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Milk Production .

By Masaji Kugimoto.

Detailed Tables.

Tables I, II, III, IV, V,

VI, and VII.

(A Study on Transference of Nutrients to Animal Body from Feed.)
By
Masaji Kugimoto.

MILK PRODUCTION

"A thesis submitted to the faculty of the Graduate School of the University of Minnesota by Masaji Kugimoto, in partial fulfillment of the requirements for the degree of Master of Science, April 1, 1912.

MILK PRODUCTION

M. Kugimoto, Jan. 1912.

I STUDY OF MILK PRODUCTION

It is desired in this thesis to discuss the relation of food or nutrients of food consumed to the quantity and quality of milk produced and finally to bring out the most ample amounts of the nutrients to be fed for the production of a certain quantity of milk of a certain quality.

II BRIEF NOTES OF SOME NOTABLE INVESTIGATIONS UP TO THE PRESENT TIME.

It may be said the first door of such investigations as now generally referred to as the science of animal nutrition, was opened in the early sixties of last century by Henneburg and Stohmann, German scientists. Liebig and Boussiugault, also for their applying chemistry, and Lawes and Gilbert, for their comparative experiments of feeding stuffs must be remembered in early history of investigations on that line.

III HAY VALUES

The first systematic feeding for practical uses considered by German $cientists was the hay value system, which at first proposed by Th$er. It was to show the value of the different feeds for feeding purposes referred to a standard unit, that is, that of good meadow-hay.

It may be very distinct that such a system was found of small value. As chemical analyses of the different feeding stuffs accumulated and the proximate composition of feeds better understood, system of valuation of feeding stuffs were based on the amount of food component like protein, fat and carbohydrates contained in the respective feeds. Thus it naturally conducted to the investigation of the so called "Feeding Standards" which have to show some definite number about the components required by for their daily sustenance, and for the production of an increase in body weight or of animal products, such as milk, wool, etc.

It will ~~not~~ be interesting, however, to notice that during recent years a modification of this system has sprung up in Denmark, and prevailed all thru the dairy districts in Northern Europe very successfully, the so called "food unit" as a matter of convenience in determining the approximate amounts of feed which a herd or individual animal ~~herein~~ receives during a given period, generally a year, and the economy of the production of the animals for this time.

IV GROUVEN'S FEEDING STANDARD

This was proposed by Grouven in 1853 and perhaps, it may be the first feeding standard. The standard showed the quantity of dry substance, protein, carbohydrates and fat, which an animal of a certain weight would require daily in its feed ration. For milch cows, weighing 450 kg. (992 lbs.) the following standard was proposed:

28.7 lbs. dry matter
2.76 lbs. protein
14.55 lbs. carbohydrates.
.86 lbs. fat.

nutritive ratio being 1:6.1.
Eight standards were proposed for milch cows, according to the live weight, ranging from 772 lbs (350 kg.) to 1.543 lbs (700 kg.)

This investigation was not based on the digestible amounts of the respective components, but on only those chemical amounts, that is on those determined by chemical analyses, of feeding stuffs.

It became, however, naturally distinct that such a system based but on chemical analyses might give a very unreliable and misleading guide to their value for feeding purposes, and, therefore, it is necessary to put into it physiological considerations. In other words, the feeding standard should be changed to show the requirements of digestible nutrients, instead of crude food materials as it was previously.

It is not the case of this thesis to go in detail on such line as to digestion experiments of cows, but it may not be unnecessary to notice here that the digestibility or coefficient of digestion of a certain kind of food-stuff is so slightly changeable by individual animals of a certain kind that practically it is negligible.

V WOLEF'S FEEDING STANDARD

Feeding standard based on the digestible nutrients was established in 1864 by the famous German Agricultural chemist Emil V. Wolff, which is really the first and fundamental for the modern investigations. It can be acknowledged as much important it was, as it subjected to so many criticisms by modern investigators. It was generally recognized as the standard guide in feeding farm animals for a long time. The Wolff standard ration for milch cows weighing 1000 lbs. is as follows;

Dry matter 24.50 lbs.
Digestible protein 2.5 lbs.
Digestible carbohydrates 12.5 lbs.
Digestible fat .4 lbs.

Total digestible substance 15.4 lbs. nutritive ratio 1:5.4.

After this Julius Kühn, having proposed his own standard (dry matter 20-23.5 lbs, albumenoids 1.5-2.4 lbs, nitrogen-free-extract, crude fiber and amides 12-14 lbs, nutritive ratio 1:5.5 to 8) a long continued controversy was waged by the respective authors, as to the advisability of placing the nutrients required by farm animals at absolute rigid values, irrespective of the production of the animals feed, or their individual characteristics.

VI WOLFF-LEHMANN'S FEEDING STANDARD.

It can be easily understood that such feeding standards as proposed by Wolff, which fixes certain amounts of nutrients, to be fed, quite irrespective of the production and individual characteristics is irrational.

C. Lehmann is the first investigator who improved the old feeding standard, though not perfectly to meet this objection. He modified Wolff's standard in 1897 by taking the flow of milk in considera tion and showed the quantity of nutrients to be supplied in the daily rations for maximum production, in case of cows yielding from 11.0 to 27.5 pounds of milk daily. This iscalled as "Wolff Lehmann Feeding Standard."

Wolff Lehmann Feeding Standards for Dairy Cows

When yielding daily	Total Dry matter	Digestible Nutrients. Protein	C. H.	Fat	Nutritive Ratio
11 lb.milk	25 lb.	1.6 lb.	10 lb.	0.3 lb.	1: 6.7
16.6 lb. milk	27	2.0	11	0.4	6.0
22.0 lb. milk	29	2.5	13	0.5	5.7
27.5 lb. milk	32	3.3	13	0.8	4.5
Standard of Maintenance ration (1000)	18.0	.7	8.0	.1	11.8

The standard given by Dr. Lehmann certainly was a great improvement because it is in a measure a guide in adjusting the ration to the needs of animals varying in productive capacity. However, the fact that there exist the great variations in the amount of solids in the same quantity of milk yielded by several cows indicate necessarily that there should be one more step to be taken in consideration. The step is to find out the amount of nutrients to meet for production of milk of certain quality of composition as well as its quantity.

VII HAECKER'S FEEDING STANDARD

The work above as suggested that is, to adjust the nutrients to be fed to the quality as well as the quantity of the milk produced, was done, first in the world by Prof. Haecker of Minnesota Station. Really, we can say that every mystery in milk-producing machinery or cows was exposed by his vast investigations to our ability. He says "It has long since been recognized that because of the difference in composition of the various kinds of feed stuffs no standard of composition for all feeds would be practical, and yet, while there is as great a difference in the composition of milks as there is in feed stuffs, there has been no adjustment of the nutrients in the ration to the quantity and character of the solids contained in the milk yielded though such an adjustment is simple and practicable.""If in formulating a ration it is deemed necessary in economic milk production, to take note of the fact that one feed stuff contains 12 per cent protein and another 20 percent, is it not equally important in our attempt to adjust the ration to the needs of the cows in milk production to also take into account the fact that one cow may give containing 3 percent fat while that of another may contain twice as much? It would seem quite as consistent to feed an animal food regardless of the composition of the product which is to be elaborated from the nutrients in the food."

It is the chief object of this thesis to discuss his work, and therefore, shall not be considered here.

VIII SOME IMPORTANT FEATURES ABOUT WOLFF-LEHMANN FEEDING STANDARD.

It will be convenient to note here the amount of protein supposed to be required for production of one pound of milk in Wolff Lehmann standard, which though Lehmann does not give it apparently, may be known by figuring it. We can notice in the standard that after the .7 of a pound of digestible protein per 1000 pounds for body maintenance was provided for, the remainder of the protein was available for milk production and that .081 of a pound was the amount of protein needed for the production of 1 pound of milk.

IX SOME OTHER FEEDING STANDARDS.

Prof. Atwood and Phelps of the Connecticut Experiment Station made a special study of this subject for several winters and submitted a standard. Prof. Woll of Wisconsin collected data from the reports from 128 dairymen and submitted a proposed American Standard ration for dairy cows based on the average obtained from the ration.

In spite of that they are all noted investigators on this line, and would have noticed Lehmann's wisdom, they didn't give any data about the quantity as well as quality of milk yielded. It will seem of little value to one who learned the subject more exactly and rationally from a practical and scientific point of view.

Heretofore it was the writer's intention to give the chief steps of improvement of the investigations along this line and thus to make the foundation of the study clear.

X FORMATION OF MILK

The writer wishes here to give briefly some necessary notes on this subject, which have some bearing tothis discussion.

It is well known fact that the milk is

not a simple excretory product, but is a substance formed from the fluid of the body by chemical changes in milk gland. The material which is brought to the mammary gland is utilized first of all to build up certain cells which on completion are wholly or partly destroyed. These productions of decomposition are milk, which in this way may be regarded as a fluid organ. It follows, the writer thinks, the important fact that the quality of milk cannot be changed materially by the feed but depends on the individualities of cows. The milk gland is filled with numerous nerves fibres along side the blood capillaries and regulate the flow of blood into the alvedi, or milk manufacturing cells and also control their activity, which is essential to the production of milk.

The fact will suggest the importance of ample supply of protein for the production of milk because it is accompanied by cell formation and destruction, to which the forming and stimulating action of protein are essential. And it will be seen that the productiveness of milk gland may to a great extent be controlled by nerves system of cows. It is a good hint to see how hard it is and how careful one must be not to disturb the nerves system of cows in carrying experiments along this line for a good or near-truth result.

XI GENERAL CONCIDERATION OF VARIOUS INFLUENCES UPON THE MILK PRODUCTION.

Preparatory to the discussion of the chief subject, that is, the study on the relation between food and milk production, it will be neceasary to consider, though briefly, the principal various influences, which effect more or less the production of milk and thus to know how far the food may play the part in that problem.

XII INFLUENCE OF BREED AND INDIVIDUALITY.

The development of the mammary gland like any other organ, cannot be increased separately by any kind of feeding, but is to a certain extent hereditary fixed. Therefore it arises between the several breeds and individuals considerable differences in the quantity and composition of milk are to be found. Definite information regarding the milk yields of the various breeds cannot be given on account of the variety of conditions and of that today there exist as much difference among each individual as among the breeds. It may be said, though, that in general, Holstein, Ayrshire, etc. give a greater quantity of milk poorer in fat and solids than such breeds as Jersey, Guernsey, etc.

The individual animals of the various breeds also behave very differently. And also there are the variations in the daily yield which are often observed with the same cow. So many attempts have been made to promote the quantity and quality of milk by giving more and richer feeds and as many results were raised. In the long run it seems was not able but to help or stimulate the development or action of mammary organ within their own natures of cows, altho it might have sometimes shown some tremendous changes in milk produced for a few days, having caused abnormal condition.

Observation of this kind shows how extraordinarily changeable is the influence of individuality upon the production and also they teach how deceptive are the results of experiments carried out upon a small number of animals and a short period of time.

XIII INFLUENCE OF THE PERIOD OF LACTATION.

The formation of milk, which begins at the time of calving, does not always remain at the same level, but in time decreases until, usually sometime before the next calving, no more milk is formed and the cow is dry. Here also the individuality of the animal gives very variable results. With many cows the yield of milk increases for several months after calving, remains for some considerable time at the highest yield, then falls quickly or slowly and remains for a period at that level; but here again no universally applicable rule exists. Generally in the course of lactation the percentage quantity of dry matter and fat increases, but to this also there are plenty of exceptions.

XIV INFLUENCE OF THE AGE.

The general capacity of the more highly developed animals increases during the first period life, then remain for sometime at the same level and afterwards begin to diminish. It is the same with the milking capacity of cows, and observations have shown that the yield of milk increases up to about the time of the fifth or sixth calf, whereas the average percentage of fat in the milk remains constant up to that time and for several years longer. Great differences are shown, though, in the behavior of individual cows.

This is one of the most important factors regarding the milk production and should be considered in more detail. (refer to XXVII)

XV INFLUENCE OF TREATMENT AND CARE

The feeling of comfort and well-being has a greater influence upon the production of milk than in almost any other direction. Everything that upset the cow, rough handling, insufficient litter, a cold stall, and similar disturbing factors, all act unfavorably upon the production of milk.

As much easier are the nerve systems of cows, which control to a great extent the secretion of milk, disturbed as more delicate are their functions than in any other stock.

It is also true that cows if they are badly treated, are inclined to lessen their production very quickly whenever the food is short, while as they are well treated, they continue their production a good while, sacrificing their own body substances.

XVI GENERAL CONSIDERATIONS OF THE EFFECTS OF FOOD ON THE MILK PRODUCTION.

Here the writer arrived at the point to go into the study of relation between food and milk production, having finished, though not satisfactory, important preliminary discussions, which he thought, must be presented previously.

As milk is practically only changed mammary gland substance, it depends largely upon the development and activity of the gland what proportion of the nutrients flowing to it are converted into milk. There is, however, a limit to the development of the mammary gland as there is to all other organs, and adaptation and heredity determine this. The individuality of the animal and the condition of the mammary gland as influenced by the period of lactation have the greatest effect upon the milk yield. The age has a large influence on its condition. The food, along with other factors, plays a less important part, and only exerts an influence within the limits of the capacity of the mammary organ. It is upon the food, though, that the efficiency of the gland very largely depends.

From the part played by the mammary gland in the process of milk secretion (refer to X), it is easily explained why the food has little influence upon the composition of the milk. The animal organs one and all have a very constant composition; the lime of bones cannot be replaced by the other similar alkaline earth, nor the potash in the organism by the very analogous soda. Further, the protein substances in the blood cannot be replaced by others of a similar kind, nor can the components of the mammary gland alter.

An organ like the mammary gland which is always of the same composition, can, therefore, when it liquifies, only yield products which are characterized by great similarity.

Same reasons are applicable for that composition of milk are characterized by the individualities of cows, because the composition of milk gland may differ to some extent by individuals.

The natural individualities of cows are so strong that when a change is made from a liberal to a scanty diet, the milk gland, as a rule, does not immediately accomodate itself to the quantity of food, but remains for a shorter or longer time at the old level, (refer to XV). In this case a greater or less portion of milk is made from body substance (flesh and fat) and the cow may consequently lose her weight without the yield of milk undergoing any noticeable diminuition in composition, though there is a rapid fall in the quantity.

XVII NECESSARY CARE IN CARRYING ON THE EXPERIMENTS ALONG THIS LINE.

If we think over the things described here to fore, it is easy to understand how difficult it is and how much care must be taken to carry on such experiments to get standard results. Cows are so easily susceptible even to a slight disturbance; their individuality differs so to a great extent, so changeable their functions are by ages or even by day.

We are able to find many of the experiments which have been conducted in the past are of a very doubtful value and in many cases safely excluded from consideration, for one or several reasons. The most frequent error of earlier experiments was that they were conducted with a small number of cows, generally one or two, and for a brief period of time, often for only a couple of weeks without any introductory or intermediate feeding periods during which the cow might become accustomed to the system of feeding adapted. Any change in the system of feeding or management is necessarily accompanied by an immediate disturbance of the normal character of production of cows, and it is only after some time has passed, from a few days to several weeks, that the system of the animal is able to adjust itself to the change in the feed ration or any other condition, so the following may be necessary to secure standard results:

1. Number of cows used for experiment should

be as many as possible (enough to eliminate individ-
ualities)

2. They should be those doing normal work.

3. They should not be too young in age, but be mature.

4. The period of experiment should be as long as possible.

5. The period should be in the average lactation period, that is, not too near the beginning nor the end.

6. Cows should be fed and managed as normal as possible. Any particular change is objectionable..

All these things will suggest that many results obtained by so called scientific methods of experiments in past failed in practical uses or were far from truth and those of Prof. Haecker's investigations in Minnesota Station alone were satisfactory and are finding a wonderful agreement with practical workers. We cannot judge the results of such kind experiments, but the facts or the cows only can.

XVIII NUTRIENTS AND THEIR FUNCTIONS.

Protein, fats, nitrogen free extract, crude fibre, water and ash serve to supply the needs of animals and all of them are to be considered as nutrients. Water and ash play very important part in animal life, and must be considered. However, here they will be excluded from discussion. Nitrogen free extract and crude fibre are classed as carbohydrates and the digestible amounts in both of these plant substances are regarded as of equal value and supply the same needs in the animal body. Besides them, there are non-protein, nitrogenous matters to be considered, which exist in notable amounts in some feed stuffs. They are, though, usually of small quantity as compared with genuine protein and also their functions have been recently found about the same with protein in ruminant animals. Amount of protein in this thesis ~~reports~~ refers to the amount of crude protein, which determined by multiplying the amount of nitrogen in feed with 6.25. Generally saying, protein builds up body, repairs the broken down tissues, stimulates animal organisms and also the action of other nutrients. Without protein the animal cannot live. When animals are fed protein in the right portions, they possess vigor and look smart and lively. Protein hardly ever performs the functions of fats and carbohydrates unless those latter nutrients are lacking in animal food.

Fats and carbohydrates perform the same functions and supply the fuel for the animal body. They are heat producers and furnish the substances that keep the animal warm. Protein can be made perfectly to take their place, but they cannot work the whole part of protein. As an energy and heat producer, fats have practically 2.25 times more value than carbohydrates.

As milk contains a lot of protein substances, milch cows must always have a sufficient quantity of this material in the ration if the tissues of the body are not to be used for the formation of milk.

All the investigations in which foods rich in protein have been compared with those poor in this material have shown the powerful influence which the former exercise upon the yield of milk. If the allowance of protein in a ration is diminished, then, altho there may be a sufficiency of non-nitrogenous matter, the yield of milk decreases rapidly.

As milk contains also in addition to the protein large quantities of fat and milk sugar, those constituents must be formed from the digested fat and carbohydrates. Many experiments proved that milk fat, like body fat, can be made from the carbohydrates of the food. These two components of milk can, it is true probably be formed from the protein of the food, but as the amount of this is not as a rule excessive, there is not likely to be much available surplus after the protein of the milk has taken what it requires. Should there be a lack of non-nitrogenous material in the ration there must, in the course of time, be a decrease in the formation of milk. In the beginning the body fat would be a substitute for the lack of carbohydrates, and would have to supply material for the formation of milk fat and milk sugar. After the gradual using up of the body fat a falling off in the milk yield is noticeable. Same thing can be seen in case of lack of protein.

As suggested above, the nutrients in feed for milk products, as ingredients of soil for crop production, are governed by "minimum Law" and therefore nitrogenous and non-nitrogenous matters should be supplied not only in a certain amount as whole, but also in certain proportion. This consideration is important when nutrients are calculated in ~~stock~~ starch equivalent.

XI DUAL OFFICE OF FOOD

The animal organism uses the nutrients contained in the food for one or two purposes, viz., (1) for maintenance, to replace the energy lost in the form of heat, through radiation, evaporation, etc., and to repair the water of all tissues incident to the vital processes, and (2) for production of work or animal production like meat, milk, wool, etc. It is essential for continued production that the supply of nutrients in the food shall be more than sufficient to cover the needs of the organism for maintenance, and it is therefore, under normal condition, only the nutrients supplied in excess of maintenance requirements which contribute toward the building up of new tissues or production of work, milk, etc. The instinct of the preservation of the race is, however, stronger than that of the preservation of the individual, and if, for instance, a cow in milk does not receive an amount of food more than sufficient to cover the needs of her own body, her production will not cease, but she will take the material required for the production from her own body tissues, hence her weight will gradually decrease; the milk produced under such conditions will not be of normal character, but will be of poorer quality than is ordinarily the case.

In the study of the relation of food to milk production the general practice has been to consider the total effect of the food for maintenance and for production. Where the object in view not is to ascertain the economy of certain combinations of feeding stuffs, this method is doubtless a rational one, the feeder must pay for the food required for the maintenance of the animal as well as for that portion which serves for productive purposes. But in case of a study of the principles which determine the utilization of the food for production, that is, the relation between food and production, a consideration of the total effect of the food would evidently only tend to conceal the laws that determine the uses which the animal makes of the productive portion of the food.

It is purposed in this thesis to discuss the relation between the milk production of cows and the excess food over and above maintenance requirements.

It is, however, very necessary to determine first of all the amounts of nutrients needed for maintenance, which will give us the exact amounts of those available to actual production. Some detail discussion on that subject will be made on next.

XX FOOD OF MAINTENANCE FOR MILCH COWS

The generally accepted feeding standard, until Prof. Haecker published his own investigation, is Wolff's which gives 18 pounds of dry matter and of nutrients, .7 of a pound of crude protein, 8 pounds of carbohydrates, and .1 of a pound of ether extract of fat, is the amount needed daily for maintenance per 1000 pounds live weight, (generally for cattle).

Against that, Sanborn of the New Hampshire Station reported in 1879 that the steer could be maintained on a smaller allowance of hay than is prescribed in the standard; Caldwell, of the Cornell Station, reports a trial where four steers gained 180 pounds during a period of 60 days, on practically a maintenance ration. Dr. Kuhn, in Germany in experiments extending over several years showed that the mature bovine could be maintained on .7 of a pound of protein and 6.6 pounds of nitrogen-free extract, and whatever was fed in excess of this amount, covered gain in weight at the rate of from 20 to 25 per cent of the amount so in excess.

In these times, Prof. Haecker observed also during his feed experiments that in some instances cows did fairly good work in the dairy during a whole winter on only a trifle more feed than that described for food of maintenance, indicating that the amount fixed by the standard in general use was in excess of the actual requirements, and it made him decide to carry on some experiments on that line. It is noticeable that the work, as he says, has been carried on from the more practical phasd in the belief that in this form it would receive more attention from milk producers than would be the case if given in more elaborate and technical form. Such forms do not cause any disturbance in normal conditions of cows and consequently those reqults may be said true both scientifically and practically. This is the reason why since Haecker's standard has been accepted applicably both by the scientist and practical men in the dairy world. A mere preliminary trial on a maintenance ration was begun on the 31st of October, 1894, when two barren cows were fed on a daily ration of 10 pounds of timothy hay and 3 pounds of ground barley for a period of 81 days. Their weight at the beginning of the trial was 1676 pounds and at the close, 1735 pounds, being a gain of 59 pounds, or .36 of a pound each per day. The average weight of the cows during the experiment was 853 pounds. The dry matter and nutrients of the ration for 1000 pounds were as follows:

Table I - Giving Food and Nutrients Consumed daily.

	Lbs.	Dry matter	Digestible Nutrients		
			Protein	Carbo-hydrates	Ether Extract.
Timothy hay	10	8.768	.318	4.509	.18
Barley meal	3	2.646	.283	1.792	.06
Total		11.414	.601	6.301	.24
Per 1000 lbs. live weight.		13.38	.701	7.386	.28

It is shown by the above table that the ration fed was practically the amount in the Wolff standard, but contained .614 of a pound less of carbohydrates and .18 of a pound more ether extract. Reducing the .18 of a pound of ether extract to a carbohydrate equivalent (.18x2.25).405 of a pound and adding this to 7.386, the carbohydrates for convenience in comparing the ration fed with the Wolff standard, we have the following:

Table II - Giving Nutrients Consumed Daily and the Wolff Standard.

	Dry Matter	Digestible Nutrients: Protein	Carbohydrates	Ether Extract
Ration fed per 1000 lbs. live weight	13.38	.704	7.791	.10
Wolff standard maintaining ration	18.00	.70	8.000	.10

The ration fed provided, practically, the amount of protein called for by the Wolff Standard and .209 of a pound less of non-nitrogenous matter, and produced daily average gain of .36 of a pound, showing that the ration fed was in excess of the amount actually needed for food of maintenance.

The second experiment was conducted with two barren dry cows during the winter of 1897-97 covering a period of 100 days. One received 18 pounds and the other 14 pounds of fodder corn daily. The following gives their weights at the beginning of the trial and at the close, being the average of daily weighings which were in all cases made in the morning after feeding and before watering, and the average of all their weights during the trial:

	Alice	Belle
Weight at beginning	797	1005
Weight at close	803	985
Average weight	808	1010

At no time after the first 11 days did Alice fall below 800 pounds and Belle maintained a weight above 1000 pounds until the month of February when her average weight was 987. The dry matter consumed daily and nutrients digested, as determined by a digestion experiment during the trial, is given in the following:

Table III - Dry matter consumed and nutrients digested daily per 1000 lbs. live weight

	Average Weight	Dry Matter	Nutrients Protein	C. H.	Fat
Alice	808	8.98	.297	5.45	.38
Belle	1010	9.23	.277	5.08	.37
Average		9.10	.287	5.27	.375

While the cows maintained their weight during the experiment, with the exception noted, there were indications that they had not been fully nourished; probably due chiefly to the small amount of protein in the ration. They looked dull, their skin was not loose and their coats were dry and harsh, and were not shed until late in the spring.

During the winter of 1897-98 three barren dry cows were fed trial rations of food of maintenance on fodder corn, beet, and oil meal. The preliminary feeding began in November but the fodder corn did not cure out to a uniform water content until the latter part of December which caused considerable variation in weight, so the data covers only a period from Dec. 20th to April 11th. The following table gives the weight of the cow Alice during the experiment:

Alice 1897-98

Table IV - Giving Dates and Weights

Date	Weight	Date	Weight	Date	Weight
Dec. 20	750	Feb. 3	750	Mar.10	755
Jan. 3	760	Feb. 7	740	Mar.14	758
Jan. 6	762	Feb. 10	735	Mar.17	755
Jan. 10	765	Feb. 14	742	Mar.21	750
Jan. 13	765	Feb. 17	748	Mar.24	748
Jan. 17	762	Feb. 21	750	Mar.28	755
Jan. 20	765	Feb. 24	750	Mar.31	752
Jan. 24	750	Feb. 28	762	Apr.4	752
Jan. 27	765	Mar. 3	752	Apr.7	760
Jan. 31	760	Mar. 7	755	Apr.11	762

During the month of February it was noticed that she seemed to have difficulty in masticating food and occassionally a swelling appeared on the right side of the jaw. She was killed at the close of the experiment and it was found that a tooth had been broken which probably was painful andcaused shrinkage in weight.

Table V. Dry matter and nutrients consumed daily

	Dry Matter	Digester Protein	Digester C. H.	Digester Fat	Daily Gain
Actually consumed	8.89	.59	4.85	.08	.27
Per 1000 lbs live weight.	11.79	.78	6.43	.10	

Record of Belle 1897-98.

Table VI - Giving Dates and Weights.

Date	Weight	Date	Weight	Date	Weight
Dec. 30	1065	Feb. 3	1055	Mar. 10	1070
Jan. 3	1052	Feb. 7	1062	Mar. 14	1075
Jan. 6	1046	Feb. 10	1060	Mar. 17	1072
Jan. 10	1032	Feb. 14	1070	Mar. 21	1075
Jan. 13	1055	Feb. 17	1070	Mar. 24	1075
Jan. 17	1028	Feb. 21	1072	Mar. 28	1075
Jan. 20	1065	Feb. 24	1062	Mar. 31	1078
Jan. 24	1045	Feb. 28	1070	Apr. 4	1080
Jan. 27	1050	Mar. 3	1070	Apr. 7	1075
Jan. 31	1045	Mar. 7	1075	Apr. 11	1082

The different weighings already show there was a steady gain. In the first column the weight ranged from 1025 to 1065, while in the second the range is from 1055 to 1075, and in the third from 1070 to 1082. Taking the first column as preliminary and the difference between her average weight reported in the second column, with that in the third as the gain made, there is a difference of 9 pounds or at the rate of .27 of a pound per day.

The dry matter consumed and nutrients actually digested as determined by a digestion experiment, were as follows:

Table III - Giving nutrients consumed Daily

	Dry Matter	Digested Protein	C. H.	Fat	Daily Gain
Actually consumed	11.70	.73	5.51	.11	.27
Per 1000 lbs. live Weight	10.93	.68	5.15	.10	

Record of Lottie 1897-8

Table VIII - Giving Dates and Weights.

Date	Weight	Date	Weight	Date	Weight
Dec. 20	680	Feb. 3	700	Mar. 10	710
Jan. 3	655	Feb. 7	697	Mar. 14	710
Jan. 6	670	Feb. 10	695	Mar. 17	710
Jan. 10	660	Feb. 14	695	Mar. 21	712
Jan. 13	678	Feb. 17	700	Mar. 24	712
Jan. 17	662	Feb. 20	700	Mar. 28	715
Jan. 20	665	Feb. 24	703	Mar. 31	715
Jan. 24	692	Feb. 28	710	Apr. 4	710
Jan. 27	700	Mar. 3	710	Apr. 7	710
Jan. 31	702	Mar. 7	705	Apr. 11	705

From a careful examination of the different weights it is evident that she was gradually gaining. Her weight in the first column ranged from 655 to 702, while in the second it ranged from 695 to 710 and in the third from 705 to 715. It is exceedingly difficult to determine exactly the gain made. But by assuming that the weight during the five weeks covered by the first column are preliminary and deducting the average weight in the second column from that of the third, there is a difference of 9 pounds or a gain of .27 of a pound daily. The cow was naturally very restless and discontented and since she was a stranger in the herd and not accustomed to confinement she probably did not do normal work.

The dry matter consumed daily and nutrients actually digested were as follows:

Table IX - Giving Nutrients Consumed Daily

	Dry Matter	Digested			Daily Gain
		Protein	C.H.	Fat	
Actually consumed	8.53	.51	3.80	.07	.27
Per 1000 lbs. live weight	12.08	.72	5.38	.10	

Record of Lottie 1898-99

Table X - Giving Dates and Weights

Date	Weight	Date	Weight	Date	Weight
Nov. 7	705	Jan. 2	750	Feb. 27	757

Nov. 14	710	Jan. 9	750	Mar. 6	762
Nov. 21	730	Jan. 16	750	Mar 13	760
Nov. 28	725	Jan. 22	757	Mar.20	760
Dec. 5	732	Jan. 30	752	Mar.27	765
Dec. 12	742	Feb. 6	755	Apr. 3	762
Dec. 19	750	Feb. 13	752	Apr.10	765
Dec. 26	745	Feb. 20	758	Apr.17	765

During the trial it is again found that there was a gradual gain though it was less after the second of January. In the first column the weights ranged from 705 to 750 lbs. while in the second they ranged from 750 to 758 lbs., and in the third from 757 to 765. The average weights in the third column exceed those of the second colimn by 9 pounds making an average daily gain of .16 of a pound.

The dry matter consumed daily and nutrients actually digested were as follows:

Table XI - Giving Nutrients consumed Daily

	Dry matter	Digested Protein	Digested C. H.	Digested Fat	Daily Gain
Actually consumed	8.42	.39	5.09	.13	.16
Per 1000 lbs. live weight	11.12	.50	6.72	.15	

At the close of the experiment the cow presented clear evidence of having been amply nourished. Her eyes were bright, her movement quick, skin loose, and coat new, soft and glossy. The cows employed in the experiment during the winter previous showed similar indications of having well nourished. Aside from gaining in weight, and on this account presenting a more smooth appearance, they shed their coat early and it had that bright, glossy appearance which is recognized among stockmen as a sure index of a healthy physical tone.

Combining the results obtained in the last three trials, we have the average daily dry matter consumed and nutrients digested and gain made for the three years:

Table XII - Giving Dry matter and Nutrients Daily per 1000 pounds Live Weight and Gain in Weight.

	Year	Dry Matter	Digested. Protein	Carbohydrates	Fat	Daily Gain in Weight
Belle	1897-8	10.93	.68	5.15	.10	.27
Lottie	1897-8	12.08	.72	5.38	.10	.27
"	1898-9	11.08	.50	6.72	.15	.16
Average		11.38	.63	5.75	.12	.23
Wolff Standard		18.00	.70	8.00	.10	

The trials on food of maintenance during the three winters with barren dry cows show that, with an average of 11.38 pounds of dry matter daily containing of digestible matter, as determined by actual digestion experiments .63 of a pound of protein, 5.75 pounds of carbohydrates and .12 of a pound of fat, the cows were amply nourished and made a daily average gain of .23 of a pound in live weight. While the cows received on an average .63 of a pound of protein daily it does not follow that it is the minimum amount required since in the last experiment the cow received only .5 of a pound with very satisfactory results.

The experiment justifies the conclusion that with cows at rest in stall in comfortable quarters, a ration of 11.5 of dry matter containing of digestible matter .06 of a pound of protein, .6 of a pound of carbohydrates and .01 of a pound of fat per hundred weight of cow, will be ample for a maintenance ration. Whether this allowance would be sufficient for cows receiving the treatment accorded them in a well regulated dairy in comfortable quarters, and allowed an outing in the yard for an hour or two during pleasant day in winter, still remains to be determined. Pending such determination it is tentatively suggested that for a cow working in the dairy and having ordinarily good care and comfortable quarters the allowance for maintenance be calculated at

1.25 pounds of dry matter containing
.07 of a pount of protein
.7 of a pound of carbohydrates
.01 of a pound of fat

per hundred pounds live weight. These factors are suggested because they seem warranted by the data obtained, and because it is deemed desirable for convenience in feeding practice, to express the requirements for food of maintenance in the simplest form possible, so it can be understood and used by the average feeder.

Since the investigation was published, it was ~~seen rapidly~~ and widely acknowledged by all scientists and practical men because the facts have proved ~~an~~ their authorization.

Since those experiments carried on by Prof. Haecker, some experiments were conducted in other Stations along same line, and they showed more or less different results from them. It will be, however, seen by careful observations that most of them had some wrong; some of them were conducted with growing animals and others in short period Recently some experiments were conducted with five Jersey cows by Prof. Eckles in Missouri Station and a very close agreement was found. He calculated the energy value of nutrients according to Kellner's figures for the comparison and gave the following tables:

Haecker's Maintenance Ration

1000 lbs cow

Digestible Nutrients	Lbs.	Energy value: per lbs. in Therms	Total Energy value in Therms
Protein	0.7	1.016	.711
Carbohydrates	7.0	1.071	7.497
Fat	0.1	2.100	.210

On the same basis the ration fed the five Jersey cows was given as follows:

Digestible nutrients per day per 1000 lbs. weight.

Cows	Lbs. Protein	Lbs. C.+H.	Lbs. Fat	Energy value in Therms
No.27	.949	6.005	.374	8.180
No.62	.839	5.210	.309	7.081
No.63	.868	5.368	.318	7.299
No. 4	1.111	7.018	.442	9.573
No.43	1.122	6.993	.492	9.663

The energy value of Haecker's ration calculated on this basis is 8.42 therms per 1000 pounds while the average required to maintain the four Jersey cows receiving normal dairy ration was 8.61 per 1000 pounds which shows a rather close agreement.

The maintenance requirement is approximately proportional to the surface of body rather than to its weight, while the surface is approximately proportional to the cube root of the square of the weight. And also it is changeable according, to temperature, to which it is exposed. However, such differences are ordinarily of small value to be considered. The individualities of animals will act to a greater extent.

XXI - GENERAL CONSIDERATION OF NUTRIENT REQUIREMENT FOR MILK PRODUCTION.

From the things suggested heretofore, we know that amounts of nutriments to be fed for milk production must be adjusted to the weight of cows, and quantity and quality of milk yielded, in mature cows.

The feeding experiment conducted at Minnesota Station during the winter of 1894-5, in which the cows were given a fixed ration for a period of 154 days, during which time a full flow of milk and yield of butter fat was secured without gain or loss in body weight seems very reliable. The average daily nutrients consumed and milk and butter fat yielded by each animal and by the herd for both periods are given in the following table.

A great many experiments, besides that were conducted in same Station, results being very fair However, it will not be necessary to introduce here all of them, but will be sufficient with this one, which is supposed to be more reliable and explanable than others.

1.

Feed Used

Grain 14 lbs.	6 parts spring wheat bran	6 parts bran.
Hay 16 lbs. (A) Grain Food	7 parts ground spring wheat Grain Fed (B)	4 parts 3 barley meal
Roots 10 lbs.	1 part linseed meal	

Table I - Giving the daily average of Dry Matter and Nutrients consumed, and milk and fat yielded from Nov. 19 1894 to Feb. 10, 1895 - 84 days.

Name of Cow	Weight	Dry Matter	Digestible Protein	Digestible C. H.	Digestible Fat	Average Daily Yield Milk	Average Daily Yield Per Cent. Fat	Average Daily Yield Butter Fat
	lbs	lbs.	lbs	lbs	lbs	lbs	%	lbs
Betty	870	20.53	1.70	10.98	.45	10.03	6.7	.672
Dora	877	22.53	1.87	12.08	.49	15.02	6.3	.949
Beckley(a)	839	20.08	1.63	10.72	.43	13.44	5.6	.751

Name of Cow	Weight	Dry Matter	Digestible Protein	Digestible C. H.	Digestible Fat	Average Daily Yield. Milk	Average Daily Yield. Per Cent Fat	Average Daily Yield. Butter Fat
	lbs.	lbs	lbs	lbs	lbs	lbs	%.	lbs.
Tricksey(a)	733	20.53	1.70	10.98	.45	16.78	4.9	.825
Houston	918	23.23	1.98	12.44	.51	25.00	5.6	1.406
Sweet B	1063	26.91	2.25	14.50	.58	30.81	4.8	1.490
Olive	794	20.08	1.63	10.72	.43	27.26	3.8	1.050
Topsy	1170	31.49	2.64	16.92	.69	44.39	3.7	1.656
Lora	1143	26.22	2.14	14.10	.55	38.01	3.7	1.410
Quidee (a)	830	23.29	1.90	12.42	.50	25.55	3.5	.908
Lydia (a)	1048	28.34	2.39	15.22	.62	32.02	3.4	1.087
Countess	1169	28.37	2.38	15.28	.61	45.27	2.4	1.094
Average	954	24.30	2.01	12.03	.53	26.96	4.1	1.109
Average (b)		24.92	2.07	13.00	.54	29.49	4.6	1.217

(a) - - - - -Heifers
(b) - - - - -Average eliminating heifers. (Report XXVII)

Grain Fed

14 parts grain silage — Spring wheat bran - 6 parts
Ground corn - 2 parts
18 parts hay — Ground spring wheat - 5 parts
Cottonseed meal - 1 part

Table II (ditto) from Feb.11 to Apr. 21,1895
70 days

Name of Cow	Weight	Dry Matter	Digestible Protein	Digestible C. H.	Digestible Fat	Average Daily Yield Milk	Average Daily Yield Per Cent Fat	Average Daily Yield Butter Fat
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	%	Lbs.
Beckley(a)	857	21.19	1 68	11.10	.51	13.17	5.59	.736
Countess	1184	29.22	2.40	15.50	.72	41.80	2.53	1.061
Houston	906	25.24	2.14	13.35	.64	24.88	5.38	1.340
Lou	1115	27.00	2.21	14.10	.67	31.46	3.67	1 154
Olive	794	21.15	1.67	11.12	.51	21.20	4.12	.884
Reddy (a)	769	20.94	1.69	11.01	.51	14.49	5.21	.755
Belle	951	20.56	1.76	10.89	.50	19.38	4.14	.803
Lydia (a)	1079	27.57	2.26	14.49	.68	27.93	3.57	.999
Quidee	875	22.73	1.86	11.94	.55	25.81	3.49	.902
Sweet B	1067	27.00	2.21	14.21	.67	26.09	5.28	1.379
Topsy	1153	31.93	2.59	16.79	.78	40.82	3.62	1.492
Tricksey(a)	748	19.61	1.56	10.33	.47	15.73	5.34	.840
Average	958	24.51	2.00	12.90	.60	25.23	4.07	1.029

Aver-age (b)	26.01	2.11	13.71	.64	28.95	4.11	1.159

(a) - - -Heifers
(b) - - -Average eliminating heifers.

It will be seen that the two periods do not cover exactly the same number of days, one being for 84 while the other is for 70 days, but since the daily average of nutrients consumed and yield of milk and butter fat were so much alike, the average of the two will be as nearly the actual average that such use is considered allowable.

Table III - Giving Daily average for 154 days

	Weight	Digestible Protein	Digestible C. H.	Digestible Fat	Milk Yielded	Percent of fat
Period I 84 days	954	2.01	12.03	.53	26.96	4.1
Period II 70 days	958	2.00	12.90	.60	25.23	4.07
Total	1912	4.01	24.93	1.13	52.19	8.17
Daily Aver-age	956	2.00	12.46	.56	26.09	4.09
Daily for Maintenance		.67	6.69	.095		
Daily avail-able for milk		1.33	5.77	.46	26.09	
Nutrients to 1 lb.milk		.051	.221	.018		

(Note) Kellner put .05 and Lehmann .081 in place of .051.

From this we can see general amounts of nutrients required for production of 1 pound of milk (testing about 4%), provided for maintenance .07 protein, .7 C. H. and .01 fat per cwt.

Also comparing this with the Lehmann standard, it may be seen that the daily average of nutrients available to a pound of milk did not differ materially from it except that the herd ~~reduced~~ returned a pound of milk for each .05 of available protein, being about 60 per cent of the amount prescribed by the standard. The variance in the amount of available carbohydrates consumed, per pound of milk yielded is greater than is indicated by the above comparison; because the Lehmann standard prescribes 8 lbs. per 1000 lbs. body weight for food of maintenance while 7 lbs. are allowed in this table . (being .27 instead of .221)

Here we have very strong evidence to prove that this experiment was quite creditable. The herd came out of the winter in excellent condition and gave every evidence of having been amply nourished, and produced a maximum yield of both milk and butter fat. The following winter, 1895-6 the herd was composed of, practically the same animals, received on an average a daily allowance of 2.59 protein, 13.24 carbohydrates and .68 fat, and its performance compared with the winter's work in review was as follows:

Table IV - Giving Daily Average of nutrients Consumed and milk and fat produced during the winter. 1894-5 and 1895-6.

Year	Weight	Digestible			Milk	Per Cent Fat	Butter Fat
		Protein	C. H.	Fat			
1894-5	956	2.00	12.46	.56	26.09	4.10	1.069
1895-6	980	2.59	12.24	.68	25.71	3.93	1.011

This shows distinctly that they were fed with sufficient amounts of nutrients during the winter 1894-5, because the cows yielded more milk and butter fat during that winter than they did during the winter 1895-6.

XXII - VARIATION OF THE NUTRIENT REQUIREMENT ACCORDING TO THE QUALITY OF MILK.

Before going into detail let the writer observe another experiment at the same Station covering a period of 130 days.

Period I - Table I - Giving average weight of cows, nutrients required, and milk and butter fat yielded during

	Weight	Digestible Protein	Digestible C. H.	Digestible Fat	Milk Yielded
Period I	1170	2.64	16.92	.69	
Period II	1153	2.59	16.79	.78	
Average	1161	2.61	16.85	.735	42.6
For maintenance		.83	8.13	.116	(fat 3.7%)
For production		1. 79	8.72	.619	

For production of 1 lb. of milk testing 3.7%, .042 protein, .20 C. H., and .014 fat required.

Comparing this with Table III (XXI) it is seen that there exists a great variation in the amount of nutrients required for production of same amount of milk, in spite of the fact that both these experiments were carried on covering so many days and with so many cows enough to eliminate any individualities and errors which cannot be prevented. . . .

	Protein	C. H.	Fat
For 1 lb. of milk testing 4.09%	.051	.221	.018
For lb. of milk testing 3.7%	.042	.20	.014

This is a perfect evidence that the quality of milk is quite as important a factor in formulating a feeding standard or guide to feeding practice, as quantity of milk yielded.

Inquiring after the subject a table can be given from the record of mature cows in the herd, (used in the previous (XXI) experiment) whose productive powers, Prof. Haecker says, had been developed to their feeding capacity by careful feeding and handling for several years, giving the per cent of butter fat in their milk and nutrients required per pound of milk yielded.

Table II - Giving Available Nutrients

Consumed per pound of milk

yielded

Name of Cow	Percent Fat	Protein	C. H.	Fat	Total	Total in Starch equivalent
Countess	2.5	.036	.16	.012	.208	.223
Lou	3.7	.040	.20	.014	.254	.234
Topsy	3.7	.042	.20	.014	.256	.236
Olive	4.0	.044	.22	.016	.280	.300
Sweet Briar	5.0	.052	.24	.018	.310	.332
Houston	5.5	.057	.26	.019	.336	.360

By this table it is clearly shown that the amount of nutrients to a pound of milk increases with the increase in the quality of the milk, but not in the same proportion; for Countess gave milk containing 2.5% of butter fat and used .208 of available nutrients while Sweet Briar gave milk containing twice as much butter fat but did not require as much protein or other nutrients. The same is the case with the other cows.

Also this table indicates that other things being equal, the richer the milk the more economical is the production of butter fat. It has been shown that the richer the milk in butter fat the more nutrient required. Indeed, it could not be otherwise, for the percent of solids in the milk increases with the increase in butter fat, and the rate of increase in energy in rich milk is even greater than the increase in solids, because the richer the milk in butter fat, the greater the percent of fat to solids not fat.

The following table shows the standard compositions of milk given by Prof. Haecker and explains itself the things suggested above.

Table III - Standard Composition of Milk
(in %)

Milk Testing	Protein	C. H.	Fat	Ash	Total Solid	T.S. in starch equivelent	Ratio of nitro. to non-nitro. matters. 1:	Ratio of fat to solid not fat. 1:
2.5	2.55	4.45	2.5	.70	10.0	12.62	3.91	2.80
3.0	2.68	4.60	3.0	.72	10.93	14.03	4.24	2.43
3.5	2.81	4.75	3.5	.70	11.75	15.43	4.49	2.16
4.0	3.08	4.85	4.0	.69	12.61	16.93	4.50	1.98
4.5	3.27	4.97	4.5	.73	13.47	16.36	4.62	1.83
5.0	3.45	4.98	5.0	.72	14.17	19.68	4.70	1.69
5.5	3.65	4.92	5.5	.73	14.79	20.94	4.74	1.59
6.0	3.82	4.91	6.0	.72	15.46	22.23	4.82	1.45
6.5	4.12	4.90	6.5	.75	16.27	23.64	4.74	1.39
7.0	4.22	4.84	7.0	.76	16.82	24.81	4.88	1.29

To illustrate the rate of increase of the amounts of nutrients required for the production of a pound of milk of different quality, the records of Houston and Countess are employed.

Altho the following figures are based upon only those two records, there are many other records kept which are to prove same.

Table IV - Showing difference in Nutrient Requirements for milk testing high and low in butter fat.

	Percent fat in milk	Protein	C. H.	Fat
Houston	5.5	.057	.26	.019
Countess	2.5	..36	.16	.012
Differences for 30 tenths	3.0	.021	.10	.007
Differences for 1 tenth		.0007	.0033	.00023

By this it is seen that in the production of the rich milk the additional nutrient requirements were at the rate of .007 of protein, .0033 of carbohydrates and .00023 of fat for each .1 per cent increase in percent of butter fat.

Taking the nutrients required for a pound of milk, testing 2.5 per cent butter fat as basis, and the nutrients required in addition for each one tenth per cent, we have the following table giving approximately the nutrients required for the production of a pound of milk of a given percent butter fat,

Table V - Giving net-nurtients used by mature Cows for the Production of one pound of Milk, testing a given percent butter fat.

		Protein	Carbo-hydrates	Ether Extract
Milk testing	2.5	.0362	.164	.0124
" "	3.0	.0397	.181	.0136
" "	3.5	.0432	.197	.0147
" "	4.0	.0467	.214	.0159
" "	4.5	.0502	.230	.0170

	Protein	Carbohydrates	Ether Extract
Milk testing 5.0	.0537	.247	.0182
" " 5.5	.0572	.263	.0194
" " 6.0	.0607	.280	.0206
" " 6.5	.0642	.296	.0217
" " 7.0	.0677	.313	.0229
Co-efficients for food of maintenance per cwt.	.07	.7	.01

(From Bul. 79 of Minnesota Exp. Sta.)

The table is very closely in accord with the nutrients used to a pound of milk yielded by the mature members of the herd not making material gain in body weight, except that it provided more than was actually used by the cows giving milk of medium quality, say for that testing from 3.5 to 4.5 percent of butter fat. In the table given, .0007 of a pound of protein available for product was allowed for each .1 of one per cent increase in the percent fat in the milk, while in fact, the difference was not so great between the lower grades of milk.

To illustrate the rate of increase of protein used, per pound of milk yielded by the cows, as their milk was richer in butter fat, after making allowance for protein needed for maintenance, the following deductions from the record are submitted, though it does not follow that the rate of increase of protein for pound of milk, as it increased in fat content was actually needed.

Table VI - Showing rate of increase in protein requirements.

	Percent fat in milk.	Protein to 1 lb. milk.
Lou and Topsy average	3.7	.041
Countess	2.5	.036
Difference for	12 points	.005
Difference for each point		.0004
Olive	4.0	.044
Countess	2.5	.036
Difference for	15 points	.008
Difference for each point		.0005

	Percent fat in Milk	Protein to 1 bl. milk
Sweet Briar	5.0	.052
Countess	2.5	.036
Difference for	15 points	.016
Difference for each point		.0006
Houston	5.5	.057
Countess	2.5	.036
Difference for	30 points	.021
Difference for each point		.0007

Table V giving net nutrients to be fed for the production of one pound of milk testing a given percent of fat preseribes more protein than actually used. The slight excess, however, is not a severe objection, but also sometimes may effect better. (The chief opinions against Haecker's Standard made by noted investigators seem "A little more protein is sometimes economical")

XXIII - USES OF NUTRIENTS CONSUMED.

The knowledge of what parts of total nutrients consumed are actually used for certain purposes, will give us inductively the concrete idea of what times of real production should be supplied to meet the cow's needs for a normal production of milk. For clear understanding of cause Table I is given, which results from the experiment in Minnesota Station since 1894-5. Table II and III are to show the detail of nutrients consumed and products produced. In reducing the nutriments to starch equivalemt the factor 2.25 for fat was used. Each one of the groups in 1902-3, 1903-4 and 1904-5, (a, f, and c) have been eliminated from average because it showed "too little protein."

Table I

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Table I Showing the Disbribution of Nutrients Consumed.

Experiment year.	Weight of animal	Total nutri. consumed.	Protein consumed.	Nutritive Ratio	For Maintenance	For Production	In Product	Expended Energy for Production	Total Expended Energy.	Lbs. of net nutri. for 1 lb. of Product	% of Product to net Nutri.	% of Expended Energy for Production to net nutri.	% of Product to Total nutri.	Gain or Loss of Body. Wei.
	Lbs.	Lbs.	Lbs.	1:	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	%	%	%	
1894-5	956	15,720	2,00	6,9	7,576	8,144	4,495	3,649	11,224	1,810	55,3	44,7	28,6	=
1895-6	979	16,338	2,07	5,5	7,759	8,579	4,295	4,284	12,043	1,977	50,5	49,5	26,3	+
1902-3 (a)	852	13.475	1.28	9,5	6,752	6,723	4,153	2,570	9,322	1.611	62.1	37,9	30,8	—
1902-3	879	14,860	1.92	6,7	6,966	7,894	4,573	3,321	10,287	1,726	57,9	46.1	32,8	=
1903-4 (b)	858	13,238	1.32	9,0	6,800	6,438	4,341	2,097	8,897	1.483	67,4	32.6	32,8	—
1903-4	908	13,770	1.97	6,0	7,[illegible]	6,574	4,102	2,472	9,668	1.602	62.4	37,6	29,8	=
1904-5 (c)	826	14,025	.131	9,7	6,546	7,479	4,009	3,470	10,016	1,866	53,6	46,4	28.6	—
1904-5	895	14,995	1.92	6,8	7,093	7.902	4,458	3,444	10,535	1,773	56,4	43,6	29,7	=
1905-6	871	15,323	1.65	8,3	6,903	8,420	4,507	3,913	10,816	1,868	53,5	46,5	29,4	+
1906-7	934	16,288	.174	8,4	7,410	8,875	4,632	4,246	11,656	1,916	52,2	47,8	28,4	+
1907-8	873	15,840	1,73	8,2	6,914	8,921	4,614	4,307	11,226	1,912	52,3	47,7	29,1	+
1908-9	935	15,988	1.83	7,8	7,410	8,588	4,585	4,003	11.413	1,873	53,4	46,6	28,7	+
Average. (a.b.c exclusive)	914	15,463	1,93	7.0	7.243	8,220	4,475	3,745	10,988	1,837	54,4	45,6	29,0	+
		100 %	- - -	- - -	46,8 %	53,2 %	29 %	24.2 %	71 %					

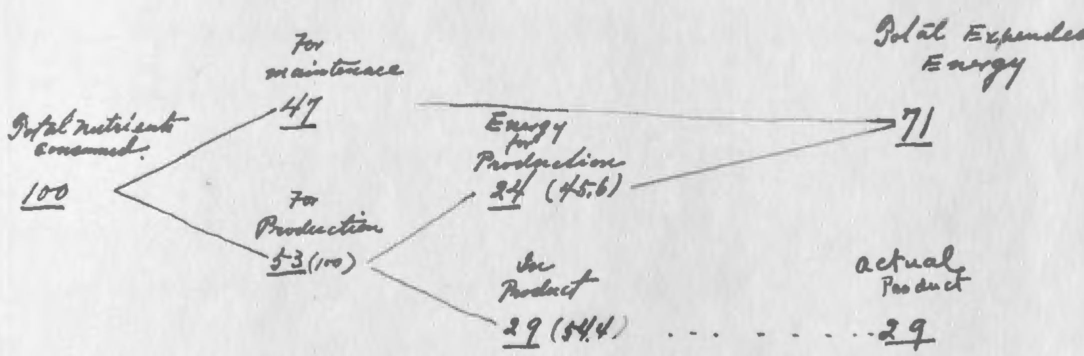
Table II - Showing the nutrients daily consumed. (in lbs)

Experiment year	Total Dry Matter	Protein	C. H.	Fat	Total Weight in Starch Equivalent	Nutritive Ratio 1:
1894-5	24.40	2.00	12.46	0.56	15.720	6.9
1895-6	23.91	2.59	12.24	0.67	16.338	5.5
1902-3 (a)	19.86	1.28	11.16	0.46	13.475	9.5
1902-3	21.77	1.92	11.86	0.48	14.860	6.7
1903-4 (b)	19.68	1.32	11.04	0.39	13.238	9.0
1903-4	20.65	1.97	10.99	0.36	13.770	6.0
1904-5 (c)	20.51	1.31	11.77	0.50	14.025	9.7
1904-5	21.97	1.92	11.95	0.50	14.995	6.8
1905-6	21.93	1.65	12.57	0.49	15.323	8.3
1906-7	23.01	1.74	13.13	0.63	16.288	8.4
1907-8	23.71	1.73	12.67	0.64	15.840	8.2
1908-9	23.77	1.83	12.40	0.79	15.998	7.8
Average	23.90	1.93	12.27	0.57	15.463	7.0

Table III - Showing the milk yielded daily.

Experiment year	Quantity of milk	% of Fat	Amount of fat	Amount of S. not Fat	Total amt. in milk.
1894-5	26.09	4.10	1.069	2.09	4.495
1895-6	25.71	3.93	1.011	2.02	4.295
1902-3 (a)	23.80	3.91	0.930	2.06	4.153
1902-3	25.20	4.16	1.050	2.21	4.573
1903-4 (b)	23.90	4.17	0.996	2.10	4.341
1903-4	22.60	4.57	1.036	1.78	4.102
1904-5 (c)	20.00	4.22	0.844	2.11	4.009
1904-5	24.30	4.24	1.030	2.14	4.458
1905-6	24.56	4.08	1.003	2.25	4.507
1906-7	25.50	4.15	1.059	2.25	4.632
1907-8	25.30	4.20	1.064	2.22	4.614
1908-9	25 10	4.20	1.060	2.20	4.585
Average	24.93	4.18	1.043	2.13	4.475

Summary of the average results are given diagramattically:



It is seen from Table I that for production of one pound of nutrients in milk, it should be supplied as much as 1.83 of a pound of net nutrients, except provided for food of body maintenance - .7 protein, 7 C. H. and .1 fat for 1000 pounds of live weight.

1.83 consumed { 1. actually produced
.83 expended for production

Also as can be noticed from the table, this amount--1.83 lbs. for 1 lb. is a little above the necessary amount for normal milk production. In the experiments during 1903-4, the equilibrium of body weight was kept with supply of 1.602 pounds of available nutrients for one pound of product, both the flow and quality of milk being normal. Same was seen in cases of supply of 1.726 and 1.773 for one pound. And whenever above those it showed more or less increase of body weight, which is due to the fact that there existed some excesses more than actual needs.

However, from the practical point of view, it is suggested that about 1.83 pound net nutrients for 1 pound production will be ample amounts to be fed. Such an excess will give good influence in working cows, for their feeling and health and next year working and also for the development of foetus. As for the protein supply, it is seen that such a narrow nutritive ratio as appeared in average--(1:7½)--is rather too narrow.

One thing attention to be given in the Table I is, the writer thinks, there exists a wonderful uniformity in the numbers of percent of products to total nutrients consumed in each experiment, while as a matter of fact there occurred some more variations than those, in the numbers of pound of net nutrients required to produce 1 pound of nutrients, or in the percentage of products to available nutrients consumed.

This may suggest, besides proving those experiments were all conducted very satisfactory, that there exists some notable variations in the individualities of cows as regards to the proportions of utilizing nutrients fed, for maintenance and for production.

XXIV - RELATION BETWEEN THE AMOUNTS OF PROTEIN IN FEEDS AND MILK.

Prof. Haecker gives the following tables, from his experiments, showing the amount of nitrogenous and non-nitrogenous matter, contained in each pound of milk of given grade, and the amounts of nitrogenous matter, carbohydrates, and fat, actually required for production of one pound of milk respectively.

Table I

Milk Testing	In 1 pound of milk: Nitro. matter	In 1 pound of milk: Non-Nitro. matter	For production of 1 pound: Protein (lbs)	For production of 1 pound: C.H. (lbs.)	For production of 1 pound: Fat (lbs)
3%	.0268	.1135	.040	.19	.015
3.5%	.0281	.1262	.042	.21	.016
4%	.0308	.1385	.046	.23	.018
4.5%	.0327	.1509	.049	.25	.019
5%	.0345	.1623	.052	.27	.021
5.5%	.0365	.1729	.055	.29	.022
6%	.0382	.1841	.057	.31	.024
6.5%	.0412	.1952	.062	.33	.025
7%	.0422	.2059	.063	.35	.027
Total	.3110	1.4495	.466	2.43	.187

(note) Compare with Table I (XXII)

From this table, dividing the number of protein required for production by the number of protein in milk, in each case of different grade of milk, it is seen that it was needed about 1.5 pounds of protein for production of each pound in milk; or about 67% of available amount of protein was actually produced in milk.

(Note) The amounts of nutrients to feed described in Table I are based on practical work, allowing some excess. We know from other records about 1.3 times of protein in milk can sustain a normal flow of milk. In this case about 77% of available protein appears in milk.

XXV - RELATION BETWEEN THE AMOUNT OF NON-NITROGENOUS SUBSTANCES IN FEED AND MILK.

Again from Table I, XXIV, we can learn that it needs about 1.97 pounds of available non-nitrogenous matter in feeds, for the production of one pound of same in milk. (14495 ÷ (2.43 +.187x2.25)

Same as protein this includes a little excess more than actual needs for milk production.

XXVI - PRACTICAL ESTIMATION OF AMPLE AMOUNTS OF NUTRIENTS TO FEED.

From above, allowing some excess, which is rather desirable in practical works, we know"1.5 part nitrogenous matter ~~of protein~~ for 1 part in milk and 1.97 parts of non-nitrogenous matter for 1 part in milk," are ample amounts of available nutrients to be fed. From this point of view, Prof. Haecker recommends the following standard:

	In Products	To feed
Protein	1	1.5
Non-Nitro.	1	1.7 C.H.+

13% of non-nitro in milk. Fat

Coef'ts ~~Calf~~ for food of maintenance per cwt. Protein.07, C.H. .7, fat .01.

The number "13%" comes from the fact that in the present time, the average feeds used in Minnesota contain about as much fat as good to allow such calculations.

Consequently the number "13%" is variable according to the kinds of feeds used. The general principle of the standard is as follows:

	In Products	Net Amt. to feed.
Nitrog. matter	1	1.5
Non-Nitrog. "	1	(C.H., 1.97-2.25X x (Fat, x

XXVII - FEEDING HEIFERS

Heifers require more nutrients per pound of milk yielded than do mature cows, because they make growth which requires nutriment as well as does the elaboration of milk. It will be equally foolish if one expects a full flow of milk from them by feeding solely according to the flow of milk and weight of heifers, i. e. with the same feeding standard as mature cows, as it is to feed same for different grade milk. There are necessarily a shortage of nutriment needed. It is obvious that heifers yielding milk similar in quantity and quality may differ in amount of nutriment actually needed, because they may differ in rate of growth, and on this account there will be a greater variation in nutriment required by different individuals than was found to be the case with mature cows.

Since the ratio of nutrients required for growth of body is practically the same that is required for milk production, the extra amount of nutrients needed for growth should be provided for, with the nutrients needed for milk production and not with those calculated for simply food of maintenance.

The factor used for food of maintenance for mature cows will, therefore, be applied to heifers. The following table gives a list of heifers in milk during the time covered by the second under review, which was 154 days and the nutrients required to a pound of milk after deducting the food of maintenance.

Table I - Giving available nutrients consumed per pound of milk yielded by the heifers.

	Percent Fat	Protein	C. H.	Fat.
Lydia	3.5	.052	.25	.018

	Percent Fat	Protein	C. H.	Fat
Quidee	3.5	.049	.24	.016
Tricksey	5.1	.068	.33	.023
Beckley	5.6	.079	.37	.027
Reddy	5.2	.079	.38	.029
Average for heifers		.065	.318	.022
Average for mature cows		.045	.213	.015

The heifers used nutrients in proportion to the quality and quantity of milk yielded, the same as was the case with the mature cows, but they returned a pound of milk to .065 of protein available for product, while the mature cows returned a pound of milk to .045 of protein. Also it gives general idea that the heifers regained nearly one half more available nutrients to a pound of milk than do the mature cows.

Again seeking the rate of increase in nutrients required for each .1 percent increase in butter fat, between the average amounts of nutrients required by the heifers yielding milk containing 3.5 percent of butter fat, and those yielding milk testing above 5 percent, it is found to be a .00125 of a pound of protein, .00567 of carbohydrates and.000432 of fat. Multiplying this by ten and substracting the product from the nutrients used by the heifer yielding milk testing 3.5 per cent butter fat, gives approximately, that required in the production of milk testing 2.5 per cent butter fat, which is .038 of protein, .1883 of carbohydrates and .01268 of fat per pound of milk yielded. From this, adding the number of each nutrient required for increase of each tenth percent of butter fat, we can learn approximately the amount of nutrients needed for the production of a pound of milk testing a given per cent of butter fat.

-:- The factors of nutrients required for the production of one pound of milk by the heifer "Reddy" are not used in calculating the rate of increase of nutrients because she made a gain more than for normal growth, as will be seen from the following table, giving the weight at the beginning and close of the experiment:

Table II - Giving gain in Weight by each heifer.

	Lydia	Quidee	Tricksey	Beckley	Reddy
At close	1083	869	763	862	791
At beginning	1014	785	723	839	747
Total gain	69	84	40	23	44
Daily gain	.47	.57	.27	.16	.78

The ratio of gain made by Reddy shows why the nutrients consumed daily were not proportionate with the yield and quality of milk. Tricksey gave milk testing 5.1 per cent fat and returned a pound of milk to .068 of a pound of protein, while Reddy gave milk testing only .1 of a percent higher returned a pound of milk to .079 of protein, showing that she converted part of the nutrients into body substances. Neither was she in milk during the last weeks of the experiment. The weights are the average of three weekly weighings at both the beginning and close, and for Lydia, Quidee, Tricksey and Beckley they cover a period of 147 days and for Reddy only 56 days.

XXVIII - EXPERIMENT IN MINNESOTA STATION ON INFLUENCE OF STAGE OF LACTATION.

In Section XIII, the writer gave some general considerations on this subject, telling that great influence. Prof. Haecker gave full records of nine cows and those in first nine weeks of fifteen cows and made very important conclusions. The following table gives two records of 15 cows, showing decrease in weight, daily average yield of butter fat, normal and excess above normal yield:

Table I

Week	Weight	Net Nutriment Daily	Butter fat Daily	Daily Normal Yield Butter fat	Daily excess yield butter fat.
1st	966				
2nd	917	4.648	1.369	.744	.620
3rd	900	5.363	1.325	.858	.467
4th	877	5.989	1.295	.958	.337
5th	873	6.156	1.259	.985	.274
6th	863	6.500	1.232	1.040	.192
7th	865	6.390	1.202	1.022	.180
8th	858	6.511	1.159	1.042	.118
9th	853	6.535	1.120	1.045	.075
Daily average		6.011	1.245	.962	.283

The cows received daily on an average 6.011 pounds of digestible matter available for product, and yielded daily 1.245 pounds of butter fat. The data in normal production shows that it requires 6.25 pounds of net digestible matter to a pound of butter fat, and this basis the nutriment provided daily was only enough for a daily yield of .962 of a pound butter fat, while the average daily excess per cow was .283 of a pound. Since the daily average loss in body weight per cow was 2 pounds, the daily compensatory yield by virtue of decrease in live weight was at the rate of .14 of a pound of butter fat per pound of decrease in weight of body, being a sacrifice of 7 pounds of live weight to 1 pound of butter fat yielded in excess of the yield provided for in the ration.

Prof. Haecker made the following deduction from his experiment:

1. During the early stages of the period of lactation cows lose rapidly in body weight; of 15 cows the average decrease per cow thefirst week was 49

pounds, and during 56 days there was a daily average loss per cow of 2 pounds.

2. During the time when the decrease in body weight takes place cows yield dairy product in excess of the amount provided for by the food consumed, the excess of yield depending upon the rate of loss in weight of body, in some instances it is more than twice the amount provided for by the available nutriment.

3. The excess yield of dairy products gradually decreases until about the 11th week when an equilibrium generally obtains between the nutriment consumed and production yielded, though in this respect cows differ, those of a pronounced dairy temperament taking less time, while those not strong in dairy temperament decrease more slowly in weight and require more time to reach normal work in milk production. Before such equilibrium is reached, the body fat and possibly other substances contribute directly or indirectly to product.

4. The normal net nutriment requirements of a pound of butter fat is approximately 6.25 pounds, with a slight increase by cows yielding milk containing a low per cent butter fat, and less with cows giving milk containing a high per cent of butter fat.

5. The normal net nutriment requirements to a pound of milk solid yielded is approximately 2.4 pounds with a slight increase with cows yielding milk rich in butter fat and less with cows giving milk containing a low percent of butter fat.

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

7. The daily yield of butter fat in excess of the nutriment supply, by virtue of an average daily loss per cow of 2 pounds in body weight, was .283 of a pound,

† refers to XXIII p.p. 69

being a sacrifice of 7 pounds in body weight to 1 pound of butter fat yielded in excess of that provided for in the ration.

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

XXIX - A FEW REMARKS ABOUT FEED-STUFFS.

As suggested in the first parts, the estimation of thevalue of feed stuffs should be based not only upon their chemical composition, but also upon their digestibility. Above those, there is one more thing to be taken in consideration, namely, productive value, which is first learned by Dr. Kellner. There exists some variations in hardiness or easiness in their assimilation into animal organism altho they may be equally digestible. Some stuffs may serve all their digestible parts as nutriments without any loss, while the others may loose themselves, those of them more or less in the course of digestion, thus making their actual net value or their really assimilated parts lessened. Practically it is good enough to calculate their efficiency as follows: grain and roots, 100%, silage 70; cured forage, 60: straws and corn stalk, 40.

The numbers brought out in this thesis, as regards the nutrient requirement were based upon the usual method of feeding in dairy farms in the state of Minnesota. When cows are fed with unusual amounts of roughage or concentrated feeds, the proper adjustment should be performed.

A Study on Transference of Nutrients to Animal Body from Feed

By

Masaji Kugimoto

A Study on Transference of Nutrients to Animal Body from Feed.

A thesis submitted to the faculty of the
Graduate School of the University of Minnesota

by Masaji Kugimoto,

in partial fulfillment of the requirements for
the degree of,

Master of Science.

April 1, 1912.

A Study on Transference of

Nutrients to Animal Body from Feed.

Content.

A Study on Transference of Nutrients to Animal Body from Feed.

The chief object of this thesis is to learn about the amounts and natures of nutrients transferred to animal bodies from feeds during certain periods by steers. Some other phases having direct bearings to this problem are also desired to observe, which can be secured from the data used.

In spite of that the clear understanding of this problem referred above is of essential importance as to the human food production thro animal bodies, which is not only a momey-making problem for stock-feeders, but also one of the greatest and permanent in its nature for the human life, it has been left from their studies by modern investigators. This is perhaps, due to the fact that they knew it does need so much efforts, time and expenses for a thoro study that they hardly would stand for and also that most of them were the investi-gators in laboratories, that is, who never were acquainted with animal life. It is certainly impossible to secure good results on such experiments as along this line, without a thoro knowledge of animal life. A keen judging of whether animals are amply nourished, or over-fed, or under-fed, which is very necessary for such kind of experiments, is only to be expected from one who studied animal life very carefully and had a practical experience in feeding animals for many years. There are almost none of data along this line to be secured heretofore except a few studies made by Lawes, Gilbert and Jordan.

The ordinary feeding experiments, while they may furnish the data of how much cost in money or of how much nutrients needed for gain of certain body weight, do not show anything about the production of nutrients in animal body and their nature, whether eidble or non-edible. Scale only can tell weights, but nothing about compositions or natures.

The data given are the slaughter records and analyses records of three steers and their feeding records in Minnesota Station. The animals were supposed to be brought into the station within a week after their birth and consequently their feeding records began some day in the first week.

The animals are detailed in following:

Steer No.177 - Lot 111 - Breed Angus.

Beginning of feeding - May 31, 1908.

Slaughtered Dec. 30, 1908.

Average live weight for three daily weighings 307 lbs.

Fasted weight 288.3 pounds.

Feeding period thirty-one weeks.

Steer No.198 - Lot 1V - Breed Angus.

Beginning of feeding - June 7, 1908.

Slaughtered March 31, 1909.

Average live weight for three daily weighings 415 lbs.

Fasted weight 392.9 pounds.

Feeding period forty-three weeks.

Steer No.192 - Lot 111 - Breed Scrub.

Beginning of feeding, May 31, 1908.

Slaughtered July 2, 1909.

Average live weight for 3 daily weighing 521 pounds.

Fasted weight 511 pounds.

Feeding period 57 weeks

The periods, taken in this thesis are:

Period 1 - From 32nd to 43rd week inclusive after beginning of feeding, covering 12 weeks.

Period 11 - From 44th to 57th week inclusive after beginning of feeding, covering 14 weeks.

Detailed Tables.

Every datum is detailed in the following tables under accompanying cover.

Table 1 - Composition of Feeds.

* Digestibility coefficients used are those determined in Minnesota Station.

Table 11 - Grain mixtures.

Table 111 - (a) Showing weekly live weights, weekly gains, average amounts of feeds and digestible nutrients consumed daily during the corresponding weeks for steer No.177.

(b) Ditto for steer No.198

(c) Ditto for steer No.192.

Table 1V - (a) Analysis of animal body for steer No.177.

(b) Ditto for steer No.198

(c) Ditto for steer No.192

Table V - (a) Deductions of analysis record to various kinds of body weight - normal live weight (3 days average), fasted weight and weight less waste for steer No.177.

(b) Ditto for steer No.198

(c) Ditto for steer No.192

Table Vl - (a) Distribution of nutrients in various parts of animal body - for steer No.177.

(b) Ditto for steer No.198

(c) Ditto for steer No.192

Table Vll - (a) Edible and non-edible nutrients in animal body - for steer No.177

(b) Ditto for steer No.198

(c) Ditto for steer No.192

Methods of feeding and management.

Steers were kept in a stall, rather comfortable and roomy. During all seasons they were allowed exercise in an adjoining yard, sunny and dry, where grasses or any other kind of feeds could not be reached, excepting during rainstorm or the severest winter days. The feeds were weighed out every time and the quantity of every kind of food feeds given was adjusted after a few days trial to their appetite, that is, as much quantity as they eat up with earnest. Water and salt they were allowed to take any time they wished and not weighed.

Methods of weighing.

Animals were weighed every Monday morning after feeding, and before watering. Before slaughtering, they were weighed three consecutive days, the last weighing being on the morning of the previous day of slaughtering. No food was given after that. They were weighed right before slaughtering. Those weights are fasted weights.

Observations.

As can be seen from table lll neither feeds fed nor the rate of gain of live weight is unusual. It is said that they showed every indication of ample nourishment. Altho, strange to see, the weekly weighing showed always some multiples of five pounds, undoubtedly owing to the fact that the scale could not indicate anymore minor number than five, it will not give any disturbance, however, for the consideration of total or average daily gain during such a long period as twelve weeks or more.

We have no ways of studying such problems as proposed in this thesis but to compare the weights and compositions of different animals of different ages. In order to secure a satisfactory result by such a method, it is very important to find animals of as much the same individualities as possible. Various sorts of individualities may be observed apparently from the various points of view, but the weights of animals are only a direct measure that we can rely on.

Uniform weights at the end and beginning of certain periods to be considered and also uniform rates of gains all thru the periods are to be desired.

Now, we are to compare steers No.177 and No.198 for Period 1, and steers No.198 and No.192 for Period 11. Weights of each animals at the beginning and end of each periods and average weights and daily gain during each period are give in the following. (refer to table No.111).

Table V111 - Showing weights of animals at the beginning and end of each period and their average weights during the period.

Steer	First 31 week			Period 1 Second 12 week			Period 11 Third 14 wk.		
	B.	E.	A.	B.	E.	A.	B.	E.	A.
177	90	310	192	–	–	–	–	–	–
198	110	310	195	310	415	358	–	–	–
192	85	300	178	300	405	354	405	520	457

B - Beginning E - End A - Average

Table 1X - Showing total gain and average gain daily and weekly.

Steer	Total gain	Average gain weekly	- daily	Daily gain in proportion to average weight.
1st 31 wk.				
177	220	7.10	1.01	1/190
198	200	6.45	.92	1/212
192	215	6.94	.99	1/180
2nd 12 wk.				
198	105	8.75	1.25	1/286
192	105	8.75	1.25	1/283
3rd 14 wk.				
192	115	8.21	1.17	1/390

As seen from above, steers No.177 and No.198 showed exactly the same weights on the end of the first 31 weeks or on the beginning of Period 1, altho they differed to some extent on the rate of gaining. No.198 showed ten pounds less than No.192 in weight both at the beginning and end of Period 11, the rate of gaining being quite uniform.

*(The rates of gaining will be compared more properly by the proportion of daily gains to average weights of animals during certain period than by absolute amounts of gains).

Considering the things described, it will be recognized that the records of the three animals taken as data for this thesis are satisfactory to learn the matters during Periods 1 and 11.

One thing to be noticed, is that the three steers are too heavy in their weights for their ages at the beginning of feeding, which were supposed to be someday within a week after birth, and looks two or three weeks old. Steer No.198 is especially heavy, being 110 pounds and seems older than that. It will be, perhaps, that this reason caused this animal to differ from the other two in the rate of gain, or of nutrient requirements, as can be see later.

Allowing these things, it will be properly considered that the results appeared in Period 1 are applicable to steers of age from about seven and one-half to ten and one-half months old, and weighing about

300 to 420 pounds, and those of Period 11, to steers of age from about ten and one-half to thirteen and one-half months old and weighing about 420 and 520 pounds.

Nutrient requirements for gaining body weights.

As regards this problem, the following tables are compiled from Table 111.

Table X - Showing total gaing of body weight and total amount of nutrients consumed by each animal during each period (in pounds).

Steer	Gain of Body Weight.	Dry Matter.	Ash.	Digestible Pro.	Digestible C.H.	Digestible Fat.	Total* Nutri-ents.
	1st 31 wk.						
177	220	738.68	48.12	97.97	387.97	24.07	540.10
198	200	773.38	50.63	101.07	406.13	27.71	569.54
192	215	708.13	46.17	96.07	371.52	22.91	519.13
	Period 1 12 wk.						
198	105	602.19	39.02	61.37	306.16	19.19	412.72
192	105	567.10	37.66	60.13	289.94	18.01	390.60
	Period 11 14 wk.						
192	115	888.21	55.52	87.40	450.02	25.85	595.58

Hereafter "Total nutrients" are always expressed in
* ~~in starch equivalents.~~
starch equivalents, using factor 2.25 for fat.

Table Xl - Showing average amounts of dry matter and nutrients consumed daily and average gains of body weight per day.

Steer	Gain of body weight	Dry matter	Ash	Digestible Pro	Digestible C.H.	Digestible Fat	Total nutri ments.	Nutri Ratio
	1st 31 wk.							
177	1.01	3.40	.22	.45	1.79	.11	2.49	1:4.5
198	.92	3.56	.23	.47	1.87	.13	2.62	1:4.6
192	.99	3.26	.21	.44	1.71	.11	2.39	1:4.4
	Period l							
198	1.25	7.17	.46	.73	3.67	.23	4.91	1:5.7
192	1.25	6.75	.45	.72	3.45	.21	4.61	1:5.5
	Period ll							
192	1.17	9.06	.57	.89	4.59	.26	6.08	1:5.8

Table Xll - Showing amounts of dry matter and nutrients consumed per one pound of gain of body weights.

Steer	Dry Matter	Ash	Digestible Pro	Digestible C.H.	Digestible Fat	Total Nutrients
	1st 31 wk.					
177	3.36	.23	.45	1.76	.11	2.46
198	3.87	.25	.51	2.03	.14	2.85

Steer	Dry Matter	Ash	Digestible Pro	Digestible C.H.	Digestible Fat	Total Nutrients.
	1st 31 wk.					
192	3.29	.21	.45	1.73	.11	2.41
	Period 1					
198	5.74	.37	.58	2.93	.18	3.93
192	5.40	.36	.57	2.76	.17	3.72
	Period 11					
192	7.72	.48	.76	3.91	.22	5.18

Now, allowing 0.6 pounds of protein, 6 pounds of carbohydrates and .1 pound of ether extract for body maintenance ration per one thousand pounds of live weight and supposing maintenance ration is required in proportion of live weight, calculations are made for finding the amounts of available nutrients required for gains of body weights.

X111 - Showing average weights of animals during each period and amounts of nutrients required daily for body maintenance.

Steer	Average Weight	Protein	C.H.	Fat	Total Nutrients.
Coeft. per 1000 lbs		.6	6.	.1	6.825
	1st 31 wks.				
177	192	.115	1.152	.019	1.310
198	195	.117	1.170	.020	1.331
192	178	.107	1.068	.018	1.215
	Period 1				
198	358	.215	2.148	.036	2.443
192	354	.212	2.124	.035	2.416
	Period 11				
192	457	.274	2.742	.046	3.119

XlV - Showing average amounts of available nutrients consumed daily.

Steer	~~Average Daily Gain.~~	Protein	C.H.	Fat	Total Nutri-ents.	Nutri Ratio.
	1st 31 wk.					
177		.339	.636	.092	1.179	1:2.5
198		.349	.702	.108	1.294	1:2.7
192		.336	.644	.088	1.177	1:2.5

Steer	~~Average Daily Gain~~	Protein	C.H.	Fat	Total Nutri-ents.	Nutri Ratio.
Period 1.						
198		.516	1.521	.193	2.470	1:3.8
192		.503	1.328	.179	2.234	1:3.4
Period 11.						
192		.618	1.850	.218	2.955	1:3.8

XV. - Showing the amounts of available nutrients required per one pound of gain of body weights.

Steer	Protein	C.H.	Fat.	Total Nutrients.
1st 31 wk.				
177	.33	.63	.09	1.17
198	.38	.76	.12	1.41
192	.34	.65	.09	1.19
Period 1.				
198	.41	1.22	.15	1.98
192	.40	1.06	.14	1.79
Period 11.				
192	.53	1.58	.19	2.53

Altho each table above gives the same things for the first 31st weeks with those for Period 1 and 11, it is excluded from the consideration. It is only to be used to show some general evidences as to the matters that there are seen the quicker gain of body weight, the less nutrient requirement for one pound gain and comparatively the more protein requirement or the narrower nutritive ratio, in the younger age.

It may be seen that it needed 1.8 to 2 pounds of net nutrients during Period 1 and 2.5 pounds during Period 11 for one pound gain of body weight, except provided for maintenance. During Period 1, No.192 used 49.8 per cent of total nutrients consumed for maintenance, and No.198, 52.4 percent, while during Period 11 No.198 used its 51.3 percent for the same purpose. Practically it may be said about one-half of the nutrients consumed, was used for body maintenance and the other half for production thro both periods.

Nutrient requirements for production of
nutrients in animal body.

This is the principal subject in this thesis with the next one. For Period 1, the analysis of records of steers 177 and 198 are to be employed and for Period 11, those of steers 198 and 192. (Refer to Tables 1V and V).

Table XV1 - Showing the increases of live weights and nutrients in animal body during period 1 and 11. (In pound).

Table XVl.

Period.	Normal live weight.	Weight less waste.	Composition of body. Water	Dry Matter	Ash	Protein	Fat	Total Nutri in Starch Equivalent.
(1)	12 weeks.							
No.177	307	247.5	163.05	84.45	10.67	47.03	26.40	106.43
No.198	415	337.8	223.70	114.10	14.68	64.81	35.14	143.87
Total increase	108	90.3	60.65	29.65	4.01	17.78	8.74	37.44
Daily increase	1.29	1.08	.73	.35	.05	.21	.10	.44
(11)	14 weeks.							
No.198	415	337.8	223.70	114.10	14.68	64.81	35.14	143.87
No.192	521	435.7	276.87	158.83	18.10	81.97	52.61	200.34
Total increase	106	97.9	53.14	44.73	3.42	17.16	17.47	56.47
Daily increase	1.08	1.00	.54	.46	.03	.18	.18	.58

Table XVll - Showing the amounts of body constituents produced in animal body per gain of one pound of live weight.

Period	Water	Dry Matter	Ash	Protein	Fat	Total Nutrients
1	.56	.27	.04	.16	.08	.35
11	.50	.42	.03	.16	.16	.53

Now, comparing these with the total and available nutrients required for one pound of gain of body weight, (Table Xll and XV), we can learn that about 9 percent of total nutrients or 18 percent of available nutrients were used for actual production of nutrients in animal body during Period 1 and about 10 percent or 21 percent during Period 11 respectively.

Apparently the animal gained its body weight more rapidly in Period 1 than in Period 11, but as it is, it showed the reverse in gaining nutrients or in true production. This is due to the fact that the younger animal gained more water per one pound gain of live weight than the older. In Period 1, 67 perwent of gain of live weight was water, while it was 54 percent in

Period 11. Altho these things are changeable according to the individualities of animals or the methods of feeding, the general tendency will remain so. This is clearly understood by looking on "% of dry matter in green material" in Table 1V and comparing three animals. Every sort of green material of No.192 shows more dry matter content compared with those of the other two, except skin of No.177, while No.198 showed less dry matter contained than No.177, though a trifle - .34%. Bones and flesh are those that give most material influence as for the dry matter ~~contained~~ content or water con~~tained~~tent of animal body.

Besides, the most striking feature in Table XV1 or XV11 is the change of the proportion of protein and fat. During the two periods fat doubled its rate of increase in animal body, while protein remained same. It became the same with protein in Period 11, while it was one-half of it in Period 1.

Looking into Table 1V and V, it is seen that the proportion of protein and fat in each animal body is

100:56 for No.177; 100:56 for No.198; 100:64 for No.192.

The following are compiled for a plain explanation from Tables X1, X11, X111, X1V and XV11.

	Period 1.	Period 11.
	%	%
A -----% of Dry Matter in Product to that consumed -------	4.7	5.4
Based on Total nutrients consumed.		
b -----% of Nutri. for maintenance	49.8	51.3
c -----% of " " production	50.2	48.7
d -----% of " in product	8.9	10.2
e -----% of " expended for production ----	41.3	38.5
f -----% of Nutri. expended in all	91.1	89.8
Based on Total Protein consumed.		
g -----% of protein for maintenance	29.6	30.8
h -----% " " production	70.4	69.2
i -----% " in product	27.6	21.1

j -----% of protein expended for production -----	42.8	48.1
k -----% of protein expended in all -----	72.4	78.9
Based on total non-nitrogenous matter consumed.		
l -----% of non-nitro for maintenance -	53.3	54.8
m -----% " for production -	46.7	45.2
n -----% " in product ----	5.5	8.1
o -----% " expended for production ---	41.2	37.1
p -----% " expended in all -	94.5	92.4

It is suggested that, though there may be some variations from those described above, among the rates of nutrients supposed to have been used for maintenance, or production or energy expended for production, the proportion between total nutrients consumed and actual production is an actual result which was determined by experiment.

As regards the metabolism of nitrogenous and non-nitrogenous substances, it agrees to the generally recognized facts that the reservation of protein in animal body is greater in yourger age and that of non-nitrogenous matter is greater rather in older age to some extent. It is supposed the differences of those during the two periods appeared above may be a trifle smaller than those in normal rates, which, though, never have been learned, becuase the steer No.198 was a little too old for Period 1 and looked to have had a tendency to use the ration of wider ratio, while it was the reverse in the Steer No.192.

Production of Edible Materials.

It is rather surprising to know how large a percent of either green material, dry matter, fat, protein or ash in animal body is found unfit for human food, such as bones, skin, etc. Strictly saying, some parts of materials classified here as non-edible may be made edible by extracting or by some other ways. However, it refers here to the materials commonly recognized as edible or those used for human food of the packing house products.

The things are understood well by studying carefully Tables VI and VII. Comparing the three animals, it is seen that the percent of edible materials increased, though a trifle, as animal grows. It is 47 percent of fat and 54 percent of protein in steer No.177; 56% of fat and 54 percent of protein in steer No.198; and 55 percent of fat and 55 percent of protein in steer No.192 respectively. Now, it may be said that practically 55 percent of fat as well as protein produced in animal bodies thru the two periods was edible, and the other 45 percent was non-edible.

During period 1, it produced .16 pounds of protein and .08 pound of fat or .35 pound of total nutrients in starch equivalents, per one pound gain of live weight. Using the coefficient 55 percent, we know that one pound gain of live weight during this period stands for production of .088 pounds of protein and .044 pound of fat or .193 pound of total nutrients in animal body which are edible.

Same as above, during the Period 11, it produced .16 pound of protein and .16 pound of fat or .53 pound of total nutrient, per one pound gain of live weight, of which .088 pounds of protein and .088 pound of fat or .293 pound of total nutrients are edible.

Comparing these with the amount of total nutrients consumed, we learn that about 5 percent in Period 1 and 5.5 percent in Period 11, of it were produced in the body of steer in the form of human food.

SUMMARY.

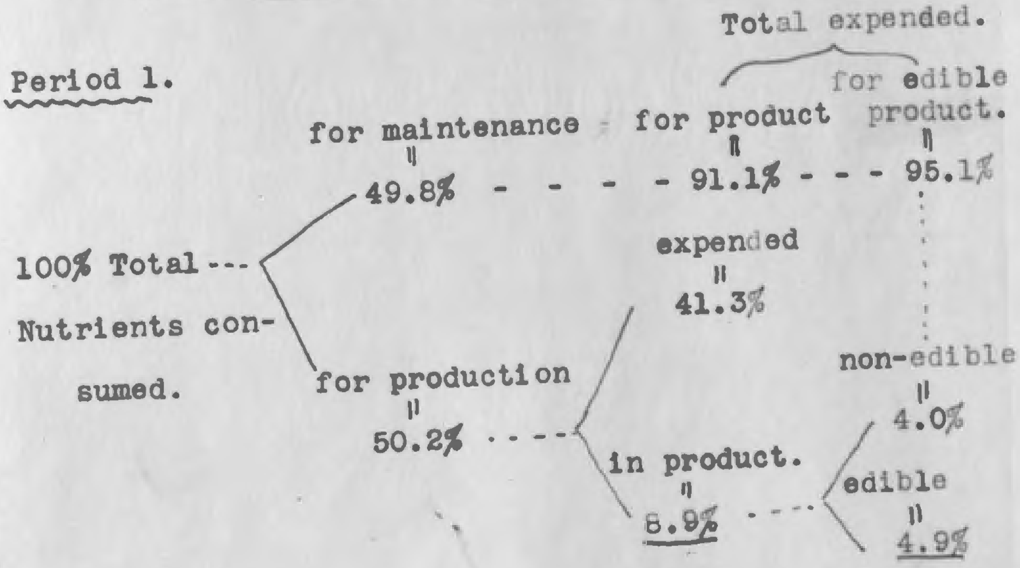
The results are summarized in the following:

	Period 1.	Period 11.
	Lbs.	Lbs.
a ---steer, weighing	300-420	420-500
(age ----------	7½ - 10½ months	10½ - 13½ months)
b --- average weight --------	358	457
c --- average daily gain of live weight	1.25	1.17
(ratio to average live weight	1/286	1/390)

d Total nutrients consumed, daily	4.91	6.08
e --- Nutrients for maintenance	2.44	3.12
f --- " for production	2.47	2.96
g Total nutrients consumed per one pound gain of live weight	3.93	5.18
h --- Available nutrients consumed per one pound gain of live weight	1.98	2.53
i --- Nutrients produced in animal body per one pound gain of live weight ---	.35	.53
j --- Edible nutrients produced in animal body per one pound gain of live weight ---	.19	.29
k --- Non-edible nutrients produced in animal body per one pound gain of live weight ---	.16	.24

Percentage of these are given below diagrammatically:

Period 1.



Period 11.

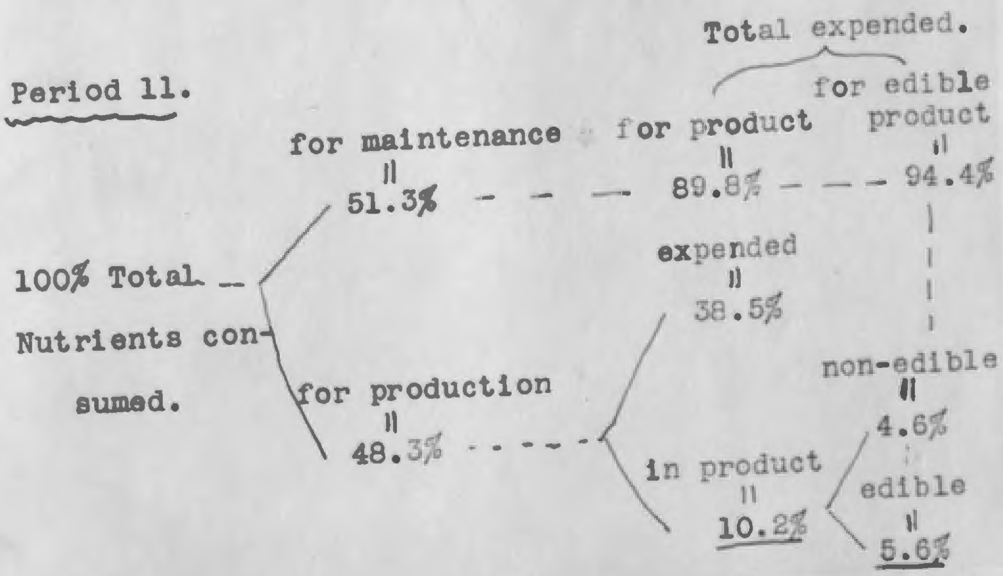


Table I.a Composition of Feeds. (Prairie Hay)

Date of Analysis	Dry matter	Ash	crude Protein	Fibre	N-free-Extract	Ether-Extract	Digestible Protein	Digestible Fibre	Digestible N-free-extract	Digestible Ether-extract
June 24 '08	89,19	6.832	6,350	24,322	46,584	5,102	2.984	14,836	26,553	2,449
Sept. 24 "	84.62	7,218	4,857	25,877	43,968	2,699	2,283	15,785	25,062	1,295
Oct 28 "	86.49	8.407	5,284	26,976	42,579	3,243	2.483	16,455	24,270	1,557
Nov. 23 "	84,00	7.274	5,124	27,770	41,605	2.226	2,408	16,940	23,715	1,068
Dec. 8 "	87,18	7.271	5,928	27,906	43,756	2.319	2,786	17,023	24,941	1.113
" 21 "	86,49	8,340	5,345	28,083	42,337	2.380	2.512	17,131	24,132	1,142
Jan. 4 '09	84,54	6,975	6,180	27,687	41,137	2.562	2,905	16,889	23,448	1,230
" 18 "	85,15	7.310	6,778	27,129	41,678	2,529	3,186	16,549	23,700	1,214
Feb 1 "	86,45	6,630	6,570	28,191	42,845	1,919	3,088	17,197	24,422	,921
" 16 "	80,26	7.343	4,358	27,312	38,822	2,424	2,048	16,660	22,129	1,164
Mar. 2 "	80,35	6.267	3,439	28,797	40,095	1,752	1,616	17,566	22,854	,841
" 16 "	79,52	5,725	3,380	27,784	41,001	1,630	1,589	16,948	23,371	,782
" 29 "	82,15	5,598	5,348	26,649	42,168	2,202	2,514	16,256	24,036	1,057
April 26 "	81,[illegible]	5,839	6,053	26,947	41,229	2,061	2,845	16,438	23,500	,989
May 12 "	[illegible]	6,823	6,727	24,579	39,667	1,904	3,162	14,993	22,610	,914
June 2 "	[illegible]	6,002	7,077	24,931	42,050	2,521	3,326	15,208	23,968	1,209
" 17 "		6,252	7.119	26,850	40,888	2,250	3,346	16,378	23,306	1,080
Digestibility Coefficient			47%	61%	57%	48%				

Table I.b Composition of Feeds. (Silage)

Date of Analyses.	Dry Matter	Ash	Crude Protein	Fibre	N-free-Extract	Ether-extract	Digestible Protein	Digestible Fibre	Digestible N-free-Extract	Digestible Ether-Extract
Sept 24 '08	22,47	1,162	1,678	6,447	11,965	1,218	,906	3,997	8256	1,035
Nov 23 "	27,00	1,347	1,920	6,747	15,555	1,431	1,037	4,183	10,733	1,216
Dec. 8 "	26,12	1,285	1,852	6,979	14,497	1,507	1,000	4,327	10,003	1,221
" 21 "	29,15	1,460	2,277	7,328	16,376	1.708	1,230	4,543	11,299	1,452
Jan 4 '09	29,44	1,251	2,173	8,102	16,428	1,481	1,173	5,027	11,335	1,259
Jan 18 "	28,45	1,394	1,930	7,508	16,026	1,542	1,069	4,655	11,058	1,311
Feb 1 "	23,23	1,152	1,540	6,755	12,821	,762	,832	4,188	8,846	,649
" 16 "	28,38	1,754	2,438	6,280	16,665	1,243	1,316	3,894	11,499	1,057
Mar. 2 "	22,80	1,482	1,651	5,955	12,861	,850	,891	3,692	8,874	,723
" 8 "	25,02	1,464	1,907	6,713	14,121	,816	1,031	4,162	9,743	,694
" 16 "	24,88	1,674	1,824	6,742	13,709	,931	,985	4,180	9,459	,791
" 22 "	27,00	1,659	2,087	6,934	15,096	1,202	1,127	4,299	10,416	1,022
" 29 "	25,81	1,543	1,894	6,556	14,547	1,270	1,023	4,065	10,037	1,080
April 6 "	26,84	1,479	1,978	6,629	15,473	1,280	1,068	4,110	10,676	1,088
" 10 "	28,09	1,643	2,084	7,090	15,983	1,289	1,125	4,386	11,029	1,096
" 26 "	25,77	1,446	2,105	6,855	14,106	1,258	1,137	4,250	9,733	1,069
May 5 "	26,16	1,900	2.187	7,074	13.888	1,112	1,181	4,386	9,583	,945
" 19 "	25,01	1,633	1,986	7,033	13,275	1,105	1,072	4,360	9,160	,939
June 2 "	23,99	1,489	1,893	6,553	13,250	,796	1,022	4,062	9,142	,677
" 17 "	22,91	1,567	1,792	6,076	12,722	,754	,968	3,767	8,778	,641
" 30 "	22,09	1,411	1,703	6,497	11,538	,884	,920	4,028	7,961	,751
Digestibility Coefficients			54%	62%	69%	85%				

Table I a Composition of Feeds. (Whole Milk, Skimmed Milk, & Blood Meal)

Date of Analyses.	Dry Matter	Ash.	Crude Protein	Fibre	N-free-extract	Ether-extract		Digestible Protein	Digestible Fibre	Digestible N-free-extract	Digestible Ether-extract
							(Whole milk)				
	12.61	.7	3,1	—	4.8	4,0		2.914	—	4,704	4,0
Digestibility Coefficients.			94%		98%	100%					
							(Skimmed milk)				
May to Dec. '08	9,09	.6	3,00	—	5,34	,15		2.820	—	5,236	,15
Dec. to Feb. '09	9.94	.83	3.618	—	5,37	,12		3,400	—	5,263	,12
Digestibility Coefficients			94%		98%	100%					
							(Blood meal)				
April 1 '08	93,13	1,872	86,350	—	4,433	,475		53,637	—	4,034	,418
June 24 "	91,76	2,120	83,951	—	5,368	,321		52,050	—	4,885	,283
			62%		91%	88%					

Table I* Composition of Feeds: (Corn)

Date of Analyses.	Dry Matter	Ash	Crude Protein	Fibre	N-free-Extract	Ether-Extract	Digestible Protein	Digestible Fibre	Digestible N-free-Extract	Digestible Ether Extract
Mar. 28 '08	82,29	1,512	8,624	1,777	68,210	2,567	5,174	,888	63,435	2,362
Sept. 24 '08	87,48	1,277	8,844	2,161	71,296	3,902	5,306	1,080	66,305	3,590
Oct 28 '08	88,56	1,346	10,043	2,196	71,052	3,924	6,026	1,098	66,078	3,610
Nov. 23 '08	87,58	1,384	9,099	2,216	71,246	3,635	5,459	1,108	66,259	3,344
Jan 4 '09	86,77	1,371	9,363	2,030	69,633	4,373	5,618	1,015	64,759	4,023
Jan 18 "	85,12	1,430	8,818	1,847	68,564	4,460	5,291	,924	63,765	4,104
Feb 1 "	85,24	1,406	8,729	2,003	68,900	4,202	5,237	1,002	64,077	3,866
Feb 16 "	83,36	1,350	8,319	1,809	67,822	4,060	4,992	,905	63,074	3,735
Mar. 2 "	85,27	1,373	8,331	2,243	68,813	4,511	4,999	1,121	63,996	4,150
Mar. 16 "	78,36	1,128	8,565	1,583	63,777	3,31	5,139	,792	59,313	3,042
Mar. 29 "	92,59	1,230	10,120	2,046	75,118	4,141	6,072	1,023	69,860	3,748
May 12 "	71,79	1,134	9,785	1,285	57,461	2,125	5,871	,642	53,439	1,955
June 17-30 "	91,23	1,277	10,336	1,770	74,580	3,266	6,202	,885	69,359	3,005
Digestibility Coefficients			60%	50%	93%	92%				

Table I^c Composition of Feeds (Oil Meal)

Date of analyses	Dry Matter	Ash	Crude Protein	Fibre	N-free-extract	Ether-extract	Digestible Protein	Digestible Fibre	Digestible N-free-extract	Digestible Ether-extract
May 28 '08	91.07	5,20	33,332	7,012	38,122	7,404	29,665	3,997	29,735	6,590
Sept. 24 "	89.79	5,055	29,074	6,779	41,411	7,470	25,876	3,864	32,301	6,648
Oct 28 "	91,66	5,545	34,803	6,975	36,765	8,706	30,975	3,976	28,677	6,763
Nov. 23 "	91,07	5,227	33,823	7,559	35,754	7,599	30,102	4,309	27,888	7,748
Jan 4 '09	90,94	5,429	34,057	6,848	36,536	8,076	30,311	3,903	28,494	7,476
" 18 "	91,57	5,375	34,394	7,509	35,758	8,534	30,610	4,280	27,891	7,596
Feb 1 "	91,50	5,554	34,001	7,750	35,218	8,976	30,261	4,418	27,470	7,989
" 16 "	9092	4,900	34,622	7,546	35,113	8,737	30,814	4,301	27,388	7,776
Mar 2 "	88,09	5,012	31,853	7,858	35,289	8,078	28,349	4,479	27,525	7,189
" 16 "	92,25	5,563	33,265	8,441	37,002	7,976	29,606	4,811	28,861	7,102
" 22 "	89,82	5,308	38,856	6,135	29,524	9,997	34,582	3,497	23,029	8,897
" 29 "	90,75	4,782	35,883	7,541	33,968	8,5759	31,936	4,299	26,495	7,633
April 13 "	90,32	5,202	36,245	8,066	32,353	8,454	32,258	4,598	25,235	7,524
May 12 "	89,41	5,463	34,700	8,351	35,004	6,892	30,883	4,760	27,303	5,244
June 27/7-30 "	92,55	5,211	37,594	7,931	35,049	7,765	33,459	4,521	27,338	6,911
Digestibility Coefficients			89%	57%	78%	89%				

Table I* Composition of Feeds (Barley)

Date of Analyses.	Dry Matter	Ash	Crude Protein	Fibre	N-free-Extract	Ether Extract	Digestible Protein	Digestible Fibre	Digestible N-free-Extract	Digestible Ether Extract
Oct 28 '08	87,93	2,638	10,868	5,838	66,748	1,838	7,608	2,919	61,408	1,636
Nov. 23 "	87,65	2,542	10,132	5,197	67,561	2,209	7,092	2,598	62,156	1,966
Dec. 8 "	87,67	2,489	11,520	5,348	66,489	1,823	8,064	2,674	61,170	1,622
Dec. 21 "	87,58	2,356	11,175	4,896	67,323	1,830	7,822	2,448	61,937	1,629
Jan 4 '09	87,60	2,637	11,300	4,318	67,172	2,173	7,910	2,159	61,798	1,934
" 18 "	87,36	2,638	11,173	6,299	64,917	2,333	7,821	3,149	59,724	2,076
Feb 1 "	86,98	2,739	11,047	5,132	65,948	2,114	7,733	2,566	60,672	1,881
" 16 "	87,64	2,507	11,060	5,705	66,370	1,998	7,742	2,853	61,060	1,778
Mar. 2 "	87,43	2,535	11,427	6,627	64,978	1,862	7,999	3,314	59,780	1,657
" 16 "	90,21	2,679	11,854	6,071	67,919	1,687	8,298	3,036	62,466	1,501
" 29 "	88,64	2,588	10,965	5,762	67,792	1,534	7,675	2,881	62,369	1,365
April 13 "	86,75	2,455	11,095	4,710	67,084	1,405	7,766	2,355	61,717	1,250
" 26 "	88,27	2,533	12,01	5,685	66,397	1,651	8,404	2,842	61,085	1,469
May 12 "	88,76	2,565	11,663	5,982	67,546	1,003	8,164	2,991	62,142	,893
June 2-7-30 "	90,60	2.787	13,708	4,793	67,660	1,713	9,596	2,397	62,247	1,524
Digestibility Coefficients			70%	50%	92%	89%				

Table II: Composition of Feeds (Bran).

Date of analyses.	Dry Matter	Ash	Crude Protein	Fibre	N-free-extract	Ether-Extract	Digestible Protein	Digestible Fibre	Digestible N-free-extract	Digestible Ether-extract
March 28 '08	89,24	6,281	13,163	11,601	53,526	4,667	10,530	2,784	37,468	3,547
Sept. 24 "	89,26	5,677	15,013	11,818	51,289	5,463	12,010	2,836	35,902	4,152
Oct 28 "	89.78	5,602	14,410	10,361	54,407	5,001	11,528	2,487	38,085	3,801
Nov. 23 "	88.38	6,699	13,363	9,563	53,275	5,480	10,690	2,295	37,292	4,165
Jan 4 '09	88,01	6,302	14,460	11,160	51,107	4,981	11,568	2,678	35,775	3,786
Jan 18 "	88.63	6,178	14,296	12,054	50,563	5,539	11.437	2,893	35,394	4,211
Feb. 1 "	87,12	5,724	14,061	10,960	50,835	5,541	11,249	2,630	35,584	3,728
" 16 "	89,68	6,223	14,367	11,712	52,478	4,906	11,494	2,810	36,730	4,175
March 2 "	88.74	6,300	14,065	11,767	51,114	5,493	11,252	2,824	35,780	3,119
" 16 "	89,79	6,465	16,153	11,475	51,592	4,103	12,923	2,754	36,115	3,728
" 29 "	89,02	6,466	15,712	11,190	50,973	4,905	12,570	2,686	35,681	3,627
April 13 "	90,73	6,814	15,016	11,858	52,270	4,772	12,013	2,846	36,589	3,627
" 26 "	90,65	6,608	14,912	12,102	52,258	4,768	11,930	2,904	36,581	3,624
May 12 "	86,33	6,345	14,831	11,128	50,244	3,781	11,865	2,671	35,171	3,874
June 27-30 "	91.40	6,654	15,419	11,672	52.400	5,255	12,335	2,801	36,680	3,994
Digestibility Coefficients			80%	24%	70%	76%				

Table II. Grain Mixtures.

From the week ending May 31 (1908) / To " " " Oct. 11	Corn 5	Bran 3	Oil m. 2	Blood m. 2	
From the week ending Oct. 18 (1908) / To " " " Dec. 27	Corn 2	Bran 4	Oil m 2	Blood m. 2	Barley 2
From the week ending Jan 3 '09 / To " " " June 27 '09	Corn 2	Bran 4	Oil m. 3	Barley 2	

Table IV A Analysis of Animal Body

Animal and Number	Kind of Material	Lbs. Green Material	% D.M. in Green Material	Lbs. Dried Material	Based on Green Material: % Ash	Lbs. Ash	% Ether Extr.	Lbs. Ether Extr.	Based on Green M.: % Nitrogen	Lbs Nitrogen	Factor	By Factor Lbs. Protein	By Diff. Lbs. Protein
	Non Edl. Off.	28,1	31,24	8,7784	1,94	,1703	66,73	5,8586	1,58	,4440	6,25	2,7750	2,7495
No 177	Edible Offal	12,5	27,40	3,4250	4,26	,1459	29,94	1,0254	2,73	,3413		2,1331	2,2537
Lot III	Flesh	122,9	28,95	35,5796	3,19	1,1350	31,91	11,3535	3,02	3,7116		23,1975	23,0911
	Bone	41,5	57,88	24,0202	37,23	8,9427	27,51	6,6080	3,00	1,2450		7,7812	8,4695
	Cart. & T.	6,1	35,37	2,1576	1,86	,0401	27,98	,6037	3,86	,2355		1,4719	1,5138
	Blood	14,1	19,17	2,7030	2,82	,0756	,55	,1487	2,89	,4075		2,5469	2,4787
	Skin	22,3	34,91	7,7849	2,02	,1573	10,25	,7980	5,11	1,1395		7,1219	6,8296
	Waste	39,7											
	Evaporation	1,1											
	Total	288,3		84,4487		10,6669		26,3959		7,5244		47,0275	47,3859

Table V A **Deductions – Based on the Normal Live Weight (3 days average), the Fasted Weight and the Weight less Waste.**

	Lbs. Animal Weight	Lbs. that are Waste	% that is Waste	Lbs other than Waste	% other than Waste	In Material other than included in Waste: Lbs. D.M.	% D.M.	% Ash	% Ether Extr.	% (N×6.25) Protein	% (by diff.) Protein	% Water	% D.M.	% Waste
Normal	307	59,5	19,38	247,5	80,62	84,4487	27,51	3,44 [7]	8,60	15,32	15,44	53,11	27,51	19,38
Fasted	288,3	40,8	14,15	247,5	85,85	84,4487	29,29	3,64 [70]	9,16	16,31	16,44	55,56	29,29	14,15
Less Waste	247,5	—	—	247,5	100,00	84,4487	34,12	4,31	10,67	19,01	19,15	65,88	34,12	—

Table II A Distribution of Nutrients in various Materials of Animal Body.

Kind of Material	In Total Green Material Lbs.	In Total Green Material %	In Total Dried Material Lbs	In Total Dried Material %	In Total Ash. Lbs	In Total Ash. %	In Total Ether Extract Lbs	In Total Ether Extract %	In Total Protein (N×6,25) Lbs	In Total Protein (N×6,25) %	~~In Total Protein (by diff.)~~ Lbs	~~In Total Protein (by diff.)~~ %
Non-Edl. Offal	28.1	11,35	8,7784	10,39	,1703	1.60	5,8586	22.20	2,7750	5,91	~~2,7495~~	
Edible Offal	12.5	5,05	3,4250	4,06	,1459	1,37	1,0254	3,88	2,1331	4,54	~~2,2537~~	
Flesh	122,9	49,66	35,5796	42,13	1,1350	10,64	11,3535	43,01	23,1975	49,33	~~23,0911~~	
Bone	41.5	16,77	24,0202	28,46	8,9427	83,84	6,6080	25,03	7,7812	16,52	~~8,4695~~	
Cartilage & Tendon	6.1	2,46	2,1576	2,55	,0401	,38	,6037	2.29	1,4719	3,12	~~1,5138~~	
Blood	14.1	5,70	2,7030	3.20	,0756	,71	,1487	,56	2,5469	5,42	~~2,4787~~	
Skin	22,3	9,01	7,7849	9,22	,1573	1,47	,7980	3,02	7,1219	15,14	~~6,8296~~	
Total	247,5	100,00 %	84,4487	100,00 %	10,6669	100,00 %	26,3959	100,00 %	47,0275	100,00 %	47,3[illegible]	

Table III A Edible and Non-Edible Substances of Animal Body.

	In Total Green Material Lbs	In Total Green Material %	In Total Dried Material Lbs	In Total Dried Material %	In Total Ash Lbs	In Total Ash %	In Total Ether Extract Lbs	In Total Ether Extract %	In Total Protein (N×6,25) Lbs	In Total Protein (N×6,25) %
Edible	135,4	54,70	39,0046	46,19	1,2809	12,01	12,3789	46,89	25,3306	53,86
Non-Edible	112,1	45,30	45,4441	53,81	9,3860	87,99	14,0170	53,11	21,6969	46,14
Total	247.5	100,00 %	84,4487	100,00 %	10,6669	100,00 %	26,3959	100,00 %	47,0275	100,00 %

Table IV B Analysis of Animal Body

Animal and Number	Kind of Material	Lbs. Green Material	% D.M. in Green Material	Lbs. Dried Material	Based on Dry Material % Ash	Lbs. Ash	% Ether Ex.	Lbs Ether Ex.	Based on Green M. % Nitrogen	Lbs. Nitrogen	Factor	By Factor Lbs. Protein	by Diff. Lbs. Protein
	Non-Edible O.	30,1	27,38	8,2414	2.33	,1920	57,27	4,7198	1.87	,5629	6,25	3,5181	3,3296
No 198	Edible Offal	18,95	28,40	5,3818	3,40	,1830	37,14	1,9988	2.67	,5060		3,1625	3,2000
	Flesh	173,2	29,42	50,9554	2,84	1,4471	34,84	17,7529	2,94	5,0921		31,8256	31,7554
Lot III	Bone	57,2	59,22	33,8738	36,93	12,5096	27,31	9,2509	3,34	1,9105		11,9406	12,1133
	Cart & T.	10,05	33,66	3,3828	3,95	,1336	20,71	,7006	3.89	,3909		2,4431	2,5486
	Blood	18,4	17,47	3,2145	1,67	,0537	,51	,0164	3.02	,5557		3,4731	3,1444
	Skin	29,9	30,25	9,0448	1,78	,1610	7,77	,7028	4.52	1,3515		8,4469	8,1810
	Waste	51,5											
	Evaporation	3,6											
	Total	392,9		114,0945		14,6800		35,1422	[illegible]	10,3696		64,8099	64,2723

Table V B Deductions – Based on the Normal Live Weight (3 days average), the Fasted Weight and the Weight less Waste.

	Lbs. Animal Weight	Lbs that are Waste	% that is Waste	Lbs other than Waste	% other than Waste	Lbs. D.M.	In Material other than included in Waste % D.M.	% Ash	% E.E.	% Protein (N×6.25)	% Protein (by diff)	% Water	% D.M.	% Waste
Normal	415	77.2	18,60	337.8	81,40	114,0945	27,49	3,54	8,47	15,62	15,49	53,91	27,49	18,60
Fasted	392.9	55,1	14,02	337.8	85,98	114,0945	29,04	3,74	8,94	16,50	16,36	56,69	29,04	14,02
Less Waste	337.8	—	—	337,8	100,0	114,0945	33,78	4,35	10,40	19,19	19,03	66,22	33,78	—

Table II B Distribution of Nutrients in various Parts of Animal Body.

Parts of Body	In Total Green Material Lbs.	%	In Total Dried Material Lbs	%	In Total Ash Lbs	%	In Total Ether Extract Lbs	%	In Total Protein (NX6,25) Lbs.	%
Non Edibl Offal	30,1	8,91	8,2414	7,22	,1920	1,31	4,7198	13,43	3,5181	5,43
Edible Offal	18,95	5,61	5,3818	4,72	,1830	1,25	1,9988	5,69	3,1625	4,88
Flesh	173,2	51,27	50,9554	44,66	1,4471	9,86	17,7529	50,52	31,8256	49,11
Bone	57,2	16,93	33,8788	29,69	12,5096	85,22	9,2509	26,32	11,9406	18,42
Cartilage & Tendon	10,05	2,98	3,3828	2,96	,1336	,91	,7006	1,99	2,4431	3,77
Blood	18,4	5,45	3,2145	2,82	,0537	,35	,0164	,05	3,4731	5,36
Skin	29,9	8,85	9,0448	7,93	,1610	1,10	,7028	2,00	8,4469	13,03
Total	337,8	100,⁰⁰ %	114,0945	100,⁰⁰ %	14,6800	100,⁰⁰ %	35,1422	100,⁰⁰ %	64,8099	100,⁰⁰ %

Table III B Edible and Non-Edible Nutrients in Animal Body.

	In Total Green Material Lbs	%	In Total Dried Material Lbs	%	In Total Ash Lbs	%	In Total Ether Extract Lbs	%	In Total Protein (NX6,25) Lbs	%
Edible	192,15	56,88	56,3372	49,39	1,6301	11,11	19,7517	56,21	34,9881	53,99
Non-Edible	145,65	43,12	57,7532	50,61	13,0499	88,89	15,3816	43,79	29,8218	46,01
Total	337,8	100,⁰⁰ %	114,0945	100,⁰⁰ %	14,6800	100,⁰⁰ %	35,1422	100,⁰⁰ %	64,8099	100,⁰⁰ %

Table III c Analysis of Animal Body.

Animal and Number	Kind of Material	Lbs. Green Material	% D.M. in Green Material	Lbs. Dried Material	Based on Dry Material: % Ash	Lbs Ash	% Ether Ex.	Lbs. Ether Ex.	Based on Green M.: % Nitrogen	Lbs. Nitrogen	Factor	By Factor Lbs. Protein	By Diff. Lbs. Protein
	Non-Edible Offal	46,9	33.08	15,5145	2,10	,3258	66,59	10,3311	1,68	,7879	6.25	4,9244	4,8576
No 192	Edible Offal	19,3	30,71	5,9270	3,13	,1855	39,59	2,3465	2,68	,5172		3,2325	3,3950
	Flesh	232,1	32,52	75,4789	2,69	2,0304	35,38	26,7044	2,91	6,7541		42,2131	46,7441
Lot III	Bone	72,3	60,33	43,6176	34,90	15,2225	26,64	11,6197	3,41	2,4654		15,4088	16,7754
	Cart. & T.	9,4	35,09	3,2985	1,22	,0402	24,65	,8131	4,14	,3892		2,4325	2,4452
	Blood	21,8	19,30	4,2074	3,72	,1565	,46	,0194	2,93	,6387		3,9919	4,0315
	Skin	33,9	31,83	10,7904	1,28	,1381	7,23	,7801	4,61	1,5628		9,7675	9,8722
	Waste	74,0											
	Evaporation	1,3											
	Total	511,0		158,8343		18,0990		52,6143		13,1153		81,9707	88,1210

Table [illegible] c Deductions – Based on the Normal Live Weight (3 days average), the Fasted Weight and the Weight less Waste

	Lbs Weight	Lbs that are Waste	% that is Waste	Lbs other than Waste	% other than Waste	In Material other than Included in Waste: Lbs D.M.	% D.M.	% Ash	% E.E.	% (N×6,25) Protein	% (by diff) Protein	% Water	% D.M.	% Waste
Normal	521,0	85,3	16,37	435,7	8363	158,8343	30,49	3,47	10,10	15,73	16,91	53,14	30,49	16,37
Fasted	511,0	75,3	14,74	435,7	85,28	158,8343	31,08	3,54	10,30	16,04	17,24	54,19	31,08	14,73
Less Waste	435,7	—	—	435,7	100,00	158,8343	36,45	4,15	12,08	18,81	20,22	63,55	36,45	—

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Table II C Distribution of Nutrients in various Parts of Animal Body.

Parts of Body	In Total Green Material Lbs	In Total Green Material %	In Total Dried Material Lbs	In Total Dried Material %	In Total Ash Lbs	In Total Ash %	In Total Ether Extract Lbs	In Total Ether Extract %	In Total Protein (N×6,25) Lbs	In Total Protein (N×6,25) %
Non-Ed'l Offal	46,9	10,76	15,5145	9,77	,3258	1,80	10,3311	19,63	4,9244	6,01
Edible Offal	19,3	4,43	5,9270	3,73	,1855	1,02	2,3465	4,46	3,2325	3,94
Flesh	232,1	53,27	75,4789	47,52	2,0304	11,22	26,7044	50,76	42,2131	51,50
Bone	72,3	16,59	43,6176	27,46	15,2225	84,11	11,6197	22,08	15,4088	18,80
Cart. & Tendon	9,4	2,16	3,2985	2,08	,0402	,22	,8131	1,54	2,4325	2,97
Blood	21,8	5,00	4,2074	2,65	,1565	,86	,0194	,04	3,9919	4,87
Skin	33,9	7,79	10,7904	6,79	,1381	,77	,7801	1,48	9,7675	11,92
Total	435,7	100,00%	158,8343	100,00%	18,0990	100,00%	52,6143	100,00%	81,9707	100,00%

Table III C Edible and Non-Edible Nutrients in Animal Body.

	In Total Green Material Lbs.	In Total Green Material %	In Total Dried Material Lbs.	In Total Dried Material %	In Total Ash Lbs.	In Total Ash %	In Total Ether Extract Lbs.	In Total Ether Extract %	In Total Protein (N×6,25) Lbs.	In Total Protein (N×6,25) %
Edible	251,4	57,70	81,4059	51,25	2,2158	12,24	29,0509	55,22	45,4456	55,44
Non-Edible	184,3	42,30	77,4284	48,75	15,8832	87,76	23,5634	44,78	36,5251	44,56
Total	435,7	100,00%	158,8343	100,00%	18,0990	100,00%	52,6143	100,00%	81,9707	100,00%

Table III (A) Showing weekly live weights and gains, and average amounts of feeds and nutrients consumed daily during the each corresponding week, for Steer No 177
(in pound)

Week ending	Live Weight: Weekly weight.	Live Weight: Weekly gain.	Daily Feeds Consumed: Milk	Skim Milk	Hay	Grain	Ensilage	Dry Matter	Ash	Digestible: Protein	C.H.	Ether Extract
1908 May 31	9 90											
June 7	100	10	4,0	4,0	,2	,2		1,2217	,0729	,2615	,5805	,1779
" 14	110	10	3,0	6,0	,3	,3		1,4542	,0884	,3048	,7296	,1468
" 21	120	10	2,0	7,0	,4	,4		1,5958	,0979	,3200	,8264	,1143
" 29	125	5	1,0	8,0	,5	,5		1,7307	,1074	,3350	,9184	,0817
July 5	130	5		9,0	,6	,6		1,8707	,1169	,3501	,8142	,0492
" 12	140	10		9,0	,7	,7		2,0461	,1274	,3662	1,1047	,0551
" 19	145	5		9,0	,8	,9		2,3078	,1415	,3954	1,2443	,0646
" 26	150	5		9,0	,9	,9		2,3970	,1483	,3983	1,2856	,0670
Aug. 2	150	0		9,0	1,0	,9		2,4862	,1552	,4013	1,3270	,0695
" 9	160	10		9,0	1,0	1,0		2,5724	,1588	,4143	1,3761	,0730
" 16	165	5		9,0	1,3	1,0		2,5724	,1588	,4143	1,3761	,0730
" 23	175	10		9,0	1,5	1,0		2,8404	,1793	,4233	1,5003	,0803
" 30	185	10		9,0	1,5	1,0		3,0184	,1930	,4292	1,5831	,0852
Sept. 6	190	5		9,0	1,5	1,2		3,1909	,2003	,4533	1,6813	,0901
" 13	190	0		9,0	1,5	1,2		3,1909	,2003	,4533	1,6813	,0901
" 20	200	10		9,0	1,5	1,2	2,0	3,2358	,2236	,4714	1,9264	,1108
" 27	210	10		9,0	1,5	1,2	3,0	3,8283	,2370	,4614	2,0538	,1082
Oct. 4	220	10		9,0	1,5	1,2	3,0	3,8283	,2370	,4614	2,0538	,1082
" 11	225	5		9,0	1,5	1,4	3,0	4,0058	,2486	,4860	2,1522	,1156
" 18	235	10		9,0	1,8	1,4	3,0	4,2582	,2452	,5088	2,2406	,1199
" 25	240	5.		8,0	2,0	1,4	3,0	4,3369	,2836	,4852	2,2699	,1225

Table III (A) (continued)

Week Ending	Live Weight: Weekly Weight	Live Weight: Weekly gain	Skim Milk	Hay	Grain	Ensilage	Dry Matter	Ash	Digestible Protein	Digestible C.H.	Ether Extract	Total nutrients in starch equivalent
1908 Nov. 1	245	5	8,0	2,0	1,6	3,0	4,5645	,2167	,5310	2,3793	,1358	
" 8	255	10	8,0	2,0	1.6	4,0	4,7892	,3283	,5401	2.4958	,1462	
" 15	260	5	8,0	2,0	1.6	4,0	4,7892	,3283	,5401	2,4958	,1462	
" 22	270	10	8,0	2,0	1,8	4,0	4,9684	,3366	,5687	2,5923	,1539	
" 29	280	10	8,0	2,2	1,8	4,0	5,2513	,3421	,5639	2,7719	,1597	
Dec. 6	290	10	8,0	2,2	2,0	4,0	5,4286	,3511	,5911	2,8677	,1681	
" 13	280	10	8,0	2,4	2,0	4,0	5,7055	,3805	,6822	2,9510	,1678	
" 20	300	10	8,0	2.6	2,0	4,0	5,8799	,3950	,6878	3,0349	,1700	
" 27	310	10	8,0	2,6	2,2	4,0	6,1605	,4289	,6963	3,1146	,1883	
							105,5257	6,8738	13,9957	56,4239	3,4390	
Total gain 220.			Total (31 weeks)				738,6799	48,1166	97,9699	387,9673	[illegible]4,0730	540,1015
Daily average 1,01.			Daily average				3,4041	,2217	,4516	1,7879	,1109	2,4889

Killed December 30 1908
Average of 3 days weighing 307. pounds.

Table III (C) - showing weekly live weights and gains, and average amounts of feeds and nutrients consumed daily during the each corresponding week — for steer No 192.

Week Ending	Live Weight Weekly Weights	Live Weight Weekly Gain	Milk	Skim Milk	Hay	Grain	Ensilage	Dry Matter	Ash	Digestible Protein	Digestible C. H.	Digestible Ether extract
		85										
1908 June 7	95	10	4,0	4,0	,2	,2		1,2217	,0729	,2615	,5805	,1779
" 14	100	5	3,0	6,0	,3	,3		1,4542	,0884	,3048	,7296	,1468
" 21	100	0	2,0	7,0	,3	,3		1,4194	,0874	,3039	,7349	,1083
" 28	110	10	1,0	8,0	,3	,3		1,3797	,0864	,3029	,7374	,0698
July 5	110	0		9,0	,3	,3		1,3443	,0814	,3017	,7427	,0331
" 12	115	5		9,0	,5	,5		1,6953	,1064	,3341	,9237	,0432
" 19	120	5		9,0	,6	,6		1,8707	,1169	,3501	,8142	,0492
" 26	120	0		9,0	,9	,9		2,3970	,1483	,3983	1,2856	,0670
Aug. 2	135	15		9,0	1,0	,9		2,4862	,1552	,4013	1,3270	,0695
" 9	140	5		9,0	1,0	1,0		2,5724	,1588	,4143	1,3761	,0730
" 16	150	10		9,0	1,0	1,0		2,5724	,1588	,4143	1,3761	,0730
" 23	150	0		9,0	1,3	1,0		2,8404	,1793	,4233	1,5003	,0803
" 30	170	20		9,0	1,5	1,0		3,0184	,1930	,4292	1,5831	,0852
Sept. 6	175	5		9,0	1,5	1,2		3,1909	,2003	,4533	1,6813	,0901
" 13	185	10		9,0	1,5	1,2		3,1909	,2003	,4533	1,6813	,0901
" 20	195	10		9,0	1,5	1,2	2,0	3,2358	,2231	,4714	1,9264	,1108
" 27	190	-5		9,0	1,5	1,2	3,0	3,8283	,2370	,4614	2,0538	,1082
Oct. 4	200	10		9,0	1,5	1,2	3,0	3,8283	,2370	,4614	2,0538	,1082
" 11	208	5		9,0	1,5	1,4	3,0	4,0254	,2436	,4860	2,1532	,1156
" 18	215	10		9,0	1,5	1,4	3,0	4,1057	,2585	,5019	2,1180	,1160
" 25	220	5		8,0	1,8	1,4	3,0	4,1683	,2692	,4806	2,1882	11,84

Table III (C) - Continued.

Week ending	Live Weight Weekly Weight	Live Weight Weekly gain	Skim milk	Hay	Grain	Ensilage	Dry matter	Ash	Protein	C.H.	Ether Extract	Total nutri- in St.ch.-equiv.
1908 Nov. 1	230	10	8,0	1,8	1,6	3,0	4,3915	,2999	,5263	2,2918	,1327	
" 8	240	10	8,0	2,0	1,6	3,0	4,5645	,3167	,5305	2,3733	,1359	
" 15	250	10	8,0	2,0	1,6	3,0	4,5645	,3167	,5305	2,3733	,1359	
" 22	260	10	8,0	2,0	1,8	3,0	4,7437	,3249	,5596	2,4700	,1436	
" 29	270	10	8,0	2,2	1,8	3,0	4,9813	,3286	,5535	2,6227	,1475	
Dec. 6	280	10	8,0	2,2	2,0	3,0	5,1586	,3376	,5807	2,7185	,1557	
" 13	285	5	8,0	2,4	2,0	3,0	5,4443	,3676	,6722	2,8086	,1556	
" 20	290	5	8,0	2,6	2,0	3,0	5,6187	,3821	,6778	2,8925	,1578	
" 27	300	10	8,0	2,6	2,2	3,0	5,8690	,4243	,6840	2,9562	,1738	
							101,1618	6,5956	13,7241	53,0741	3,2724	
Total gain	215			Total (31 weeks)			708,1326	46,1692	96,0687	371,5187	22,9068	519,1273
Daily ~~average~~	,99			Daily average			3,2633	,2127	,4427	1,7121	,1056	2,3923
1909 Jan 3.	310	10	8,0	2,6	2,2	3,0	5,8735	,4568	,6915	3,0170	,1825	
" 10	320	10	7,0	2,8	2,4	3,0	6,0720	,3990	,7326	3,1025	,1898	
" 17	320	0	6,0	2,8	2,6	3,0	6,1497	,3997	,7301	3,1326	,1977	
" 24	330	10	6,0	3,0	2,6	3,0	6,3070	,4328	,7461	3,2118	,2168	
" 31	345	15	5,0	3,0	2,8	3,0	6,4841	,4429	,7875	3,2509	,2289	
Feb. 7	350	5	5,0	3,2	3,0	3,0	6,5998	,4187	,7348	3,3640	,1976	
" 14	365	15	4,0	3,4	3,2	3,0	6,8482	,4324	,7364	3,4864	,2077	
" 21	380	15	3,0	3,6	3,4	3,0	7,0480	,4880	,7496	3,5894	,2294	
" 28	390	10	2,0	3,8	3,6	3,0	7.2966	,5029	,7511	3,7069	,2398	

Table III (C) - Continued

Week Ending	Live Weight Weekly Weight	Weekly Gain	Skim milk	Hay	Grain	Ensilage	Dry Matter	Ash	Digestible Protein	Digestible C.H.	Ether Extract	Total Nutri- in Starch-Equiv.
1909 March 7	390	0		4,0	3,8	3,0	7.2645	,4609	,6331	3,7649	,2272	
" 14	400	10		4,0	3,8	4,0	7,5036	,4756	,6427	3,8973	,2343	
" 21	405	5		4,1	3,8	4,0	7,5673	,4706	,7098	3,8967	,2250	
							8,0142	5,3803	8,5893	41,4204	2,5735	
Total gain	105			Total (12 weeks)			567,1001	37,6621	60,1251	289,9428	390,6005	
Daily average	1,25			Daily average			6,7512	,4484	,7158	3,4517	4,6501	
1909 March 28	410	10		4,0	4,0	4,0	7,7436	,4793	,7416	3,9870	,2332	
April 4	415	5		4,2	4,0	4,0	8,1063	,4695	,7810	4,1541	,2624	
" 11	445	30		4,4	4,0	4,0	8,2706	,4807	,7860	4,2346	,2645	
" 18	445	0		4,4	4,2	4,0	8,5279	,5038	,8143	4,3644	,2701	
" 25	450	5		4,6	4,2	4,0	8,6922	,5071	,8193	4,4450	,2722	
May 2	450	0		4,6	4,2	4,0	8,6501	,5248	,8395	4,3704	,2632	
" 9	445	-5		4,8	4,4	4,0	8,9969	,5455	,8452	4,5442	,2738	
" 16	450	5		4,8	4,4	4,0	8,5685	,5895	,8674	4,3651	,2132	
" 23	470	20		5,0	4,6	4,0	8,8980	,6121	,9043	4,5318	,2210	
" 30	470	0		5,0	4,6	4,0	8,8980	,6121	,9043	4,5318	,2210	
June 6	481	11		6,0	4,8	4,0	10,2921	,6470	1,0294	5,1424	,2956	
" 13	499	18		6,0	4,8	4,0	10,2921	,6470	1,0294	5,1424	,2956	
" 20	506	7		6,0	5,0	4,0	10,4752	,6562	1,0623	5,2375	,3040	
" 27	520	14		6,0	5,0	4,0	10,4752	,6562	1,0623	5,2375	,3040	

Table III (C) - Continued

Week ending	Live weight: Weekly weight	Live weight: Weekly gain	Skim milk	Hay	Grain	Ensilage	Dry matter	Ash	Digestible: Protein	Digestible: C.H	Digestible: Ether extract	Total nutrients in Starch Equi.
							126,8865	7,9308	12,4863	64,2882	3,6928	
Total gain	115			Total (14 weeks) - - - -			888,2055	55,5156	87,4041	450,0174	25,8496	595,5834
Daily Average	1,17			Daily average - - - - - -			9,0633	,5651	,8919	4,5920	,2638	6,0774
Grand Total gain	435			Grand Total (57 weeks) - -			2163,4282	139,3469	243,4979	1111,4789	66,7709	1505,3109
Daily average	1,09			Daily average - - - - -			5,4222	,3492	,6105	2,7857	,1673	3,7726

Slaughtered July 2 - 1909
Average of 3 days weighing 521 pounds.

Table III (B) showing weekly live weights and gains, and average amounts of feeds and nutrients consumed daily during the each corresponding week, for Steer No 198

Week Ending	Live Weight: Weekly Weight	Live Weight: Weekly gain	Milk	Skim Milk	Hay	Grain	Ensilage	Dry Matter	Ash	Digestible Protein	Digestible C.H.	Digestible Ether Extract
	110.											
1908 June 14	115	5	3,0	6,0	,3	,3		1,4542	,0884	,3048	,7296	,1468
" 21	120	5	2,0	7,0	,4	,4		1,5958	,0979	,3200	,8264	,1143
" 28	125	5	1,0	8,0	,5	,5		1,7307	,1074	,3350	,9184	,0817
July 5	125	0		9,0	,6	,6		1,8707	,1169	,3501	,8142	,0492
" 12	135	10		9,0	,7	,7		2,0461	,1274	,3662	1,1047	,0557
" 19	140	5		9,0	,8	,9		2,3078	,1415	,3954	1,2443	,0646
" 26	140	5		9,0	,9	,9		2,3970	,1483	,3983	1,2856	,0670
Aug. 2	150	10		9,0	1,0	,9		2,4862	,1552	,4013	1,3276	,0695
" 9	160	10		9,0	1,0	1,0		2,5724	,1588	,4143	1,3761	,0730
" 16	170	10		9,0	1,0	1,0		2,5724	,1588	,4143	1,3761	,0730
" 23	170	0		9,0	1,3	1,0		2,8404	,1793	,4233	1,5003	,0803
" 30	175	5		9,0	1,5	1,0		3,0184	,1930	,4292	1,5831	,0852
Sept. 6	175	0		9,0	1,5	1,2		3,1909	,2003	,4533	1,6813	,0901
" 13	180	5		9,0	1,5	1,2		3,1909	,2003	,4533	1,6813	,0901
" 20	190	10		9,0	1,5	1,2	2,0	3,2358	,2235	,4714	1,9264	,1108
" 27	205	15		9,0	1,5	1,2	3,0	3,8983	,2370	,4614	2,0538	,1082
Oct. 4	210	5		9,0	1,5	1,2	3,0	3,8283	,2370	,4614	2,0538	,1082
" 11	220	10		9,0	1,5	1,4	3,0	4,0054	,2436	,4860	2,1532	,1156
" 18	225	5		9,0	1,8	1,4	3,0	4,2[illegible]	,2752	,5088	2,2406	,1199
" 25	230	5		8,0	2,0	1,4	3,0	4,5369	,2836	,4852	2,2699	,1225
Nov. 1	240	10		8,0	2,0	1,6	3,0	4,5645	,3167	,5210	2,3733	,1358

Table III (B) - continued.

Week ending	Live Weight: Weekly Weight	Live Weight: Weekly gain	Skim milk	Hay	Grain	Ensilage	Dry matter	Ash	Digestible Protein	Digestible C. H.	Digestible Ether Extract	Total nutri. in Starch Equiv.
1908 Nov. 8	245	5	8,0	2,0	1,6	4,0	4,7892	,3283	,5401	2,4958	,1462	
" 15	260	15	8,0	2,0	1,6	4,0	4,7892	,3283	,5401	2,4958	,1462	
" 22	265	5	8,0	2,0	1,8	4,0	4,9684	,3365	,5687	2,5923	,1539	
" 29	270	5	8,0	2,2	1,8	4,0	5,2573	,3421	,5639	2,7719	,1597	
Dec. 6	280	10	8,0	2,2	2,0	4,0	5,4286	,3511	,5911	2,8677	,1681	
" 13	290	10	8,0	2,4	2,0	4,0	5,7055	,3805	,6822	2,9510	,1678	
" 20	295	5	8,0	2,6	2,0	4,0	5,8799	,3950	,6878	3,0349	,1700	
" 27	305	10	8,0	2,6	2,2	4,0	6,1605	,4389	,6963	3,1146	,1883	
1909 Jan. 3	310	5	8,0	2,6	2,2	4,0	6,1605	,4422	,7038	3,1753	,1970	
							119,4689	7,2330	14,4380	58,0187	3,9581	
Total gain 200				Total (31 weeks)			773,2823	50,6310	101,0660	406,1309	27,7067	569,5370
Daily gain ,92				Daily average			3,5635	,2333	,4657	1,8718	,1277	2,6246
Jan. 10	315	5	7,0	2,8	2,4	4,0	6,3664	,4116	,7443	3,2661	,2023	
" 17	330	15	6,0	2,8	2,6	4,0	6,4441	,4122	,7418	3,3063	,2103	
" 24	330	0	6,0	3,0	2,6	4,0	6,5915	,4468	,7508	3,3689	,2299	
" 31	335	5	5,0	3,0	2,8	4,0	6,7690	,4579	,7482	3,5081	,2390	
Feb. 7	350	15	5,0	3,2	3,0	4,0	6,8321	,4302	,7431	3,3812	,2041	
" 14	360	10	4,0	3,4	3,2	4,0	7,0807	,4439	,7447	3,4943	,2142	
" 21	365	5	3,0	3,6	3,4	4,0	7,3318	,5015	,7628	3,7433	,2400	
" 28	370	5	2,0	3,8	3,6	4,0	7,5036	,5204	,7643	3,8608	,2501	

Table III (B) — continued.

Week Ending	Live Weight: Weekly Weight	Live Weight: Weekly gain		Skim Milk	Hay	Grain	Ensilage		Dry Matter	Ash	Digestible Protein	Digestible C. H.	Ether Extract	Total nutri. in Starch Equivalent
1909 March 7	370	0			4,0	3,8	4		7,5036	,4756	,6427	3,8973	,2343	
" 14	400	30			4,0	3,8	5		7,7427	,4904	,6523	4,0296	,2414	
" 21	410	10			4,0	3,8	5		7,8267	,4874	,7204	4,0385	,2341	
" 28.	415	5			4,0	4,0	5		8,0030	,4961	,7522	4,1288	,2423	
									86,0267	5,5739	8,7676	44,0232	2.7420	
Total gain	105				Total (12 weeks)				602,1869	39,0173	61,3732	308,1624	19,1940	412,7221
Daily gain	1,25				Daily average				7,1689	,4645	,7306	3,6686	,2285	4,9133
Grand Total gain		305			Grand Total (43 weeks)				1375,4692	89,6483	162,4392	714,2933	46,9007	982,2591
Daily average		1,01			Daily average				4,5697	2,9782	,5397	2,3731	,1558	3,2634

Slaughtered March 31 – 1909.
Average of 3 days weighing 415 pounds