7-21:	80	76	...	304.1	899
30	7-22-- 7-31:	80	80	...	289.2	901
31	8- 1-- 8-10:	80	80	...	400	906
32	8-11-- 8-20:	80	80	...	400	928
33	8-21-- 8-30:	80	80	...	400	935.5
34	8-31-- 9- 9:	80	80	...	326	938
35	9-10-- 9-19:	80	80	160	160	938.5
36	9-20-- 9-29:	80	80	315.1	...	937.5
37	9-30--10- 9:	80	80	312.2	...	956.5
Total ..		3424	2904.1	8777.9	4325.2	...

TABLE-3

Cow No. 62

SUMMARY OF FEED CONSUMED.

(Weights in Pounds)

Period No:	Date1907	:Grain:	Alfalfa Hay	:Silage	:Green feed	:Average weight of cow
1	:10-6--10-15	:74	:90	:30	: ...	: 888
2	:10-16-10-25	:62	:85	:49.5	: ...	: 875
3	:10-26-11-4	:58	:78	:204	: ...	: 882
4	:11-5--11-14	:62	:54.5	:206	: ...	: 882
5	:11-15-11-24	:70	:60	:220	: ...	: 884
6	:11-25-12-4	:70	:60	:220	: ...	: 882
7	:12-5--12-14	:70	:60	:220	: ...	: 880
8	:12-15-12-24	:70	:60	:220	: ...	: 894
9	:12-25--1--3	:70	:60	:220	: ...	: 895
10	:: 1-4---1-13	:70	:60	:230.5	: ...	: 886
11	: 1-14--1-23	:70	:60	:244.5	: ...	: 894
12	: 1-24--2-2	:70	:60	:220	: ...	: 898
13	: 2-3---2-12	:62.8	:55.8	:210.2	: ...	: 875
14	.: 2-13--2-22	:65	:53	:207	:....	: 872
15	: 2-23--3-3	:63.5	:51.4	:200.2	: ...	: 912
16	: 3-4---3-13	:60	:49	:190	: ...	: 906
17	: 2-14--3-23	:60	:49	::190	: ...	: 909
18	: 3-24--4-2	:60	:53.5	:208	: ...	: 907
19	: 4-3---2-12	:60	:54	:210	: ...	: 919
20	: 4-13--4-22	:54	:47.6	:177.4	: .12	: 913
21	: 4-23--5-2	:50	:20.9	:155.2	: 84.9	: 910

Second part table 3

22	5- 3--5-12	:50	:28	:125.1	:148.4	:910
23	4-13--5-22	:50	:44	:108.7	:172.1	:919
24	5-23--6- 1	:50	:31.3	:136.5	:166	:925
25	6- 2--6-11	:45	:27.1	:129.4	:160.7	:926
26	6-12--6-21	:40	:25	:123.7	:145	:923
27	6-22--7- 1	:40	:25	:124.6	:117.5	:931
28	7- 2--7-11	:33	:21.1	: 55	:135	:929
29	7-12--7-21	:30	:28.6	:....	:120.3	:911
30	7-22--7-31	:30	:30	:....	:117	:897
31	8- 1--8-10	:34	:34	:....	:170	:884
32	8-11--8-20	:37	:37	:....	:185	:905.7
		:1790.3	:1552.8	:4835.5	:1733.9	

TABLE 4

Cow No. 4

SUMMARY OF FEED CONSUMED

Period	Date 1907	Grain	Alfalfa	Silage	Green Feed	Average Weight
1	10- 6--10-15	92	129			
2	10-16--80-25	98	98			
3	10-26--10- 4	100	114	180		805
4	11- 5--11-14	100	90	300		800
5	11-15--11-24	100	90	300		815
6	11-25--12- 4	100	90	300		817
7	12- 5--12-14	100	90	300		815
8	12-15--12-24	100	90	300		821
9	12-25-- 1-3	100	90	300		816
10	1-4-- 1-13	100	90	300		813
11	1-14-- 1-23	100	90	294.5		814
12	1-24-- 2- 2	100	90	300		807
13	2- 3-- 2-12	100	90	300		819
14	2-13-- 2-22	100	90	300		813
15	3-23--3---3	100	90	300		818
16	3- 4--3--13	100	90	300		820
17	3-14-- 3-23	100	100	300		815.5
18	3-24-- 4- 2	100	100	285		810
19	4- 3-- 4-12	76	78	112		804.5
20	4-13-- 4-22	90	92	262.5	12	807.5
21	4-23-- 5- 2	90	66	213.3	144	810.5
22	5- 3-- 5- 1	90	64	180	216	808
23	5-13-- 5-22	90	105	115.5	12	800.7
24	5-23-- 6- 1	90	88	175.3	30	808
25	6- 2-- 6-11	81	74	187	134.5	822
26	6-12-- 6-21	71	80	234.2	145	839
27	6-22-- 7- 1	70	80	217.2	128	859
28	7- 2-- 7-11	65	80	114.8	190.8	855
29	7-12-- 7-21	65	98		235.2	841
30	7-22-- 7-31	65	100	[illegible]	242.6	843
31	8- 1-- 8-10	65	100		250	836.5
32	8-11-- 8-20	[illegible]5	100		250	832.5
33	8-21-- 8-30	65	100		250	851
34	8-31-- 9- 9	49.8	100		250	852.5
35	9-10-- 9-19	36.5	100	250		860.5
36	9-20-- 9-29	21	100	250		865.5
37	9-30--10- 5		60	63		849.5
Total		3035.3	3376	7034.3	2490.1	

TABLE 5.

Cow No. 63

SUMMARY OF FEED CONSUMED

Period	Date 1907	Grain	Alfalfa	Silage	Green Feed	Average Weight
1	10- 3--10- 5	23	60			960
2	10- 6--10-15	120	90	300		
3	10-16--10-25	120	90	300		
4	10-26--11- 4	106	90	300		930
5	11- 5--11-14	100	90	300		910
6	11-15--11-24	100	90	300		945
7	11-25--11- 4	100	90	300		941
8	12- 5--12-14	100	90	300		942
9	12-15--12-24	100	90	300		941
10	12-25-- 1- 3	100	90	300		951
11	1- 4-- 1-13	91	90	300		939
12	1-14-- 1-23	90	90	300		946
13	1-24-- 2- 2	90	90	300		935
14	2- 3-- 2-12	90	90	300		939
15	2-13-- 2-22	90	90	300		941
16	2-23-- 3- 3	90	90	300		942
17	3- 4-- 3-13	90	90	300		935
18	3-14-- 3-23	90	90	300		947.4
19	3-24-- 4- 2	90	90	300		950.7
20	4- 3-- 4-12	87	90	300		956
21	4-13-- 4-22	80	86	294	12	951.5
22	4-23-- 5- 2	80	56	216.3	144	933.5
23	5- 3-- 5-12	80	54	180	234	919
24	5-13-- 5-22	80	104	156.5	15	914
25	5-23-- 6- 1	80	80	193.5	40	936
26	6- 2-- 6-11	80	80	206.5	137.5	941
27	6-12-- 6-21	80	80	207.1	145	942.5
28	6-22-- 7- 1	80	80	228.6	126	962.0
29	1- 2-- 7-11	68.5	80	89.6	190.1	968
30	7-12-- 1-21	50	98		232.1	947.5
31	7-22-- 7-31	80	100		225.6	951
32	8- 1-- 8-10	80	100		250	951.5
33	8-11--8-20	80	100		250	962.5
34	8-21-- 8-30	54.5	100		250	977.2
35	8-31-- 9- 9	18	100		250	973
36	9-10-- 9-19		100	249.6		972.5
37	9-20-- 9-30	21	100	250		967
38	10- 1--10- 2	9	30	75		953
Total		2968	3298	8046.7	2501.3	

TABLE 6
Cow No. 43

SUMMARY OF FEED CONSUMED.

Period	Date 1907	Grain	Alfalfa	Silage	Green Feed	Average Weight
1	9-24--9 -25	12	40			825
2	9-26--10- 5	91	200			
3	10- 6--10-15	120	90	300		
4	10-16--10-25	120	90	300		
5	10-26--11- 4	120	90	300		795
6	11- 5--11-14	120	90	235		790
7	11-15--11-24	114	90	230		810
8	11-25--11- 4	110	90	250		809
9	12- 5--12-14	106	90	270		816
10	12-15--12-24	100	90	270		810
11	12-25-- 1- 3	103	90	270		812
12	1- 4-- 1-13	100	92	259		793
13	1-14-- 1-23	100	100	277.5		819
14	1-24-- 2- 2	100	100	211.5		805
15	2- 3-- 2-12	100	100	221		799
16	2-13-- 2-22	100	100	250		806
17	2-23-- 3- 3	100	100	231		799
18	3- 4-- 3-13	103	103	196		793
19	3-14-- 3-23	110	110	200		791.5
20	3-24-- 4- 2	109	110	168		801.5
21	4- 3-- 4-12	100	110	185.5		803
22	4-13-- 4-22	98	108	192.5	12	807
23	4-23-- 5- 2	93	76	145.8	144	796
24	5- 3-- 5-12	90	78	129.5	234	779.5
25	5-13-- 5-22	90	108	99.5	15	777
26	5-23-- 6- 1	90	88	150	40	793
27	6- 2-- 6-11	81	80	131.2	122.7	793.5
28	6-12-- 6-21	80	80	141.2	133.6	789.5
29	6-22-- 7- 1	80	80	138.9	122.6	815.0
30	7- 2-- 7-11	80	80	68.2	187.5	811.5
31	7-12-- 7-21	80	98		219.1	812
32	7-22-- 7-31	80	100		223.0	808
33	8- 1-- 8-10	80	100		250	809.5
34	8-11-- 8-20	80	100		250	820.4
35	8-21-- 8-30	80	100		250	823.7
36	8-31-- 9- 9	68	100		247.4	838
37	9-10-- 9-19	50	100		70.4	842.5
38	9-20-- 9-29	16	40		94.9	840
Total		3454	3591	5821.3	2616.2	

It seems that some of the cows made a small gain in weight. This factor is a hard one to control. A cow kept under entirely uniform conditions will sometimes vary 100 lbs. in live weight from day to day. On account of the difficulty of determining the true weight of a cow too much importance must not be attached to this seeming gain in weight, especially since it is distributed over a period of one year.

Tables 7, 8, 9, 10 and 11 show the nutrients consumed during the period in milk as estimated from the weights of the feeds and from the chemical analyses made by the Agricultural Chemistry Department of this Station.

TABLE: 7
Cow No. 27

NUTRIENTS CONSUMED DURING YEAR IN MILK

Feed	Amount	Dry Matter	Protein	Fiber	Nitrogen free extract	Ether extract	Ash
Corn	1956.6	1709.54	166.17	35.85	1365.28	116.96	25.64
Bran	978.3	877.56	141.67	87.32	522.76	60.09	65.73
Oilmeal	489.1	444.58	168.08	39.01	178.31	32.95	26.23
Alfalfa	2904.1	2714.02	416.31	894.31	1078.23	72.10	252.80
Silage	8777.9	2455.77	184.93	561.60	1466.69	93.93	148.73
Green Clover	297.4	115.36	15.74	32.80	56.86	2.54	7.43
Green Corn	1891.7	519.62	42.66	134.38	286.16	17.13	36.50
Green Alfalfa	2136.1	525.55	99.49	156.14	206.14	8.86	56.45
Total		9362.00	1235.05	1941.41	5160.43	404.56	619.51

TABLE 8
Cow No. 62

NUTRIENTS CONSUMED DURING YEAR IN MILK

Feed	Amount	Dry Matter	Protein	Fiber	Nitrogen-free Ext.	Ether Extract	Ash
Corn	1023.0	887.53	85.92	19.24	704.35	59.78	13.17
Bran	511.5	458.73	74.12	45.38	274.35	30.55	34.34
Oilmeal	255.8	232.46	87.89	20.40	93.23	17.23	13.72
Alfalfa	1552.8	1468.80	219.61	490.12	585.77	37.43	135.89
Silage	4835.5	1347.72	100.48	304.84	809.51	52.18	80.71
Gr. Clover	135.0	52.37	7.14	14.89	25.81	1.15	3.37
Gr. Corn	439.0	98.23	7.96	25.03	53.34	3.19	6.79
Green Alfalfa	1159.9	277.47	52.51	82.44	108.97	4.68	29.80
Total		4823.31	635.63	1002.34	2655.33	206.19	317.79

TABLE 9
Cow No. 4

NUTRIENTS CONSUMED DURING YEAR I N MILK

Feed	Amount	Dry Matter	Protein	Fiber	Nitrogen-free Ext.	Ether Extract	Ash
Corn	1734.5	1505.40	137.58	24.40	1232.39	92.66	18.13
Bran	867.2	777.87	125.60	77.30	463.77	52.95	58.26
Oilmeal	433.6	394.10	149.00	34.58	158.05	29.21	23.25
Alfalfa	3376.0	3186.92	493.63	1042.14	1270.08	84.80	296.27
Silage	7034.3	2005.98	149.70	456.09	1198.21	77.61	120.65
Green Clover	190.8	74.01	10.10	21.04	36.48	1.63	4.77
Green Corn	1195.0	321.44	26.37	83.15	176.98	10.59	22.60
Green Alfalfa	1104.3	304.77	57.69	90.55	120.26	5.14	32.73
Total		8570.49	1149.67	1829.25	4636.12	354.59	576.66

TABLE 10

Cow No. 63.

NUTRIENTS CONSUMED DURING YEAR IN MILK:

Feed	Amount	Dry Matter	Protein	Fiber	Nitrogen-free Ext.	Ether Ext.	Ash
Corn	1696.0	1473.77	142.73	27.60	1191.04	91.70	21.15
Bran	848.0	760.50	122.87	75.26	454.74	50.71	56.93
Oilmeal	424.0	385.37	145.70	33.81	154.55	28.56	22.74
Alfalfa	3298.0	3114.39	482.76	1016.83	1242.52	82.77	289.49
Silage	8046.7	2193.22	167.73	510.97	1290.06	85.33	134.91
Green Clover	190.1	73.74	10.06	20.96	36.35	1.62	4.75
Green Corn	1178.8	318.61	26.13	82.44	175.39	10.49	22.42
Green Alfalfa	1132.4	310.41	58.76	92.23	122.57	5.24	33.34
Total		8630.01	1156.74	1860.10	4667.22	356.32	585.73

Cow No. 43 Table 11

Nutrients consumed during year in milk:

Feed	Amount	Dry Matter	Protein	Fiber	Nitrogen free extract	Ether extract	Ash
Corn	1973.8	1717.45	166.73	32.42	1387.09	106.94	24.83
Bran	986.8	884.97	142.97	87.61	528.94	59.21	66.25
Oilmeal	493.4	448.45	169.55	39.35	179.84	33.24	26.46
Alfalfa	3591.0	3394.15	526.30	1097.48	1364.61	90.61	315.10
Silage	5821.3	1607.03	120.41	372.86	955.36	60.88	97.62
Gr. Clover	187.5	72.73	9.92	20.68	35.85	1.60	4.68
Gr.Corn	1249.2	339.14	27.79	87.54	187.12	11.18	23.77
Gr. Alfalfa	1179.5	296.71	56.17	88.15	117.23	5.00	31.87
Total		8760.63	1219.84	1826.09	4756.04	368.66	590.58

A ten days digestion trial was conducted with Nos. 27 and 62 during their milking period and also when they were on maintenance. A summary of these trials is presented in Research Bul. No. 2. It was desired in this investigation to ascertain the amount and the energy value of the digested nutrients actually required for milk production. To do this it was necessary to estimate the actual digestion coefficients of protein, carbohydrates and ether extract for each of the feeds used. This was done by determing the relation existing between the average and the actual digestion coefficients of a ration with the same composition, and then using such a factor as will reduce the average coefficients of each feed to the actual. To illustrate, in the digestion trial with cow No. 27 the protein of her ration was found to be 58.75% digestible. Using average coefficients for the digestion of this protein it would have been 71.24% ~~.of the average.~~ The actual then is 82.47% of the average. To reduce the average to actual the protein of each feed was multiplied by .8247. The same system was followed with the carbohydrates and ether extract. The factors used in reducing the average to the actual for the two cows 27 and 62 during the milking period were as follows:

Number of cow	Protein	Carbohydrates	Ether Extract
27	.8247	.9585	.8155
62	.8493	.9695	.7301

Since no digestion trial was conducted with green feeds in the ration these were assumed to be of average digestibility.

Table 12 shows the average digestion coefficients of the

feed used in this investigation calculated from Farmers' Bulletin 22 revised. Tables 13, 14, and 15 show the actual digestion coefficients for Nos. 27 and 62 and the average of 27 and 62. The last is used with the rations of the other three cows as no digestion trial was conducted with them.

TABLE 12

AVERAGE DIGESTION COEFFICIENTS:

	Protein	Carbohydrates	Ether extract
Corn	68	92.2	97.6
Bran	78	65.5	71.7
Oilmeal	85.2	84.9	96.7
Alfalfa	74	55.1	62.7
Silage	55	70.0	80.0
Green clover	70	68.6	62.6
Green corn	61.1	70.2	74.0
Green Alfalfa	81.	56.8	41.0

TABLE 13

Actual digestion coefficients of feeds supplied during milking period.

Cow NO. 27.

	Protein	Carbohydrates	Ether Extract
Corn	56.1	88.4	79.6
Bran	64.3	62.8	58.5
Oilmeal	70.3	81.4	78.9
Alfalfa	61.0	52.8	51.1
Silage	45.4	67.1	65.2

TABLE 14

Actual digestion coefficients of feeds supplied during milking period.

Cow No. 62

	Protein	Carbohydrates	Ether Extract
Corn	57.8	89.4	71.3
Bran	66.2	63.5	52.4
Oilmeal	72.4	82.3	70.6
Alfalfa	62.8	53.4	45.8
Silage	46.7	67.9	58.4

TABLE: 15

Digestion coefficients average of 27 and 62.

	Protein	Carbohydrates	Ether extract
Corn	56.9	88.9	75.4
Bran	65.3	63.1	55.4
Oilmeal	71.3	81.8	74.7
Alfalfa	61.9	53.1	48.5
Silage	46.0	67.5	61.8

The next five tables give the digestible nutrients and the energy values during the year in milk. The figures given for digestible albuminoids represent the digestible protein minus the protein in the amide form. The "amides" are assumed to be entirely digestible. (21) The percentage of "amides" in the different feeds is as follows:

Corn	.58	Silage	.33
Bran	1.80	Green clover	.86
Oilmeal	.58	Green Corn	.69
Alfalfa hay	3.02	Green alfalfa	1.39

The first four analyses were made by the writer. Stutzer's reagent was used. (22) Representative samples of the remainder were not available so the percentages of "amides" were calculated from Farmers' Bulletins 22 and 346. The digestible protein (albuminoids) in Bul. 346 is subtracted from the digestible protein in Bul. 22. The difference represents the "amides."

The total crude fiber is included in these tables as it is used in computing the energy values of the rough feeds. For each pound of crude fiber in the hay .617 Therm is deducted.

(21. Bul. 101 B. A. I.) (22.Bul. 107 Revised; Bureau of Chemistry)

In the case of silage and the green feeds the deduction per pound of fiber is dependent upon the percentage of fiber present.(23)

Feeds with 4%	fiber or less	.308 therm
6"	"	.362 "
8%	"	.404 "
10%	"	.457 "
12%	"	.511 "
14	"	.564 "
16	or more	.617 "

With the concentrated feeds instead of making a deduction for fiber the energy values are multiplied by these figures: Corn 100, bran 77, oilmeal 96.

TABLE 16

Digestible nutrients and energy values during year in milk:

COW NO 27

Feed	Digestible Protein	Digestible Carbohydrates	Ether Extract	Total Crude Fiber	Digestible Albuminoids	Energy value Therms.
Corn	93.19	1237.93	93.09	35.85	81.84	1649.62
Bran	91.14	382.95	35.13	87.32	73.53	443.26
Oilmeal	118.10	176.81	25.98	39.01	115.26	358.69
Alfalfa	254.08	1041.58	36.86	894.31	116.37	808.00
Silage	83.88	1360.65	61.28	561.60	54.92	1430.23
Gr. Clover	11.01	61.51	1.59	32.80	8.46	61.83
Gr. Corn	26.06	295.22	12.67	134.38	13.01	303.52
Gr. Alfalfa	80.58	205.78	3.63	156.14	50.89	218.72
Total	758.04	4762.43	270.23	1941.41	564.28	5273.87

(23) Kellner-Ernährung der Landwirtschaftlichen Nutztiere.

TABLE. 17

Digestible nutrients and energy values during year in milk:

COW 62.

Feed	Digestible Protein	Carbo-drates	Ether Ext.	Total Crude Fiber	Digestible albuminoids	Energy value therms
Corn	49.62	646.81	42.60	19.24	43.69	847.34
Bran	49.10	203.02	15.99	45.38	39.90	230.47
Oilmeal:	63.60	93.52	12.16	20.40	62.11	186.92
Alfalfa:	138.02	574.70	17.13	490.12	91.13	440.66
Silage	46.93	756.21	30.48	304.84	30.98	791.38
Gr. Clover	5.00%	27.92%	.72	14.89	3.84	28.85%
Gr. Corn:	4.86	55.02%	2.36	25.03	1.83	56.74%
Gr. Alfalfa	42.54	108.72	1.92%	82.44	26.41	115.45
Total	399.67	2465.92	133.36	1002.34	299.89	2697.71

TABLE 18

Digestible nutrients and energy values during year in milk.

COW 4

Feed	Digestible Protein	Carbo-Hydrates	Ether Extract	Total Crude fiber	Digestible Albuminoids	Energy value therms
Corn	78.28	1117.20	69.87	24.40	68.22	1446.44
Bran	82.02	341.42	29.33	77.30	66.41	391.89
Oilmeal:	106.24	157.57	21.82	34.58	103.72	317.32
Alfalfa	305.56	1227.79	41.13	1042.14	203.60	962.77
Silage	68.86	1116.65	47.96	456.09	45.65	1170.53
Gr. Clover	7.07	39.46	1.02	21.04	5.43	39.67
Gr. Corn	16.11	182.61	7.84	83.15	7.86	187.71
Gr. Alfalfa	46.73	119.74	2.11	90.55	31.38	127.49
	710.87	4302.44	221.08	1829.25	532.27	4643.82

TABLE 19.

Digestible nutrients and energy values during year in milk:

COW 63

Feed	Digestible Protein	Carbo-hydrates	Ether extract	Total crude fiber	Digestible albuminoids	Energy value Therms.
Corn	81.21	1083.37	69.14	27.60	71.37	1411.53
Bran	80.23	334.43	28.09	75.26	64.97	382.53
Oilmeal	103.88	154.08	21.33	33.81	101.42	310.27
Alfalfa	298.83	1199.71	40.14	1016.83	199.23	941.86
Silage	77.16	1215.70	52.67	510.97	50.61	1270.85
Gr. Clover	7.04	39.31	1.01	20.96	5.41	39.52
Gr. corn	15.97	181.00	7.76	82.44	7.84	176.31
Gr. Alfalfa	47.60	122.01	2.15	92.23	31.86	129.80
Total	711.92	4329.61	222.29	1860.10	532.71	4662.67

TABLE 20--

Digestible nutrients and energy values during year in milk:

COW 43:

Feed	Digestible Protein	Carbo-hydrates	Ether extract	Total crude fiber	Digestible albuminoids	Energy values Therms
Corn	94.87	1261.94	80.63	32.42	83.42	1644.72
Bran	93.36	389.04	32.80	87.61	75.60	445.26
Oilmeal	120.89	179.30	24.82	39.35	118.03	361.07
Alfalfa	325.78	1307.37	43.95	1097.48	217.34	1033.56
Silage	55.39	896.55	37.62	372.86	36.18	936.11
Gr. Clover	6.94	38.78	1.00	20.68	5.33	38.98
Gr. Corn	16.98	192.81	8.27	87.54	8.36	198.34
Gr. Alfalfa	45.50	116.66	2.05	88.16	29.10	133.99
Total	759.71	4382.45	231.14	1826.10	573.36	4782.03

Nutrients for Maintenance

The next question is to find out how much of these nutrients were used for maintenance. Four of the cows after being dried off were maintained in a farrow condition for periods ranging from 120 to 180 days. Tables 21, 22, 23 and 24 show the feed consumed and the weights of the cows by 10 day periods. In tables 25, 26, 27, and 28 are given the total nutrients consumed as estimated from the weights of the feeds and their actual chemical composition.

TABLE 21

Cow No. 27:

SUMMARY OF FEED CONSUMED ON MAINTENANCE

Period No.	Date 1908	Grain	Alfalfa hay	Silage	Average weight of cow
1	10-30--11-8	40	40	160	881.1
2	11- 9--11-18	37.5	37.5	150	889.5
3	11-19--11-28	33	33	132	887.4
4	11-29--12- 8	33	33	132	884.2
5	12-9-- 12-18	33	33	132	888.9
6	12-19--12-28	32.4	32.4	129.6	895.7
7	12-29-- 1- 7	31	31	124	891.4
8	1- 8-- 1-17	31	31	124	871
9	1-18-- 1-27	31	33	132	882.4
10	1-28-- 2- 6	32	32	128	888.9
11	2- 7-- 2-16	32	32	128	898.5
12	2-17-- 2-26	32	32	128	891.1
13	2-27-- 3- 8	32	32	128	902.8
14	3- 9-- 3-18	32	32	128	891.1
15	3-19-- 3-28	32	32	128	889.4
16	3-29-- 4- 7	32	32	128	896.7
Total		525.9	527.9	2111.6	

TABLE :-- 22

Cow No. 62

SUMMARY OF FEED CONSUMED ON MAINTENANCE:

Period No :	Date 1908	Grain	Alfalfa	Silage	Average weight of cow
1	8-31-- 9- 9	30	30	123	906
2	9-10-- 9-19	30	30	120	904.5
3	9-20-- 9-29	30	30	120	911.
4	9-30--10- 9	30	30	120	911
5	10-10--10-19	30	30	120	913.5
6	10-20--10-29	31	31	124	904
7	10-30--11- 8	30	30	120	908.9
8	11- 9--11-18	30	30	120	911.6
9	11-19--11-28	30	30	120	917.4
10	11-29--12- 8	30	30	120	921.2
11	12- 9--12-18	29.4	29.4	117.6	929.2
12	12-19--12-28	28	28	112	924.6
13	12-29-- 1- 7	28	28	112	923.7
14	1- 8-- 1-17	28	28	112	924.5
15	1-18-- 1-27	28	28	112	918.3
16	1-28-- 2- 6	28	28	112	922.4
17	2- 7-- 2-16	28	28	112	924.1
18	2-17-- 2-26	28	28	120	924.4
Total		526.4	526.4	2116.6	

TABLE 23
No. 4

SUMMARY OF FEED CONSUMED ON MAINTENANCE:

Period:	Date 1908	Grain	Alfalfa Hay:	Silage	Average Weight
1	10-20--10-29	38	38	152	794.5
2	10-30--11- 8	36.1	36.1	144.4	819.1
3	11- 9--11-18	30.	30	120	799.4
4	11-19--11-28	30	30	120	806.4
5	11-29--12- 8	30	30	120	792.5
6	12- 9--12-18	31	31	124	794.2
7	12-19--12-28	31	31	124	785.6
8	12-29-- 1- 7	31	31	124	788.4
9	1- 8---1-17	31	31	124	772.5
10	1-18-- 1-27	33	33.1	132	766
11	1-28-- 2- 6	35.8	35.8	143.2	768.4
12	2- 7-- 2-16	40	40	160	786
13	2-17-- 2-26	40	40	160	796.8
14	2-27-- 3-8	37.3	37.3	158.8	803.4
15	3- 9-- 3-18	39.7	39.7	160	810.7
Total		513.9	514.	2066.4	

TABLE 24

No. 63

SUMMARY OF FEED CONSUMED ON MAINTENANCE:

Period:	Date 1908	Grain	Alfalfa Hay	Silage	Average Weight
1	10-20--10-29	32	32	136	895
2	10-30--11- 8	32	32	132	918.6
3	11- 9--11-18	30	30	120	878
4	11-19--11-28	30	30	120	891.7
5	11-29--12- 8	30	30	120	882.3
6	12- 9--12-18	30	30	120	888.4
7	12-19--12-28	29.4	29.4	117.6	900.1
8	12-29-- 1- 7	28	28	112	883.9
9	1- 8-- 1-17	28	28	112	874.5
10	1-18--1 -27	28	28	112	882.7
11	1-28-- 2- 6	28	28	112	885.7
12	2- 7-- 2-16	28	28	112	881.8
Total		353.4	353.4	1425.6	

TABLE 25

No. 27

NUTRIENTS CONSUMED DURING MAINTENANCE PERIOD OF 160 DAYS

Feed	Amount	Dry Matter	Protein	Fiber	N. F. E	Fat	Ash
Corn	300.5	271.91	26.75	5.49	219.78	15.45	4.45
Bran	150.2	134.90	21.71	13.90	78.91	10.27	10.10
Oilmeal	75,1	68.29	25.82	5.99	27.38	5.06	4.03
Alfalfa	527.9	480.86	77.86	166.82	183.71	10.93	41.55
Silage	2111.6	635.06	42.30	153.24	371.53	27.38	40.66
Total		1591.02	194.44	345.44	881.31	69.09	100.79

TABLE 26

No. 62

NUTRIENTS CONSUMED DURING MAINTENANCE PERIOD OF 180 DAYS

Feed	Amount	Dry Matter	Protein	Fiber	N. F. E.	Fat	Ash
Corn	300.8	272.08	26.93	5.49	219.86	15.50	4.46
Bran	150.4	135.05	21.73	13.91	78.98	10.32	10.11
Oilmeal	75.2	68.35	25.84	6.00	27.41	5.06	4.03
Alfalfa	526.4	480.69	78.14	165.48	184.21	11.09	41.78
Silage	2116.6	647.60	49.27	159.25	372.82	24.29	42.00
Total		1603.77	201.91	350.13	883.28	66.31	102.38

TABLE 27
No. 4

NUTRIENTS CONSUMED DURING MAINTENANCE PERIOD OF 150 DAYS

Feed	Amount	D. M.	Protein	Fiber	N. F. E.	Fat	Ash
Corn	293.7	265.06	26.16	5.32	213.83	15.36	4.41
Bran	146.8	131.86	21.20	13.49	77.01	10.25	9.91
Oilmeal	73.4	66.81	25.26	5.87	26.71	4.94	3.92
Alfalfa	514.	468.20	75.82	162.42	178.87	10.64	40.45
Silage	2066.4	621.28	42.35	150.38	362.54	26.17	39.88
Total		1553.21	190.79	337.48	858.96	67.36	98.57

TABLE 28
Cow 63

NUTRIENTS CONSUMED DURING MAINTENANCE PERIOD OF 120 DAYS

Feed	Amount	D. M.	Protein	Fiber	N. F. E.	Fat	Ash
Corn	202.	182.30	17.99	3.66	147.06	10.56	3.03
Bran	101.	90.72	14.58	9.28	52.98	7.05	6.82
Oilmeal	50.4	45.82	17.34	4.02	18.35	3.38	2.70
Alfalfa	353.4	321.91	52.13	111.67	122.98	7.32	27.81
Silage	1425.6	427.99	32.40	105.16	246.65	15.97	27.83
Total		1068.74	134.44	233.79	588.02	44.28	68.19

Tables 29, 30, 31, and 32 showing the digestible nutrients and energy values were prepared in precisely the same way as tables 16 to 20 except that different factors were used in reducing the average digestion coefficients to the actual. Following are the factors used:

Number of cow	Protein	Carbohydrates	Ether Extract
27	.9349	1.0671	.9120
62	.9100	1.0427	.9214

For Nos. 4 and 63 an average between 27 and 62 was employed.

TABLE 29
Cow No 27

Digestible nutrients and energy values on maintenance

Feed	Protein	Carbo-hydrates	Ether Extract	Total Crude Fiber	Digestible Albuminoids	Energy value Therms
Corn	17.01	221.67	13.75	5.49	15.27	288.46
Bran	15.83	64.87	6.72	13.90	13.13	77.15
Oilmeal	20.55	30.23	4.46	5.99	30.11	61.77
Alfalfa	53.88	206.11	6.25	166.82	37.94	169.12
Silage	21.74	392.00	19.99	153.24	14.77	422.70
Total for 160 days	129.01	914.88	51.17	345.44	101.22	1019.20
For one day	.81	5.72	.32		.63	6.37
For 365 days	294.30	2087.07	116.73		230.90	2325.05

TABLE 30
Cow No 62

DIGESTIBLE NUTRIENTS AND ENERGY VALUES ON MAINTENANCE

Feed	Digestible Protein	Carbo-hydrates	Ether Extract	Total crude fiber	Digestible albuminoids	Energy value Therms
Corn	16.67	216.56	13.93	5.49	14.93	283.12
Bran	15.43	63.44	6.82	13.91	12.72	75.84
Oilmeal	20.03	29.57	4.51	6.00	19.59	60.71
Alfalfa	52.59	201.07	6.41	165.48	36.69	163.61
Silage	24.63	388.41	17.90	159.25	17.66	407.78
Total for 180 days	129.35	899.05	49.57	350.13	101.59	991.06
For one day	.72	4.99	.28		.56	5.51
For 320 days	229.96	1598.31	88.12		180.60	1761.88

TABLE 31
Cow No. 4

DIGESTIBLE NUTRIENTS AND ENERGY VALUES ON MAINTENANCE

Feed	Digestible Protein	Carbo-hydrates	Ether Extract	Total Crude Fiber	Digestible albuminoids	Energy value Therms
Corn	16.40	213.23	13.75	5.32	14.70	278.72
Bran	15.24	62.54	6.73	13.49	12.60	74.81
Oilmeal	19.85	29.19	4.38	5.87	19.42	59.82
Alfalfa	51.79	198.29	6.12	162.42	36.27	161.48
Silage	21.47	378.53	19.18	150.38	14.65	398.08
Total for 150 days	124.75	881.78	50.16	337.48	97.64	972.91
For one day	.83	5.88	.33		.65	6.49
For 365 days	303.56	2145.66	122.06		237.59	2367.39

TABLE 32

Cow No.63

DIGESTIBLE NUTRIENTS AND ENERGY VALUES ON MAINTENANCE

Feed	Digestible Protein	Carbohydrates	Ether Extract	Total crude fiber	Digestible albuminoids	Energy value Therms
Corn	11.28	146.65	9.45	3.66	10.11	191.76
Bran	10.48	43.02	4.63	9.28	8.66	51.47
Oilmeal	13.63	20.04	3.03	4.02	13.34	41.13
Alfalfa	35.60	136.33	4.21	111.67	24.93	111.03
Silage	16.43	259.64	11.71	105.16	11.73	270.98
Total for 120 days	87.42	605.68	33.03	233.79	68.77	666.37
For one day	.73	5.05	.28		.57	5.55
For 365 days	265.76	1841.27	100.41		209.06	2026.85

In the following tables are given the digested nutrients and energy values available for milk production. The maintenance requirement of No. 43 is considered to be an average of the other four.

TABLE 33
Cow No. 27

NUTRIENTS AVAILABLE FOR PRODUCTION OF MILK

365 days	Digested nutrients Protein	Carbohydrates	Ether Extract	Digested Albuminoids	Energy value Therms
For maintenance and milk	758.04	4762.43	270.25	564.27	5273.86
For maintenance	294.30	2087.07	116.73	230.90	2325.05
For milk-8522.9 lbs	463.74	2675.36	186.23	333.37	2948.81
For 1 lb milk-5.5% fat	.054	.314	.022	.039	.346

Cow 62, 320 days.					
For maintenance and milk	399.67	2465.93	123.37	299.88	2697.71
For maintenance	229.96	1598.31	88.12	180.60	1761.88
For milk-3188.9 lbs.	169.71	867.62	35.25	119.28	935.83
For 1 lb.milk-5.3 % fat	.053	.272	.011	.037	.293
Cow 4, 365 days					
For maintenance and milk	710.87	4302.44	221.08	532.27	4643.82
For maintenance	303.56	2145.66	122.06	237.59	2367.39
For milk 6773.6 lbs.	407.31	2156.78	99.02	294.68	2276.43
For 1 lb.milk 5.5% fat	.060	.318	.015	.044	.336
Cow 63, 365 days					
For maintenance and milk	711.92	4329.61	222.29	532.71	4662.67
For maintenance	265.76	1841.27	100.41	209.06	2026.85
For milk 6033.9 lbs.	446.16	2488.34	121.88	323.65	2635.82
For 1 lb.milk-6.1 % fat	.074	.412	.020	.054	.437
Cow 43, 365 days					
For maintenance and milk	759.71	4382.45	231.14	573.36	4782.03
For maintenance	281.05	1974.65	109.50	219.00	2182.70
For milk-7939.5 lbs.	478.66	2407.80	121.64	354.36	2599.33
For 1 lb.Milk-4.9%-fat	.060	.303	.015	.045	.327

TABLE 34

YIELD OF MILK AND AVERAGE COMPOSITION

No.27

Period	Lbs. Milk	% Fat	%Nitrogen	Protein: N x 6.38	Sugar	Ash
1	181.3	4.20	.52	3.32	5.00	.745
2	292.6	6.20	.52	3.32	4.70	.744
3	310.4	5.60	.52	3.32	5.30	.745
4	325.5	5.25	.55	3.51	5.00	.723
5	314.3	5.30	.56	3.57	3.55	.736
6	289.2	5.10	.58	3.70	3.76	.730
7	287.6	5.60	.59	3.76	4.40	.764
8	283.0	5.40	.58	3.70	4.86	.698
9	272.3	5.10	.61	3.89	5.03	.762
10	274.9	5.60	.62	3.96	5.30	.691
11	266.7	5.10	.64	4.08	4.30	.721
12	240.5	5.60	.62	3.96	4.98	.677
13	243.1	5.80	.64	4.08	4.83	.750
14	234.6	5.75	.64	4.08	4.35	.727
15	245.6	5.60	.66	4.21	5.08	.776
16	243.9	5.75	.65	4.15	4.66	.812
17	244.2	5.70	.65	4.15	3.90	.775
18	235.0	5.70	.67	4.27	5.30	.771
19	231.6	5.60	.68	4.34	4.96	.789
20	242.3	5.60	.66	4.21	4.60	.787
21	243.9	5.50	.67	4.27	4.90	.737
22	236.6	5.55	.68	4.34	4.50	.758
23	218.4	5.50	.66	4.21	4.50	.754
24	222.2	5.70	.65	4.15	3.60	.852
25	204.0	5.90	.62	3.96	4.70	.841
26	191.1	5.70	.64	4.08	4.50	.767
27	173.8	5.70	.61	3.89	4.67	.711
28	194.3	5.50	.68	4.34	4.69	.660
29	189.3	5.40	.63	4.02	4.80	.704
30	182.8	5.40	.63	4.02	4.08	.655
31	183.5	5.00	.65	4.15	4.50	.672
32	182.2	5.30	.67	4.27	4.93	.646
33	173.7	5.70	.62	3.96	4.58	.597
34	184.9	5.60	.67	4.27	4.93	.660
35	161.6	5.60	.71	4.53	3.79	.705
36	162.6	5.80	.70	4.47	4.33	.703
37	149.4	6.00	.69	4.40	4.35	.689

TABLE 35

YIELD OF MILK AND AVERAGE COMPOSITION.

(By Periods.)

No. 62

Period	Lbs. Milk	% Fat	% Nitrogen	Protein: n x 6.38	Sugar	Ash
1	115.9	5.14	.63	4.02	5.08	.763
2	139.6	5.80	.63	4.02	4.85	.764
3	147.3	5.20	.63	4.02	5.30	.761
4	156.4	5.00	.62	3.96	3.42	.770
5	150.2	5.30	.62	3.96	6.48	.765
6	137.5	5.10	.63	4.02	3.41	.750
7	135.2	5.60	.63	4.02	3.93	.761
8	138.4	5.55	.63	4.02	4.61	.702
9	134.9	5.10	.65	4.15	4.55	.768
10	123.2	5.20	.62	3.96	5.00	.700
11	119.4	5.60	.62	3.96	4.23	.750
12	114.5	5.40	.63	4.02	4.43	.757
13	112.0	5.55	.62	3.96	3.93	.754
14	104.7	5.45	.65	4.15	3.52	.759
15	104.8	5.65	.66	4.21	6.18	.700
16	103.8	5.30	.65	4.15	4.48	.712
17	98.8	5.20	.63	4.02	3.88	.735
18	96.5	5.50	.64	4.08	4.85	.778
19	87.9	5.10	.66	4.21	4.51	.785
20	90.9	5.40	.60	3.83	4.30	.720
21	84.4	4.95	.58	3.70	5.00	.657
22	77.6	5.45	.64	4.08	4.70	.837
23	72.6	5.30	.61	3.89	4.40	.800
24	79.3	5.50	.60	3.83	3.50	.916
25	73.0	5.30	.62	3.96	4.50	.723
26	68.0	5.20	.64	4.08	4.20	.732
27	65.5	5.30	.63	4.02	4.40	.655
28	64.6	5.20	.60	3.83	4.61	.713
29	56.2	5.20	.59	3.76	4.58	.686
30	49.2	5.10	.58	3.70	4.55	.688
31	45.6	5.00	.60	3.83	4.50	.690
32	41.0	5.10	.60	3.83	4.25	.689

TABLE 36--

YIELD OF MILK AND AVERAGE COMPOSITION

No. 4

30 days ending	Lbs. Milk	% Fat	% Nitrogen	% sugar	% Ash
Nov. 24	*1366.4	5.18	.63	4.97	.842
Dec. 24	631.5	5.67	.64	3.83	.768
Jan. 23	643.6	5.80	.62	----	.800
Feb. 22	623.2	5.95	.62	4.00	.760
Mar. 23	622.4	5.97	.65	4.20	.791
Apr. 22	524.3	6.10	.63	4.70	.792
May 22	454.3	5.72	.66	4.60	.702
June 21	454.7	5.40	.67	4.10	.661
July 21	489.9	5.17	.64	4.41	.737
Aug. 20	475.5	4.67	.65	4.36	.684
Sep. 19	426.1	5.00	.68	4.16	.732
Oct. 5	#161.7	5.20	.70	4.36	.731

*48 days
#16 days

TABLE 37

YIELD OF MILK AND AVERAGE COMPOSITION

No. 63

30 days ending :	Lbs. Milk	% Fat	% Nitrogen	% Sugar	% Ash
Oct. 25:	*500.2	5.90	.69	4.70	.778
Nov. 24:	641.4	6.22	.72	3.83	.780
Dec. 24:	579.0	6.50	.69	----	.741
Jan. 23:	563.3	6.40	.67	4.08	.740
Feb. 22:	523.6	6.43	.70	4.35	.741
Mar. 23:	520.9	6.35	.70	4.60	.771
Apr. 22:	590.0	6.60	.70	5.05	.795
May 22:	463.3	6.28	.68	4.50	.744
June 21:	470.6	5.77	.65	4.40	.713
July 21:	419.9	5.57	.68	4.10	.707
Aug. 20:	420.1	5.20	.66	4.53	.684
Sep. 19:	323.0	5.40	.69	3.66	.703
Oct. 2:	#118.6	5.56	.67	4.28	.696

*22 days
#13 days

Table 37a

Yield of Milk and Average Composition

No. 43

30 days ending	Lbs. Milk	% Fat	% Nitrogen	% Sugar	% Ash
Oct. 25	*920.5	4.60	.57	5.30	.710
Nov. 24	776.4	5.18	.59	5.45	.770
Dec. 24	680.0	5.42	.55	4.50	.747
Jan. 23	6748	5.15	.52	4.55	.615
Feb. 22	652.5	5.35	.56	3.70	.707
Mar. 23	669.5	5.02	.55	4.10	.712
Apr 22	634.9	5.20	.55	4.35	.720
May 22	615.6	5.03	.53	4.60	.728
June 21	586.8	4.80	.56	4.00	.697
July 21	619.0	4.20	.55	4.78	.664
Aug. 20	599.7	4.20	.57	4.49	.697
Sep. 23	*509.8	4.30	.59	3.89	.609

* 32 days
* 34 days

In estimating the combustion value of the milk in table 38 the following values of the milk solids in calories per gram are used: fat 9.23, protein, 5.86, sugar 3.95 (24).

TABLE 38
TOTAL YIELDS OF MILK AND MILK CONSTITUENTS

No. of cow	Lbs milk	Lbs. fat	Lbs. protein	Lbs sugar	Combustion value Therms
27	8522.9	470.0	339.4	392.5	3576.2
62	3188.9	169.4	127.3	144.4	1307.4
4	6773.6	372.9	278.3	290.2	2823.3
63	6033.9	367.9	263.8	265.4	2719.3
43	7939.5	387.9	282.5	359.7	3022.0

(24) Hammersten's Physiological Chemistry.

TABLE 39

COMPARISON WITH HAECKER'S STANDARD

DIGESTIBLE NUTRIENTS FOR 1 POUND OF MILK

	Actually used				Haecker's standard (7)			
Cow No.	% Fat in milk	Protein	Carbohydrates	Fat	Protein	Carbohydrates	Fat
27	5.5	.054	.314	.022	.057	.263	.019
62	5.3	.053	.272	.011	.056	.256	.019
4	5.5	.060	.318	.015	.057	.263	.019
63	6.1	.074	.412	.020	.061	.283	.021
43	4.9	.060	.303	.015	.053	.243	.018
Average	5.5	.060	.324	.017	.057	.262	.019
Average carbohydrate equivalent		.422				.362	
Assuming feeds to be of Average composition and digestibility and deducting .7 lb. protein, 7. carbohydrates and .1 lb. fat for daily maintenance of each 1000 lbs. live weight							
27		.083	.292	.028	.057	.263	.019
62		.089	.133	.036	.056	.256	.019
4		.098	.330	.032	.057	.263	.019
63		.105	.342	.036	.061	.283	.021
43		.091	.296	.028	.053	.243	.018
Average		.093	.279	.032	.057	.262	.019
Average carbohydrate equivalent		.444				.362	

(7) Bul.79 Minn.

It will be noticed from the first part of this table that the nutrients required to produce ~~required to produce~~ a pound of milk is very uniform for all of the cows with the exception of No. 63. No. 63 yielded the richest milk and her requirement was the highest. This would seem to indicate that rich milk required more food for its production than we have ordinarily assumed. Definite conclusions can not be drawn, however, from the results obtained with this one animal as there may have been some abnormality or condition overlooked.

The carbohydrate equivalent mentioned in the table was obtained by multiplying the fat by 2.25 and then adding the three components together. These five cows used 16% more nutriment than is prescribed by Haecker's standard for the production of the same quality of milk.

In the second part of this table it will be noticed that the protein and fat are higher and the carbohydrates lower than in the first part. The reason for this is that Haecker's standard for maintenance calls for less protein and fat and more carbohydrates than were actually supplied to these animals. The very low requirement of No 62. is due to the fact that Haecker's standard for maintenance prescribes considerably more nutriment than this cow actually used.

In the formulation and use of this standard for milk, Haecker no doubt employed for the feed average figures of composition and digestibility. The reason then for presenting the second part of this table is to show whether or not Haecker's standard is applicable when the conditions under which it is supposed to be used are prtvided. It will be noticed that the

discrepancy is even greater than in the first part of the table.

Armsby's method prescribes .05 lb. digestible albuminoids and .3 therm for the production of one pound of 4% milk. (4) Since these cows did not yield 4% milk it was necessary to establish some basis for comparison. This was done by first ascertaining the combustion value of average 3, 4, 5 and 6% milk and then assuming that the nutrient requirement is proportional to the combustion value of the milk. Whether or not we are justified in such an assumption may be shown in some of the data which follows. Table 40 gives the results of this computation.

TABLE 40

ARMSBY'S STANDARD FOR PRODUCTION OF 1 LB. MILK:

% Fat in milk	Combustion value of 1 lb. milk Therms	Digestible albuminoids	Energy value Therms in feed
3.0	.28	.040	.24
4.0	.35	.050	.30
5.0	.40	.057	.34
6.0	.45	.064	.38

(4) Farmers' Bul., 346

TABLE 41

COMPARISON WITH ARMSBY'S STANDARD NUTRIENTS FOR 1 LB. OF MILK:

Cow No.	Actually required			Armsby's Standard	
	% Fat in milk	Digestible albuminoids	Energy value Therms	Digestible albuminoids	Energy value Therms
27	5.5	.039	.346	.060	.36
62	5.3	.037	.293	.059	.35
4	5.5	.044	.336	.060	.36
63	6.1	.054	.437	.065	.38
43	4.9	.045	.327	.056	.34
Average	5.5	.044	.348	.060	.36
Assuming feeds to be of average composition and digestibility and deducting .5 lb. albuminoids and 6. therms for daily maintenance of each 1000 lbs. live weight					
27		.065	.418	.060	.36
62		.072	.344	.059	.35
4		.075	.452	.060	.36
63		.082	.498	.065	.38
43		.071	.409	.056	.34
Average		.073	.424	.060	.36

It will be seen in the first part of this table that the average energy value of the nutrients required to produce one pound of milk checks closely with the figures computed as described above. This does not necessarily mean that Armsby's standard for 4% milk is correct nor that the nutrient requirement for milk is proportional to the combustion value of the milk.

In the second part of this table it will be noticed that more protein and energy are required than in the first. This shows that Armsby's allowance for the maintenance of a milking cow when average figures of composition and digestibility are used is too low. For milk these cows used 18% more nutrients than prescribed by Armsby.

The next table was prepared for the purpose of ascertaining whether the nutrients of the ration varied least with the pounds of milk, the pounds of fat, or the combustion value of the milk produced.

TABLE 42

Number of cow	27	62	4	63	43	Average	% Variation
Ratio between the energy value of the feed available for milk and Pounds of milk 1	2.89	3.41	2.98	2.29	3.05	2.92	49
Pounds of fat 1	.159	.181	.164	.140	.150	.159	29
Combustion value of the milk 1	1.21	1.40	1.24	1.03	1.16	1.21	36

No.62 was the most economical producer and No. 63 the most expensive. The per cent of variation between these two is shown in the last column and it will be noticed that the variation is least with the fat. This would seem to indicate that in estimating the nutrients required for milk the pounds of fat produced should be taken as a basis rather than the pounds of milk or the combustion value of the milk solids. Definite conclusions concerning this matter can not, however, be drawn from this data alone. The combustion value of the milk is greater than the energy value of the feed available for milk which shows that the figures given by Armsby on the energy values of protein, carbohydrates and fat are not high enough for milk production. (3) This does not mean that the relative values assigned to protein, carbohydrates and fat are incorrect nor that the methods for calculating the relative values of the different feeds is inaccurate.

(3) Bul. 71 Pa.

The data obtained from cows 206, 400, 304, and 303 is presented separately and in an abbreviated form, since the investigation is as yet incomplete and the results are therefore tentative in nature.

Tables 43, 44, 45 and 46 contain summaries of feed consumed and the average weights of the cows.

TABLE 43

Cow No. 206 (Holstein)

SUMMARY OF FEED CONSUMED

(Weights in pounds)

Period No.	Date 1910	Grain	Hay.	Silage	Average weights of cow
1	11-27--12- 1	59	59	233	1292
2	12- 2--12-11	116	116	464	1295
3	12-12--12-21	120	116	461	1286
4	12-22--12-31	120	120	394	1286
5	1- 1-- 1-10	120	116.5	386	1284
6	1-11-- 1-20	100	94.5	312.5	1236
7	1-21-- 1-30	110	110	400	1291
8	1-31-- 2- 9	110	110	400	1330
9	2-10-- 2-19	110	110	400	1328
10	2-20-- 3- 1	110	110	400	1311
11	3- 2-- 3-11	110	110	400	1340
12	3-12-- 3-21	110	110	400	1353
13	3-22-- 3-31	101	101	400	1349
14	4- 1-- 4-10	100	100	400	1340
15	4-11-- 4-20	92	100	400	1364
16	4-21-- 4-30	90	90	400	1367
Total	155 days	1678	1673	6250.5	1316

TABLE 44

Cow No. 400 (Shorthorn)

SUMMARY OF FEED CONSUMED

(Weights in pounds)

Period No	Date 1910	Grain	Hay	Silage	Average weight of cow
1	12-27--12-31	35	35	140	1134
2	1- 1-- 1-10	70	70	329	1111
3	1-11-- 1-20	79	79	350	1120
4	1-21-- 1-30	80	80	350	1144
5	1-31-- 2- 9	80	80	350	1150
6	2-10-- 2-19	80	80	350	1151
7	2-20-- 3- 1	80	80	350	1162
8	3- 2-- 3-11	71	71	350	1173
9	3-12-- 3-21	70	70	350	1170
10	3-22-- 3-31	61	61	350	1168
11	4- 1-- 4-10	60	60	350	1174
12	4-11-- 4-20	44	60	350	1180
13	4-21-- 4-30	50	50	300	1154
Total	125 days	860	876	4269	1153

TABLE 45

Cow No. 304 (Ayrshire)

SUMMARY OF FEED CONSUMED

(Weights in pounds)

Period No	Date 1911	Grain	Hay	Silage	Average weight of cow
1	1-11— 1-20	99	95.5	304	976
2	1-21— 1-30	105	97	305	973
3	1-31— 2- 9	120	90	294	995
4	2-10— 2-19	100	85	300	972
5	2-20— 3-1	97.5	90	265	973
6	3- 2— 3-11	82	90	257	959
7	3-12— 3-21	100	90	300	965
8	3-22— 3-31	100	90	300	962
9	4- 1— 4-10	76	75.5	259	963
10	4-11— 4-20	69	69	283	953
11	4-21— 4-30	70	70	300	967
Total	110 days	1018.5	942	3167	969

TABLE 46

Cow No. 303 (Ayrshire)

SUMMARY OF FEED CONSUMED

(Weights in pounds)

Period No.	Date 1911	Grain	Hay	Silage	Average weight of cow
1	1-23-- 1-30	67	67	240	990
2	1-31-- 2- 9	96	96	300	1010
3	2-10-- 2-19	100	93.5	280	1004
4	2-20-- 3- 1	91	89	295	1003
5	3- 2-- 3-11	90	90	300	1028
6	3-12-- 3-21	90	90	300	1024
7	3-22-- 3-31	81	81	300	1039
8	4- 1-- 4-10	70	70	300	1029
9	4-11-- 4-20	54	70	340	1047
10	4-21-- 4-30	60	60	300	1039
Total	98 days	799	806.5	2955	1021

It will be noticed that Nos. 206, 400, and 303 show gains in weight while 304 has about the same weight at the end as at the beginning. The indications are that the cows have been amply nourished and that on the whole they have been overfed rather than underfed. These weights will be reduced before the investigation ends.

The next three tables show the yields of milk and fat for these four animals. Complete analyses of the milk have not yet been made so the combustion value of the milk as given in

table 49 is estimated from the average of milks containing the same percentages of fat.

TABLE 47.

YIELDS OF MILK AND FAT

Period No.	No. 206 Lbs. milk	% fat	Lbs. fat	No. 400 Lbs. milk	% fat	Lbs. fat.
1.	217.4	3.4	7.392	105.7	4.4	4.651
2.	402.6	3.8	15.299	207.7	4.4	9.139
3.	427.3	3.7	15.810	213.0	4.3	9.159
4.	432.8	3.5	15.148	228.4	3.9	8.908
5.	409.2	3.4	13.913	228.8	4.0	9.152
6.	372.6	3.4	12.668	227.6	4.0	9.104
7.	445.4	3.4	15.144	224.6	4.1	9.209
8.	403.3	3.5	14.115	225.5	3.9	8.794
9.	427.5	3.6	15.390	220.1	3.9	8.584
10.	403.1	3.6	14.512	207.3	4.1	8.499
11	412.8	3.7	15.274	199.5	4.1	8.180
12	410.0	3.6	14.760	199.2	3.9	7.769
13	360.0	3.8	13.680	192.9	3.9	7.523
14	377.4	3.8	14.341			
15	372.1	3.7	13.768			
16	349.0	3.7	12.913			
Total	6222.5	3.6	224.13	2680.3	4.1	108.67

TABIE 48

YIELDS OF MILK AND FAT

Period:	No. 304			No. 303		
	Lbs. milk	% Fat	Lbs. Fat	Lbs. milk	% Fat	Lbs. fat
1	366.8	4.3	15.772	238.1	4.1	9.762
2	389.2	4.0	15.568	307.5	4.1	12.607
3	397.6	4.1	16.302	312.9	3.9	12.203
4	388.2	3.9	15.140	293.4	4.1	12.029
5	344.9	4.0	13.796	297.2	4.0	11.888
6	326.5	3.8	12.407	297.2	3.9	11.591
7	336.9	3.8	12.802	284.3	4.0	11.372
8	322.1	3.8	12.240	270.8	4.1	11.103
9	260.3	4.1	10.672	264.3	4.0	10.572
10	276.8	3.6	9.965	254.2	4.1	10.422
11	264.3	3.9	10.308			
Total	3673.6	3.9	144.97	2819.9	4.0	113.55

TABLE 49

TOTAL YIELDS OF MILK AND FAT AND THE ESTIMATED COMBUSTION VALUE OF THE MILK

Number of cow	Pounds of milk	Pounds of fat	Combustion value of milk
206	6222.5	224.13	2003.64
400	2680.3	108.67	951.51
304	3673.6	144.97	1260.04
303	2819.9	113.55	986.96

In preparing the next four tables the average figures for digestible nutrients and energy values are used since complete analyses of the feed are not available. The maintenance requirements are calculated according to Haecker and Armsby.

TABLE 50

Cow No. 206

DIGESTIBLE NUTRIENTS AND ENERGY VALUES OF FEED CONSUMED

Feed	Amount	Digestible: Protein	Digestible: Carbo-hydrates	Digestible: Ether Ext.	Digestible albuminoids	Energy values Therms
Corn	958.9	68.47	634.02	47.66	65.11	851.89
Bran	479.4	57.58	197.66	13.76	48.95	231.21
Oilmeal	239.7	73.32	92.81	6.95	70.14	178.98
Alfalfa	1673.0	177.00	624.53	23.09	115.94	575.68
Silage	6250.6	75.63	910.07	55.00	55.00	1035.08
Total for maintenance & milk		452.00	2459.09	146.46	355.14	2872.84
Total for maintenance		142.79	1427.86	20.40	93.00	1116.00
Total for milk 6222.5 lbs		309.21	1031.23	126.06	262.14	1756.84
For 1 lb. milk	3.6 %fat	.050	.166	.020	.042	.282

TABLE 51

Cow No. 400

DIGESTIBLE NUTRIENTS AND ENERGY VALUES OF FEED CONSUMED

Feed	Amount	Digestible: Protein	Carbohydrates	Ether Ext.	Digestible albuminoids	Energy value Therms
Corn	491.4	35.09	324.91	24.42	33.37	436.56
Bran	245.7	29.51	101.30	7.05	25.09	118.50
Oilmeal	122.9	37.60	47.59	3.56	35.96	91.77
Alfalfa	876.0	92.68	327.01	12.09	60.71	301.43
Silage	4269.0	51.65	621.57	37.57	37.57	706.95
Total for maintenance and milk		246.53	1422.38	84.69	192.70	1655.21
Total for maintenance		100.89	1008.87	14.41	68.75	825.00
Total for milk 2680.3 lbs		145.64	413.51	70.28	123.95	830.21
For 1 lb. milk 4.1% fat		.054	.154	.026	.046	.310

TABLE 52

Cow No. 304.

DIGESTIBLE NUTRIENTS AND ENERGY VALUES OF FEED CONSUMED

Feed	Amount	Digestible. Protein	Carbohydrates	Ether Ext.	Digestible albuminoids	Energy value Therms
Corn	582.0	41.55	384.82	28.93	39.52	517.05
Bran	291.0	34.95	119.98	8.35	29.71	140.35
Oilmeal	145.5	44.51	56.34	4.22	42.57	108.64
Alfalfa	942	99.66	351.65	13.00	65.28	324.14
Silage	3167	38.32	461.12	27.87	27.87	524.46
Total for maintenance and milk		258.99	1373.91	82.37	304.95	1614.64
Total for maintenance		74.61	746.13	10.66	53.90	646.80
Total for milk 3673.6 lbs.		184.38	627.78	71.71	151.05	967.84
For 1 lb. milk 3.9 % fat		.050	.171	.020	.041	.263

TABLE 53

DIGESTIBLE NUTRIENTS AND ENERGY VALUES OF FEED CONSUMED

Cow No. 303

Feed	Amount	Digestible. Protein	Carbohydrates	Ether Ext.	Digestible albuminoids	Energy value Therms
Corn	456.6	32.60	301.90	22.69	31.00	405.64
Bran	228.3	27.42	94.13	6.55	23.31	110.11
Oilmeal	114.1	34.90	44.18	3.31	33.39	85.20
Alfalfa	806.5	85.33	301.07	11.13	55.89	277.52
Silage	2955.0	35.76	430.25	26.00	26.00	489.35
Total for maintenance and milk		216.01	1171.53	69.68	169.59	1367.82
Total for maintenance		70.04	700.41	10.01	49.49	553.88
Total for milk 2819.9 lbs		145.97	471.12	59.67	120.10	813.94
For 1 lb. milk 4.0 % fat		.052	.167	.021	.043	.289

TABLE 54

COMPARISON WITH HAECKER'S STANDARD

Digestible nutrients for 1 lb. of milk

	HAECKER'S STANDARD						
NO. of cow:	% Fat in milk	Protein	Carbo-hydrates	Fat	Protein	Carbo-hydrates	Fat
206	3.6	.050	.166	.020	.044	.200	.015
400	4.1	.054	.154	.026	.047	.217	.016
304	3.9	.050	.171	.020	.046	.210	.016
303	4.0	.052	.167	.021	.047	.210	.016
Average	3.9	.052	.164	.022	.046	.209	.016
Average carbohydrate equivalent			.265			.291	

These cows used more protein and fat and less carbohydrates than ~~is~~ are prescribed in Haecker's standard. The standard calls for about 10% more nutriment than these cows received, and it should be remembered that they were overfed rather than underfed. This data taken in connection with that in table 39 admits in the writer's opinion of only one conclusion---- Haecker's standard does not call for as much difference between the nutrients required for milk of medium and high qualities as was found in this investigation.

TABLE 55

COMPARISON WITH ARMSBY'S STANDARD

Nutrients for 1 lb. milk

No. of cow	%Fat in milk	Digestible albuminoids	Energy value Therms	Armsby's Standard: Digestible albuminoids	Armsby's Standard: Energy value Therms
206	3.6	.042	.282	.046	.28
400	4.1	.046	.310	.051	.30
304	3.9	.041	.263	.049	.29
303	4.0	.043	.289	.050	.30
Average	3.9	.043	.286	.049	.29

It will be observed that the energy value of the feed used by these cows corresponds almost exactly with Armsby's standard. Taken in connection with the latter part of table 41, it is evident that rich milk requires more nutriment for its production than the combustion value of the milk would indicate.

TABLE 56

Number of cow	206	400	304	303	Average	Average of 5 Jerseys under comparable conditions:	%Variation between the two averages
Ratio between the energy value of the feed available for milk and Pounds of milk, 1	3.54	3.23	3.80	3.46	3.51	2.36	49
Pounds of fat, 1	.128	.131	.150	.140	.137	.129	6
Combustion value of the milk, 1	1.14	1.15	1.30	1.21	1.20	1.00	20

This table shows that the four cows yielding milk testing an average of 3.9% are more economical producers of milk, butterfat and milk solids than are the Jerseys, the milk of which tests 5.5% on the average. The data concerning the economy of production of fat runs contrary to the general opinions of dairymen. Jerseys have been found to be more economical producers of fat than are the cows of the other breeds. This has been commonly explained on the basis of the composition of the milk. Jersey milk contains more fat in proportion to the other milk constituents. It is barely possible that we shall be compelled to seek some other explanation. It seems to the writer that this matter could be explained upon other grounds. Jersey cows will produce more butterfat in proportion to their size than will the cows of the larger breeds. The food of maintenance, therefore, per unit of butterfat produced is less than with the other breeds, which would make the production more economical.

The last column shows unmistakably that the nutrients required per lb. of milk varies to such an extent that the amount of milk produced is in itself an unsafe guide to follow in practical feeding operations. The quality of the milk must be taken into account when it varies to any considerable extent. Feeding in accordance with the production of butterfat is the most accurate method.

Conclusions-- The data presented will admit of the following conclusions:

Milking cows when fed just short of the limit of their appetites will digest a smaller percentage of their food than when they are dry and receiving a maintenance ration.

The amounts of digestible food components required for the production of rich milk as suggested by Haecker were less than these Jersey cows used; for the production of medium quality milk the results check very well.

Armsby's allowance for the production of a pound of four per cent milk corresponds closely with what was found in this investigation when average figures of composition and of digestion coefficients were employed in making the computations. With actual coefficients his standard would call for more than was used.

The food requirements do not vary in the same proportion as the combustion value of the product. Butterfat requires more food for its production than its combustion value would indicate to be necessary.

Feeding operations based upon the amounts of fat produced more nearly meet the actual requirements than do those based upon the amounts of milk or milk solids produced.

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