EXPERIMENT STATION

OF THE

KANSAS STATE AGRICULTURAL COLLEGE,

MANHATTAN.

BULLETIN No. 115—DECEMBER 1902.

CHEMICAL DEPARTMENT.

J. T. WILLARD, M. S., Chemist and Director.

THE EXACT CALCULATION OF BALANCED RATIONS.

THE importance of an economical as well as nutritive ration is realized by every feeder. "How shall our feeds be made to yield the most in animal products?" is the ever-present question. That certain combinations of feeds are more profitable than others is to be expected, and is conceded by all, but the great problem is to determine what combinations are most profitable under given conditions. It is the opinion of the writer that the most profitable combinations of Western feeds for Western conditions are not yet known, and that a most promising field is here presented for the execution of varied and repeated feeding tests with fattening cattle, dairy cows, swine, horses, and sheep. Until such tests shall have been carried out, we shall have to depend upon the results of other (largely European) investigators, whose work in many cases was upon a very small scale and with feeds not in use here.

WHAT IS A BALANCED RATION?

Considerable misapprehension exists as to the meaning of the term "balanced ration," the idea being prevalent that the balanced ration is a certain combination of feeds, and always the same. In point of fact, a combination of feeds that is best adapted, that is, balanced, for one purpose, with one species of animal of a given age and condition, might be unbalanced if the purpose, the species, the age or condition were different. Thus, a ration balanced for a growing calf is unbalanced for a fattening steer; a balanced ration for a dairy cow is still different, and even the best ration for a cow giving a large yield of milk is not the best for the same cow at a later period when the milk flow has become small. A balanced ration is simply one in which the feeds are mixed in such proportions as to provide constituents in such relative quantities as experience has shown to give the best results under the given set of conditions.

OBJECT OF THIS BULLETIN.

Many farmers realize the importance of a properly balanced ration, but do not know how to compound one. The methods hitherto in use tend to discourage making the necessary calculations, as they involve guesswork, on unfamiliar ground, followed by tedious calculations, to be followed by another guess and the succeeding calculations, and so on, until approximately the correct quantities have been arrived at by this cut-and-try process. All the authorities agree that there is no method known for exact calculation of a ration. The object of this bulletin is to explain and illustrate a method, discovered by the author, by which it is possible to calculate a ration exactly, if the composition of the feeds to be used admit of the compounding of the required ration from them. Since rations cannot be calculated without a knowledge of the composition of the digestible constituents of the feeds, and of the standard rations to be approximated, this bulletin will include tables providing these data. Further, certain factors are required for each feed, and by calculating these once and embodying them in the tables, this labor is saved for others. This has, therefore, been done.

The bulletin as a whole is issued in the hope that the calculation of a ration has been so simplified as to enable any intelligent farmer to undertake it, and to accomplish it with but little labor. Directions are given by which it is hoped that these calculations may be made, even if the operator does not understand entirely the reasons for the operations. At the same time, for the benefit of students and others who wish a thorough understanding of the method, a simple and detailed explanation is given and illustrated. After a sufficient exposition of the complete calculation, tables will be given that abridge the work required, their use will be illustrated by an exact calculation, which will be followed by a modification of the process designed to meet ordinary requirements, and which is certainly within the mathematical range of all, and demands a very slight expenditure of time. Finally, lists of rations balanced as to nutritive ratio will be included.

THE METHOD OF CALCULATION.*

The method of exactly balancing rations by direct calculation depends on the principles of alligation, a somewhat neglected chapter in arithmetic, and perhaps the solution of a simple problem in alligation will suitably introduce the more complex problem of calculating rations. Suppose that a grocer has two grades of tea, worth 20 cents. and 50 cents per pound respectively, and wishes to make a mixture of them which shall be worth 30 cents per pound: what amounts. must he take of each ? It will be seen that for each pound of the 50-cent tea that he uses he will lose 20 cents, and that on each pound of the 20-cent tea he will gain 10 cents. He must, therefore, put in two pounds of the 20-cent tea for each pound of the 50-cent tea. To put the matter another way: The total amount that the grocer gains on the one tea must be exactly equal to the total amount that he loses. on the other, and consequently the quantities of each required will be inversely proportional to the amount gained or lost on one pound in each case. Hence, the amount required of the first is to the amount required of the second as the gain (or loss) on each pound of the second is to the loss (or gain) on each pound of the first. On each pound of the first tea used the grocer gains 10 cents; on each pound of the second he loses 20 cents; hence the quantity to be used of the first is to the quantity to be used of the second as 20 is to 10, or as 2 is to 1. The following calculation shows the correctness of these proportions:

2 pounds at 20 cents are worth . . . . 40 cents
1 pound at 50 cents is worth . . . . . . 50 cents

3 pounds of the mixture are worth 90 cents, or 30 cents per pound.

The analysis of this problem is so simple that one can solve it almost by inspection. If the values were in less simple ratios the case would be more difficult, and the arithmetics give a somewhat mechanical method of solving problems in allegation something as follows: Arrange the several values, including the mean to be produced, in the order of their magnitude, or at least bringing all values below the mean in one group and all values above the mean in another. Then pair off these values so that each one is balanced against one in the other group. In case the values are not equal in number in the two groups, it will be necessary to balance one or more in one of the groups against more than one in the other group. Consider, then, one pair at a time. Find the difference between each value and the desired mean value, and set this opposite the *other* value. Each differ-

*The method of exactly calculating rations here described was first published in *The Industrialist*, March 11, 1902. At a later date, Prof. E. B. Cowgill, editor of the *Kansas Farmer*, published an algebraic solution of the problem as far as it relates to obtaining the correct nutritive ratio.

ence will represent the amount to be taken of the article of the value opposite which the difference is set. Of course, other amounts which are in the same ratio may be taken instead of the quantities represented by the differences. Proceed in this way with all the pairs. If a value is paired with more than one in the other group, the differences set opposite this value are added together to get the total amount to be taken of the article having that value. It must not be forgotten, however, that this quantity is a sum, and, if any variation in its amount is desired, all of the items paired with it in the other group must be varied in the same proportion. If this is not desirable, each pair may be separately multiplied or divided in any way that one wishes before adding the several amounts set opposite the values.

Applying these directions to the problem previously solved, we arrange the values and differences as follows, the mean being in italic figures:

Cents.	Difference.
50	10 = pounds to be taken at 50 cents.
30	
20	20 = pounds to be taken at 20 cents.

Proof:

10 lbs. at 50 cents are worth	$5 00
20 lbs. at 20 cents are worth	4 00
30 lbs. at 30 cents are worth	$9 00

It is evident, also, that any other quantities may be taken that are in the ratio of 10 to 20; for example, 5 to 10, 2 to 4, or 15 to 30.

Let us take another example: Suppose the grocer wishes to mix five kinds of tea, worth 20, 25, 30, 35, and 40 cents, so as to obtain a mixture worth 28 cents. Separating these into two groups, as explained above, we have 20 and 25 in the group having values less than the mean to be obtained, and 30, 35 and 40 having values greater than the mean. We may pair them and take the differences, as follows:

Cents.	Difference.	
30	8 = pounds to be taken at 30 cents, value	$2 40
28		
20	2 = pounds to be taken at 20 cents, value	40
	10 = pounds at 28 cents give a total value of . . .	$2 80
35	3 = pounds to be taken at 35 cents, value	$1 05
28		
25	7 = pounds to be taken at 25 cents, value	1 75
	10 = pounds at 28 cents give a total value of	$2 80
40	3 = pounds to be taken at 40 cents, value	$1 20
28		
25	12 = pounds to be taken at 25 cents, value	3 00
	15 = pounds at 28 cents give a total of	$ 4 20

It will be seen that each pair produces a mixture of the required value. These pairs may therefore be taken in any quantities desired, only being certain that if the quantity of one member of a pair is altered the quantity of the other member is altered in the same ratio.

Adding together the above quantities and amounts, we have the following:

Pair 1	8 lbs. 30-cent tea are worth	$2 40
	2 lbs. 20-cent tea are worth	40
Pair 2	3 lbs. 35-cent tea are worth	1 05
	7 lbs. 25-cent tea are worth	1 75
Pair 3	3 lbs. 40-cent tea are worth	1 20
	12 lbs. 25 cent tea are worth	3 00
Totals:	35 lbs. 28-cent tea are worth	$9 80

It will be noticed that the 25-cent tea is used in both the second and third pairs, so that the total amount of that to be used is 19 pounds. Suppose, now, that the grocer has a large quantity of the 35-cent tea which he wishes to use. Since each pair is exactly balanced within itself, he may use 30 pounds of the 35-cent tea, but must offset that by 70 pounds of the 25-cent tea as shown in pair 2; that is, if he takes ten times as much of the 35-cent tea he must take ten times as much of the 25-cent tea as was required to balance it, not ten times 19, that is the total amount of the 25-cent tea, since 12 pounds of the 19 pounds went to balance the 40-cent tea. The values could have been paired in any other way, provided only that one less than the mean is always paired with one greater than the mean. This, with the fact mentioned, that the quantities obtained in any pair may be multiplied or divided at will, enables him to adapt his mixture to the amounts of the several grades that he has.

The problem of the tea has been treated thus minutely, since the principles involved in its solution are used in the balancing of rations. The latter case involves another complication or two, however, which will be treated at the proper place.

In balancing rations, the problem primarily is not one of balancing values, which could be done in the manner indicated above, but in balancing the energy obtainable from nitrogenous organic constituents of feeds against that obtainable from non-nitrogenous organic constituents; the protein against the fats and carbohydrates. The ratio of the energy that can be obtained from the protein to the energy that can be obtained from the fats plus the carbohydrates is called the nutritive ratio. In calculating this ratio, since fats give about 2¼ times as much energy as protein or carbohydrates, we multiply the amount of the fats by 2¼ to reduce them to an equivalent amount of protein or carbohydrates.

In the discussion which follows, since the energy yielded by a food principle is directly proportional to its weight, weights will be considered rather than energy values, and, to simplify expression, *protein* will mean the nitrogenous substances of the feeds, and *non-protein* will mean fats multiplied by 2¼, plus carbohydrates.

When we speak of a feed having a nutritive ratio of 1 to 5, then, we mean that in a quantity sufficient to contain 1 pound of protein the weight of the carbohydrates plus 2¼ times the weight of the fats will be 5 pounds, or, to use the simplified form of expression, the protein is to the non-protein as 1 is to 5.

In applying the principles of alligation to the calculation of the quantities of each of two feeds with different nutritive ratios that must be taken to produce a mixture that will have a definite nutritive ratio of any intermediate value, we must deal *not with equal weights as units, but with weights of each that contain equal weights of protein.* Figures proportional to these weights are obtained by dividing 100 by the percentage of protein contained in the feeds respectively. Thus, if a feed contains 5 per cent. of protein, 100 pounds of it will contain 5 pounds, and 100 divided by 5 — that is, 20 — is the number of pounds that will contain 1 pound of protein. Similarly, if a feed contains 12.5 per cent. of protein, 100 divided by 12.5 — that is, 8 — will be the number of pounds of the feed that will contain 1 pound of protein. I propose to call the quotient obtained by dividing 100 by the per cent. of protein the *protein-equating factor.* Let us proceed, then, remembering that our units are to contain equal weights of protein; that is, they will contain as many units of weight, say pounds, for instance, as are expressed by the protein-equating factors.

To simplify calculations, let us assume that we have two feeds, *a* and *b,* containing the following percentages of digestible constituents:

	Protein.	Carbohydrates.	Fat.
a	5.0	65.5	2.0
b	12.5	68.25	3.0

The nutritive ratio of a is calculated as follows: Multiply the fat by 2¼, and add it to the carbohydrates to get the non-protein term. 2¼ × 2 given 4.5. This added to 65.5 gives 70. The protein is to the non-protein as 5 is to 70; therefore, dividing both terms of the ratio by 5 to make the protein unity, we get the ratio, 1:14, as the nutritive ratio of feed *a*. Proceeding in the same way with feed *b,* 3 × 2¼ gives 6.75, which added to 68.25 gives 75. The nutritive ratio, then, is 12.5 to 75, or 1:6.

The protein-equating factors of each are found by dividing 100 by the respective percentages of protein; 100 divided by 5 gives 20 as the protein-equating factor of *a*, and 100 divided by 12.5 gives 8 as the protein-equating factor for *b*. Collecting all these data in one view, we have:

	Protein.	Carbo-hydrates.	Fat.	Nutritive ratio.	Protien equating factor.
a	5.0	65.5	2.0	1:14	20
b	12.5	68.25	3.0	1:6	8

Let it be required to make from these two feeds a mixture the nutritive ratio of which is 1:9. Regarding this as a problem in alligation, in reference to the second terms of the ratios, we have:

	Second term of ratio.	Difference.
a	14	3
Mixture	9	
b	6	5

The numbers 3 and 5 obtained give, with *a* and *b*, respectively, the number of times that a weight of the feed containing one pound of protein must be taken. In other words, those figures multiplied by the protein-equating factors will give the number of pounds of each that must be taken to produce the required mixture.

In the ration to be compounded, for each pound of protein there are 9 pounds of non-protein. For each pound of protein in *a* there are 14 pounds of non-protein, namely, 5 *more* than the ration requires. For each pound of protein in *b* there are 6 pounds of non-protein; that is, 3 *less* than the ration requires. By using enough of *a* to get 3 pounds of protein, one gets an *excess* of 15 pounds of non-protein. By using enough of *b* to get 5 pounds of protein, one gets a *deficiency* of 15 pounds in the non-protein. The excess in the one case being equal to the deficiency in the other, a mixture of sufficient of *a* to contain 3 pounds of protein with enough of *b* to contain 5 pounds of protein will contain 9 pounds of non-protein for each pound of protein. The protein-equating factor of *a* is 20; that is, 20 pounds of it will contain 1 pound of protein; hence, to get 3 pounds of it we must take 60 pounds. Similarly, the protein-equating factor of *b* is 8; that is, 8 pounds of *b* will be required to get 1 pound of protein; hence 40 pounds will contain 5 pounds of protein. We must, therefore, take these feeds in the ratio of 60 of *a* to 40 of *b*.

Let us see that this is true. Calculating from the percentage composition the weights of each food principle contained in these weights of the two feeds, we have the following:

	Protein.	Carbohydrates.	Fat.
a	.05 60	.655 60	.02 60
Pounds:	3.00	39.300	1.20 × 2¼ = 2.70.
b	.125 40	.6825 40	.03 40
Pounds:	5.000	27.3000	1.20 × 2¼ = 2.70.

Collecting quantities, we have:

	39.3
	27.3
3	2.7
5	2.7
8 lbs. protein.	72.0 lbs. non protein.

Hence, the nutritive ratio is 8:72, or 1:9, the ratio required.

Let us now apply the method to the balancing of a ration consisting of corn and alfalfa. The percentages of digestible nutrients, nutritive ratios and protein-equating factors are shown in the following table:

	Protein.	Carbo-hydrates.	Fat.	Nutritive ratio.	Protein-equating factor.
Corn,	7.14	66.12	4.97	1:10.826	14.0
Alfalfa,	10.58	37.33	1.38	1: 3.82	9.45

The nutritive ratio of corn given above is calculated as follows:

$$\frac{7.14: (4.97 \times 2\frac{1}{4}) + 66.12}{7.14} = 1:10.826.$$

The protein-equating factor for corn is: 100 ÷ 7.14 = 14.0.

The nutritive ratio of alfalfa is:

$$\frac{10.58: (1.38 \times 2\frac{1}{4}) + 37.33}{10.58} = 1:3.82.$$

The protein-equating factor for alfalfa is: 100 ÷ 10.58 = 9.45.

Let it be required to calculate what amounts of alfalfa and corn of the above composition must be mixed to produce a balanced ration for fattening cattle in the first period, the nutritive ratio to be 1:6.5, according to the Wolff- Lehmann standard.

Applying the methods of calculation described, we have:

	Second term of ratio.	Differ-ence.		Protein-equating factor.		Relative quantities.
Corn,	10.826	2.68	×	14.0	=	37.52
Proposed,	*6.50*					
Alfalfa,	3.82	4.326	×	9.45	=	40.88

That is, 37.52 pounds of corn with 40.88 pounds of alfalfa of the composition specified will produce a mixture having the nutritive ratio 1:6.5.

Proof:

37.52 × .0714 = 2.680 = lbs. protein in 37.52 lbs. corn.
40.88 × .1058 = 4.325 = lbs. protein in 40.88 lbs. alfalfa.
7.005 = lbs. protein in 78.40 lbs. corn and alfalfa.

37.52 × .6612 = 24.81 = lbs carbohydrates in 37.52 lbs. corn.
40.88 × .3733 = 15.26 = lbs. carbohydrates in 40.88 lbs. alfalfa.
40.07 = lbs. carbohydrates in 78.40 lbs. corn and alfalfa.

37.52 × .0497 = 1.865 = lbs. fat in 37.52 lbs. corn.
40.88 × .0138 = 0.564 = lbs. fat in 40.88 lbs. alfalfa.
2.429 = lbs. fat in 78.40 lbs. corn and alfalfa.

Calculating the nutritive ratio: $\frac{7.005 : 40.07 + (2.429 \times 2\frac{1}{4})}{7.005} =$ 1:6.5, which is the proposed nutritive ratio.

Let us now calculate the proportion in which corn-stover and alfalfa must be taken to produce a mixture in which the nutritive ratio is 1:6.5. The following table shows the composition, the nutritive ratios and the protein-equating factors of these feeds:

	Protein.	Carbohydrates.	Fat.	Nutritive ratio.	Protein-equating factor.
Corn-stover,	1.98	33.16	0.57	1 : 17.39	50.51
Alfalfa,	10.58	37.33	1.38	1 : 3.82	9.45

The necessary calculation is indicated in the following:

	Second term of ratio.	Difference.		Protein-equating		Pounds required.
Corn-stover,	17.39	2.68	×	50.51	=	135.36
Proposed,	*6.50*					
Alfalfa,	3.82	10.89	×	9.45	=	102.91

That these quantities are correct may be proved by making the necessary calculations in the same manner as with the ration of corn and alfalfa.

We now have two mixtures which possess the same nutritive ratio; let us call the first one A, and the second one B. The following table shows certain data concerning them:

		Total lbs.	Protein, lbs.	Carbohy-drates, lbs.	Fat, lbs.	Nutritive ratio.	Ratio of fat to carbohydrates.
A	Corn,	37.52	2.68	24.81	1.86	1 : 10.826	
	Alfalfa,	40.88	4.32	15.26	0.56	1 : 3.82	
	Mixture,	78.40	7.00	40.07	2.42	1 : 6.5	1 : 16.55
B	Corn-stover,	135.36	2.68	44.88	0:77	1 : 17.39	
	Alfalfa,	102.91	10.89	38.42	1.42	1 : 3.82	
	Mixture,	238.27	13.57	83.30	2.19	1 : 6.5	1 : 38.03

We have, then, in A and B two mixtures with the same nutritive ratio, and may therefore combine these mixtures in any proportion, and the nutritive ratio of the compound mixture will be the same, viz., 1:6.5. Now, if we compare A and Bin respect to relative amounts of fat and carbohydrates, the two groups of substances composing the non-protein, we see that they differ materially. In A the fats are to the carbohydrates as 1:16.55, while in B the ratio is 1:38. According to the Wolff-Lehmann standards, the ratio of fats to carbohydrates in a ratio for fattening cattle during the first period should be 1:30. It may well be doubted whether it is necessary or even best to reduce the fat to so low a proportion; but be that as it may, our method enables us to calculate the exact amounts that must be taken of each of two feeds or mixtures possessing the same nutritive ratio, but one having more fat and the other less than a standard chosen. We proceed exactly as in balancing the ration as to protein and non-protein, except that we must calculate a fat-equating factor for each feed or mixture to be used. This factor represents the *number of pounds that must be taken to get a pound of fat* in the several cases, and is obtained by dividing the total weight by the amount of fat. Thus, in A we have, in a total of 78.40 pounds, 2.42 pounds of fat; 78.40 divided by 2.42 gives 32.4, which is the number of pounds of that mixture necessary to use in order to get one pound of fat, and is the fat-equating factor of A. In B, in a total of 238.27 pounds, we have 2.19 pounds of fat; 238.27 divided by 2.19 gives 108.8 which is the number of pounds of B that contains one pound of fat, and is the fat-equating factor for B.

Proceeding by allegation as before, we get the following:

	Second term of ratio.	Difference.		Fat-equating factor.		Pounds required.
Mixture B,	38.03	13.45	×	108.8	=	1463.36
Standard,	*30*					
Mixture A,	16.55	8.03	×	32.4	=	260.17

From this we see that 260.17 pounds of A will be required for 1463.36 pounds of B.

Proof: In the compound mixture we have 260.17 ÷ 78.4 = 3.318 units of mixture A; and 1463.36 ÷ 238.27 = 6.141 units of mixture B. Calculating the quantities of fats and of carbohydrates which these quantities contain, we have:

3.318 × 2.42 = 8.03 lbs. fat in 260.17 lbs. of mixture A.
6.141 × 2.19 = 13.45 lbs. fat in 1463.36 lbs. of mixture B.
21.48 lbs. fat in compound mixture.

3.318 × 40.07 = 132.95 = lbs. carbohydrates in 260.17 lbs. of mixture A.
6.141 × 83.3 = 511.54 = lbs. carbohydrates in 1463.36 lbs. of mixture B.
644.49 = lbs. carbohydrates in compound mixture.

21.48 is to 644.49 as 1 is to 30, the proposed ratio of fats to carbohydrates.

For use later, we may at this point calculate in a similar manner the total amount of digestible protein in the compound mixture:

3.318 × 7.00 = 23.23 = lbs. of protein in 260.17 lbs. of mixture A.
6.141 × 13.57= 83.33 = lbs. of protein in 1463.36 lbs. of mixture B.
106.56 = lbs. of protein in the compound mixture.

The quantities of corn, alfalfa and corn-stover required to compound a ration in which the nutritive ratio is 1:6.5, and the ratio of fats to carbohydrates is 1:30, are found by the following calculations:

37.52, the pounds of corn in A, multiplied by 3.218, the units of A used, gives a product of 124.49, the corn required.

40.88, the pounds of alfalfa in A, multiplied by 3.318, the units of A used, gives 135.64 as the number of pounds of alfalfa required in A for the compound mixture.

135.36, the pounds of corn-stover in B, multiplied by 6.141, the number of units of B used, gives 831.25, the amount of corn-stover required.

102.91, the pounds of alfalfa in B, multiplied by 6.141, the units of B used, gives 631.97 as the alfalfa in B required for the compound mixture.

Adding together the quantities of alfalfa, we have the following:

Alfalfa, 135.64 + 631.97 =	767.61	lbs.
Corn.	124.49	"
Corn stover	831.25	"
Total	1,723.35	lbs.

These figures represent the proportions in which these three feeds must be mixed to produce a ration with the nutritive ratio 1:6.5, and with the fats to the carbohydrates as 1 is to 30. Any change of one only of these quantities will alter these ratios. The component A or B may be altered to any desired extent without altering the nutritive ratio, but the ratio of fats to carbohydrates would be changed. Since fats and carbohydrates can to a considerable extent replace each other in a ration, it seems almost certain that for Western practice it would be better to use more of mixture A, and therefore more corn, and less of mixture B, and therefore less corn-stover. The nutritive ratio would thus be preserved, but the proportion of fat would be increased. However, the present object is not to discuss any particular ration, but to show that a ration can be calculated exactly which will possess a given nutritive ratio, and a given relation between fat and carbohydrates. The preceding calculations demonstrate this, and the principles there illustrated are capable of still greater extension by application of the same general method.

It was shown above that the 1723.35 pounds contained 106.56 pounds protein, 644.49 pounds carbohydrates, and 21.48 pounds fat, or a total of 772.53 pounds of these nutrients. In this ration, then, we may readily calculate the percentage of total digestible nutrients, and it is found to be 44.82. From this the amount to be fed to obtain any desired amount of digestible nutrients is readily computed.

From the principles illustrated in the preceding examples we may derive the following:

RULES FOR THE EXACT CALCULATION OF BALANCED RATIONS.

1. Unless shown in tables, calculate the *nutritive ratio* of the ration to be compounded, and of each of the feeds entering into it. To do this, multiply the percentage of fat by 2¼, add the product to the percentage of carbohydrates, and divide the sum by the percentage of protein. The quotient will be the second term of the ratio, the first being 1, since protein has been made unity by taking it as the divisor.

2. Unless shown in tables, calculate the *protein-equating factor* for each feed by dividing 100 by the percentage of protein contained in the feed. The quotient will show the number of pounds of the feed that must be taken to get one pound of protein, and is the protein-equating factor.

3. Compare the second term of the nutritive ratio of the ration to be compounded with that of each feed that is to enter into it by arranging these second terms for the several feeds in two groups, placing all greater than that from the proposed ration in one group, and all less in the other. Pair off the second terms in one group against those in the other. If the items in the two are not equal in number, pair one or more in the group having the smaller number of items against two or more in the other group.

4. Consider now each pair separately. Mark each second term with the name of the feed from which it is derived. Find the difference between each second term and the second term for the proposed ration, and set each difference opposite the name of the *other* feed. Each difference multiplied by the protein-equating factor for the feed opposite the name of which it is set will give the number of units of weight to be used of that feed. Proceed with each pair in the same manner. Each pair will then constitute a mixture having the required nutritive ratio. The several pairs may then be mixed in any desired quantities to compound the ration, only remembering that each pair must be taken in its entirety, and the two items in it always taken in the ratio indicated by the units of weight obtained. These units may be multiplied or divided in any way desired, provided that the ratio between them is kept the same. If a feed has been paired with more than one other, the units of weight obtained for that feed in the several pairs must be kept separate until the amounts of each pair to be taken have been determined. Finally all the quantities for each feed are united, but in this sum a part may balance one feed, another part another.

5. To provide the fat and the carbohydrates in quantities that shall possess a given ratio to each other, and at the same time have a definite nutritive ratio for the ration, it is necessary to have two or more feeds or mixtures of feeds that have the required nutritive ratio, one or more of which has too much fat and one or more too little fat. Calculate a *fat-equating factor* for each of these feeds or mixtures of feeds by dividing the weight of a given amount of the feed by the weight of the fat which that amount contains. The fat-equating factor is thus the number of pounds of feed having the desired nutritive ratio that contains one pound of fat.

6. For the ration to be made, and for each of the feeds or mix-

tures of feeds that is to enter into it, calculate the ratio of the fat to the carbohydrates. Make the first term of the ratio 1, and let it represent the fat by dividing the quantity of carbohydrates by the quantity of fat. The quotient will be the second term of the ratio. Arrange the second terms in two groups, one of which shall contain all that are greater than that of the proposed ration, and the other all that are less. Mark each second term with the name of the feed to which it belongs, and pair off the second terms as before. Consider each pair separately; find the difference between each second term and that of the proposed ration, and set each difference opposite the name of the *other* feed or mixture of feeds. Each difference multiplied by the fat-equating factor for the feed opposite the name of which it is set will give the units of weight to be taken of that feed or mixture. Proceed with each pair in the same way. Each pair, taking its components in the proportions indicated by the units of weight, will constitute a ration having the required nutritive ratio, and having the required ratio between the fat and carbohydrates. If more than one pair have been thus balanced, they may be mixed with each other in any proportion desired.

7. The weight of digestible matter in the ration may be calculated by obvious processes, by means of the quantities used, and the percentage of digestible nutrients which they contain.

It will be seen that by proceeding in a similar manner the ration, if desired, might be balanced in still other respects; for example, in percentage of digestible matter. The process could be continued until it had been applied to all of the imaginable differences, being limited only by the composition of available feeds. It is apparent that the labor of calculation may be much abridged by the use of tables which show the nutritive ratios, and the protein-equating factors with the composition of the feeds.

The accompanying table, giving the dry matter and digestible food ingredients in a number of the more common feeding-stuffs, is taken chiefly from Farmers' Bulletin No. 22,* revised edition, 1902. Items marked (K) are from results obtained at this Station; those marked (H) are from Professor Henry's compilation given in his valuable book. "Feeds and Feeding." For all of these the nutritive ratio and the protein-equating factor have been calculated.

*Farmers' Bulletin No. 22 is issued by the U. S. Department of Agriculture, and may be obtained free through members of Congress, or on direct application to the secretary of agriculture, Washington, D. C. It discusses the principles and practice of the feeding of animals, and should be in the hands of every farmer.

Table I — Showing percentages of dry matter and digestible food ingredients — that is, pounds per 100 pounds — in certain feeding-stuffs: also fuel value, nutritive ratio, and protein-equating factor.

Feeding-stuff.	Total dry matter.	Protein.	Carbohydrates.	Fat.	Fuel value, Calories.	Nutritive ratio.	Protein-equating factor.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per lb.*		
GREEN FODDER:							
Corn-fodder (av. all varieties)	20.7	1.1	12.08	0.37	260.76	1:11.7	90.9
Kafir-corn fodder	27.0	0.87	13.8	0.43	291.01	1:17.0	114.9
Sorghum fodder (H)	20.6	0.6	12.2	0.4	254.96	1:22.0	166.7
Rape	14.3	2.16	8.65	0.32	214.57	1: 4.3	46.3
Rye fodder	23.4	2.05	14.11	0.44	319.14	1: 7.4	48.8
Oat fodder	37.8	2.44	17.99	0.97	420.93	1: 8.3	41.0
Redtop, in bloom	34.7	2.06	21.24	0.58	457.85	1:10.9	48.5
Orchard-grass, in bloom	27.0	1.91	15.91	0.58	355.93	1: 9.0	52.4
Meadow fescue, in bloom	30.1	1.49	16.78	0.42	357.55	1:11.9	67.1
Timothy, different stages	38.4	2.01	21.22	0.64	459.09	1:11.3	49.8
Kentucky blue-grass	34.9	2.66	17.78	0.69	409.3	1: 7.3	37.6
Hungarian grass	28.9	1.92	15.63	0.36	341.62	1: 8.6	52.1
Red clover, different stages	29.2	3.07	14.82	0.69	361.87	1: 5.3	32.6
Crimson clover	19.3	2.16	9.31	0.44	231.91	1: 4.8	46.3
Alfalfa, different stages	28.2	3.89	11.2	0.41	297.98	1: 3.1	25.7
Cow-pea	16.4	1.68	8.08	0.25	192.09	1: 5.1	59.5
Soy-bean	28.5	2.79	11.82	0.63	298.33	1: 4.7	35.8
Corn silage (recent analyses)	25.6	1.21	14.56	0.88	330.46	1:13.7	82.6
Corn-fodder, field cured	57.8	2.34	32.34	1.15	693.58	1:14.9	42.7
Corn-stover, "	59.5	1.98	33.16	0.57	677.66	1:17.4	50.5
Kafir-corn stover, field cured	80.8	1.82	41.42	0.98	845.62	1:24.0	55.0
Kafir-corn stover, " (K)	57.7	3.22	48.72	1.15	1,014.61	1:15.9	31.1
Sorghum silage (H)	23.9	0.6	14.9	0.2	296.74	1:25.6	166.7
Sorghum fodder, cured	90.0	2.6	53.2	1.7	1,109.62	1:21.9	38.5
HAY FROM —							
Barley	89.4	5.11	35.94	1.55	828.94	1: 7.7	19.6
Oats	84.0	4.07	33.35	1.67	766.49	1: 9.1	24.6
Orchard-grass	90.1	4.78	41.99	1.4	929.0	1: 9.4	20.9
Redtop	91.1	4.82	46.83	0.95	1,000.78	1:10.2	20.8
Timothy (all analyses)	86.8	2.89	43.72	1.43	927.29	1:16.2	34.6
Kentucky blue-grass	78.8	4.76	37.46	1.99	869.27	1: 8.8	21.0
Hungarian grass	92.3	4.5	51.67	1.34	1,101.31	1:12.2	22.2
Meadow fescue	80.0	4.2	43.34	1.73	957.25	1:11.3	23.8
Mixed grasses	87.1	4.22	43.26	1.33	939.25	1:11.0	23.7
Rowen (mixed)	83.4	7.19	41.2	1.43	960.4	1: 6.2	13.9
Buffalo-grass (K)	50.1	6.2	42.01	1.28	950.72	1: 7.2	16.1
Prairie-grass (K)	51.5	0.61	46.9	1.97	966.82	1:84.2	163.9
Mixed grasses and clover	87.1	6.16	42.71	1.46	970.59	1: 7.5	16.2
Red clover	84.7	7.38	38.15	1.81	923.24	1: 5.7	13.6
Alsike clover	90.3	8.15	41.7	1.36	984.6	1: 5.5	12.3
White clover	90.3	11.46	41.82	1.48	1,053.46	1: 3.9	8.7
Crimson clover	91.4	10.49	38.13	1.29	958.77	1: 3.9	9.5
Alfalfa	91.6	10.58	37.33	1.38	949.36	1: 3.8	9.5
Alfalfa hay, first stage (K)	59.5	13.24	39.26	0.89	1,014.05	1: 3.1	7.6
Alfalfa hay, second stage (K)	58.3	11.9	40.67	0.89	994.26	1: 3.5	8.4
Alfalfa hay, third stage (K)	60.0	10.43	43.17	0.69	1,026.07	1: 4.3	9.6
Cow-pea	89.3	10.79	38.4	1.51	978.65	1: 3.9	9.3
Soy-bean	88.7	10.78	38.72	1.54	985.69	1: 3.9	9.3
Wheat straw	90.4	0.37	36.3	0.4	698.94	1:100.5	270.3
Rye straw	92.9	0.63	40.58	0.38	782.54	1:65.8	158.7
Oat straw	90.8	1.2	38.64	0.76	773.1	1:33.6	83.3
Soy-bean straw	89.9	2.3	39.98	1.03	829.80	1:18.4	43.5
ROOTS AND TUBERS:							
Potatoes	21.1	1.36	16.43	....	330.89	1:12.1	73.5
Beets	13.0	1.21	8.84	0.05	189.04	1: 7.4	82.6
Beets, sugar (H)	13.5	1.1	10.2	0.1	215.4	1: 9.5	90.9

Table I — *Continued.*

Feeding-stuff.	Total dry matter.	Pro-tein.	Carbo-hy-drates.	Fat.	Fuel value, Calories.	Nutri-tive ratio.	Protein-equating factor.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per lb.*		
ROOTS AND TUBERS:							
Mangel-wurzels	9.1	1.03	5.65	0.11	128 89	1: 5.7	97.1
Turnips	9.5	0.81	6.46	0.11	139.86	1: 8.3	123.5
Rutabagas	11.4	0.88	7.74	0.11	164.97	1: 9.1	112.5
Carrots	11.4	0.81	7.83	0.22	169.99	1: 10.3	123.5
GRAINS AND OTHER SEEDS:							
Corn (av. of dent and flint)	89.1	7.14	66.12	4.97	1,572.37	1: 10.8	14.0
Kafir-corn	87.5	5.78	53.58	1.33	1,160.22	1: 9.8	17.3
Barley	89.1	8.69	64.83	1.6	1,434.99	1: 7.9	11.5
Oats	89.0	9.25	48.34	4.18	1,247.57	1: 6.2	10.8
Rye	88.4	9.12	69.73	1.36	1,524.0	1: 8.0	11.0
Wheat (all varieties)	89.5	10.23	69.21	1.68	1,548.48	1: 7.1	9.8
Cottonseed (whole)	89.7	11.08	33.13	18.44	1,600.47	1: 6.7	9.0
MILL PRODUCTS:							
Corn-meal	85.0	6.26	65.26	3.5	1,477.97	1: 11.7	16.0
Corn-and-cob meal	84.9	4.76	60.06	2.94	1,329.72	1: 14.0	21.0
Oatmeal	92.1	11.53	52.06	5.93	1,433.02	1: 5.7	8.7
Barley meal	88.1	7.36	62.88	1.96	1,389.18	1: 9.1	13.6
Ground corn and oats, equal parts	88.1	7.01	61.2	3.87	1,432.02	1: 10.0	14.3
Pea meal	89.5	16.77	51.78	0.65	1,302.46	1: 3.2	6.0
Kafir-corn meal (K)	61.2	6.13	54.72	....	1,131.81	1: 8.9	16.3
Soy-bean meal (K)	71.8	36.09	17.01	25.38	2,058.69	1: 2.1	2.8
BY-PRODUCTS obtained in various industries:							
Gluten meal—							
Buffalo	91.8	21.56	43.02	11.87	1,702.1	1: 3.2	4.6
Chicago	90.5	33.09	39.96	4.75	1,559.18	1: 1.5	3.0
Hammond	91.9	24.9	45.72	10.16	1,742.28	1: 2.8	4.0
King	92.8	30.1	35.1	15.67	1,873.99	1: 2.3	3.3
Cream gluten (recent analyses)	90.4	30.45	45.36	2.47	1,514.2	1: 1.7	3.3
Gluten feed (recent analyses)	91.9	19.95	54.22	5.35	1,605.33	1: 3.3	5.0
Buffalo (recent analyses)	91.0	22.88	51.71	2.89	1,509.33	1: 2.5	4.3
Rockford (Diamond)	91.3	20.38	54.71	3.82	1,557.88	1: 3.1	4.9
Hominy chops	88.9	8.43	61.01	7.06	1,589.52	1: 9.1	11.9
Malt sprouts	89.8	18.72	43.5	1.16	1,206.24	1: 2.5	5.3
Brewers' grains (wet)	24.3	4.0	9.37	1.38	306.92	1: 3.1	25.0
Brewers' grains (dried)	92.0	19.04	31.79	6.03	1,199.9	1: 2.4	5.3
Distillery grains (dried), principally corn	93.0	21.93	38.09	10.83	1,573.4	1: 2.8	4.6
Distillery grains (dried), principally rye	93.2	10.38	42.48	6.38	1,252.43	1: 5.5	9.6
Atlas gluten feed (distillery by-product)	92.6	23.33	35.64	11.88	1,598.18	1: 2.7	4.3
Rye bran	88.2	11.47	52.4	1.79	1,263.52	1: 4.9	8.7
Wheat bran (all analyses)	88.5	12.01	41.23	2.87	1,111.38	1: 4.0	8.3
Wheat middlings	84.0	12.79	53.15	3.4	1,369.96	1: 4.8	7.8
Wheat shorts	88.2	12.22	49.98	3.83	1,318.55	1: 4.8	8.2
Buckwheat bran	88.5	19.29	31.65	4.56	1,139.92	1: 2.2	5.2
Buckwheat middlings	88.2	22.34	36.14	6.21	1,349.79	1: 2.3	4.5
Cottonseed feed	92.0	9.65	38.57	3.37	1,039.11	1: 4.8	10.4
Cottonseed meal	91.8	37.01	16.52	12.58	1,526.53	1: 1.2	2.7
Cottonseed hulls	88.9	1.05	32.21	1.89	698.39	1: 34.7	95.2
Linseed meal (old process)	90.8	28.76	32.81	7.06	1,443.13	1: 1.7	3.5
Linseed meal (new process)	90.1	30.59	38.72	2.9	1,411.55	1: 1.5	3.3
Sugar-beet pulp (fresh)	10.1	0.63	7.12	....	144.15	1: 11.3	158.7
Sugar-beet pulp (dry)	93.6	6.8	65.49	....	1,344.59	1: 9.6	14.7
Sugar-beet leaves (H)	12.0	1.7	4.6	0.2	20.15	1: 3.0	58.8
Beet molasses (H)	79.2	9.1	59.5	....	127.59	1: 6.1	11.0
Meat scrap (H)	89.3	66.2	0.3	13.7	1,415.04	1: 0.5	1.5
Dried blood (H)	91.5	52.3	....	2.5	1,078.28	1: 0.1	1.9

Table I — *Concluded.*

Feeding-stuff.	Total dry matter.	Pro-tein.	Carbo-hy-drates.	Fat.	Fuel value, Calories.	Nutri-tive ratio.	Protein-equating factor.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per lb.*		
MILK and its by-products:							
Whole milk	12.8	3.38	4.8	3.7	308.29	1: 3.9	29.6
Skim-milk, cream raised by setting	9.6	3.1	4.61	0.9	181.39	1: 2.1	32.3
Skim-milk, cream raised by separator	9.4	3.01	5.1	0.3	163.51	1: 1.9	33.2
Buttermilk	9.0	2.82	4.7	0.5	160.97	1: 2.1	35.5
Whey	6.2	0.56	5.0	0.1	107.64	1: 9.3	178.6

EXPLANATION OF TERMS.

It is not the intention in this bulletin to enter into any extended discussion of the functions of the several constituents of feeds, but something should be said in explanation of the tables. All feeds, no matter how dry they appear, contain some water, and the *total dry matter* includes everything but this. Of the total dry matter, the principal nutritive substances may be grouped under the headings protein, carbohydrates, and fat, and the tables take the digestible parts of these principles into consideration. The *protein* contains carbon, hydrogen, oxygen, nitrogen, and sulphur, while the carbohydrates and fat contain carbon, hydrogen and oxygen only. The protein, because of its nitrogen and sulphur, can perform functions in nutrition that fat and carbohydrates cannot, such as the formation of muscular tissue and the casein of milk. It is, therefore, of special importance that a ration should contain a sufficient amount of protein. Excessive quantities beyond the needs of the organism are undesirable, for, while protein can be used by the body for the same functions that fat and carbohydrates are, the unnecessary nitrogen brings an extra tax upon the excretory organs. Common examples of protein are the gluten of grains, the albumen of eggs and blood, and the curd of milk.

The *carbohydrates* include sugars, starch, fiber, etc. *Fat* of vegetable foods is similar to that from animals. Fats contain the same elements as carbohydrates, but in different proportion, having much less oxygen. On this account they require more oxygen to burn them in the air, or in the animal body, and in this burning or oxidation they yield about 2¼ times as much heat as an equal weight of carbohydrates. When oxidized in the tissues, fats and carbohydrates yield heat or other energy, such as muscular force, to the body. They also contribute to the formation of fat. Fats and carbohydrates perform similar offices in nutrition; protein can perform these also, but others in addition. It is, therefore, of more importance that a ration be balanced in respect to protein and non-protein than in respect to the relation between the fat and the carbohydrates of the non-protein.

The *fuel value* of a food is a measure of the energy that it can yield to the body it may be heat or some other form, all forms being convertible into heat units and expressible in heat units or Calories. A *Calory* is an amount of heat that is equal to that required to raise the temperature of a kilogram of water one degree C. or four pounds of water about four degrees F. In obtaining the fuel values given in the table, it was assumed that one pound of digestible fat yields 4220 Calories, and that a pound of digestible carbohydrates or protein yields 1860 Calories. These values are taken as averages, there being considerable differences among the individual members of these groups of food principles.

The terms *nutritive ratio* and *protein-equating factor* have been discussed in detail on previous pages, but it may be stated here that the former is the ratio of the weight of the protein in a feed to that of the carbohydrates plus 2¼ times the fat, and in the table protein is made unity, and the second term of the ratio correspondingly reduced. The protein-equating factor shows the number of pounds of a feed that must be taken to get a pound of protein, In the column showing the ratio of the fats to the carbohydrates the fats are made unity, and the second term of the ratio shows the amount of carbohydrates compared with this. The fats are not multiplied by 2¼ in this case; so the ratio shows relative weights, not relative energy values.

FEEDING STANDARDS.

In balancing a ration, it is obvious that there must be in view some standard which the feeder is attempting to approach. The best standard in any given instance cannot be said to be known. Experiments touching this question are long, costly, and should be repeated several times. The standards most used now are known as the Wolff-Lehmann standards. They rest upon European experiments. We still lack in this country comprehensive investigations on this subject, though some work has been done in certain lines. A standard ration is designed to represent the physiological requirements of the animal. It may often occur, however, that greater profit is obtained in feeding a ration that is unbalanced to a certain extent, rather than in selling a cheap feed in order to purchase a better one which is dear. The cheap feed may not be as well utilized as it would be if mixed with another, but the waste from this source may entail less loss than the balancing feed would cost. Modifications of a ration may be required by individual peculiarities of the animal, or advantageous from time to time for the sake of affording variety, as a stimulus to appetite and digestion. These and other practical points are

Table II.—Wolff-Lehman Feeding Standards. Showing the amounts of nutrients required per day for 1000 pounds live weight, and to which nutritive ratios and ratios of fat to carbohydrates in the several rations have been added.

Animal.	Total dry matter.	Digestible nutrients.				Fuel value.	Nutritive ratio.	Ratio of fat to carbo-hydrates.
		Total.	Protein.	Carbohy-drates.	Fat.			
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*		
Oxen:								
At rest in stall	18	8.8	0.7	8.0	0.1	16,600	1: 11.75	1: 80.0
At light work	22	11.7	1.4	10.0	0.3	22,500	1: 7.63	1: 33.3
At medium work	25	14.0	2.0	11.5	0.5	27,200	1: 6.31	1: 23.0
At heavy work	28	16.6	2.8	13.0	0.8	32,755	1: 5.29	1: 16.3
Fattening cattle:								
First period	30	18.0	2.5	15.0	0.5	34,650	1: 6.45	1: 30.0
Second period	30	18.2	3.0	14.5	0.7	35,500	1: 5.36	1: 20.7
Third period	26	18.4	2.7	15.0	0.7	35,900	1: 6.14	1: 21.4
Milch cows:								
Giving 11 pounds milk a day	25	11.9	1.6	10.0	0.3	22,850	1: 6.67	1: 33.3
Giving 16½ pounds milk a day	27	13.4	2.0	11.0	0.4	25,850	1: 5.95	1: 27.5
Giving 22 pounds milk a day	29	16.0	2.5	13.0	0.5	30,950	1: 5.65	1: 26.0
Giving 27½ pounds milk a day	32	17.1	3.3	13.0	0.8	33,700	1: 4.48	1: 16.3
Sheep:								
Coarse wool	20	11.9	1.2	10.5	0.2	22,600	1: 9.13	1: 52.5
Fine wool	23	13.8	1.5	12.0	0.3	26,400	1: 8.45	1: 40.0
Breeding ewes, with lambs	25	18.4	2.9	15.0	0.5	35,400	1: 5.56	1: 30.0
Fattening sheep:								
First period	30	18.5	3.0	15.0	0.5	35,600	1: 5.38	1: 30.0
Second period	28	18.6	3.5	14.5	0.6	36,000	1: 4.53	1: 24.2
Horses:								
Light work	20	11.4	1.5	9.5	0.4	22,150	1: 6.93	1: 23.8
Medium work	24	13.6	2.0	11.0	0.6	26,700	1: 6.18	1: 18.3
Heavy work	26	16.6	2.5	13.3	0.8	32,750	1: 6.04	1: 16.6
Brood sows	22	18.4	2.5	15.5	0.4	35,170	1: 6.56	1: 38.8
Fattening swine:								
First period	36	30.2	4.5	25.0	0.7	57,800	1: 5.90	1: 35.7
Second period	32	28.5	4.0	24.0	0.5	54,200	1: 6.28	1: 48.0
Third period	25	21.1	2.7	18.0	0.4	40,200	1: 7.00	1: 45.0
Growing cattle:								
Dairy breeds—								
2 to 3 months old, weighing about 150 lbs.	23	19.0	4.0	13.0	2.0	40,050	1: 4.38	1: 6.5
3 to 6 " " " " 300 "	24	16.8	3.0	12.8	1.0	33,600	1: 5.02	1: 12.8
6 to 12 " " " " 500 "	27	15.0	2.0	12.5	0.5	29,100	1: 6.81	1: 25.0
12 to 18 " " " " 700 "	26	14.7	1.8	12.5	0.4	28,300	1: 7.44	1: 31.3
18 to 24 " " " " 900 "	26	13.8	1.5	12.0	0.3	26,350	1: 8.45	1: 40.0

Growing cattle:								
Beef breeds—								
2 to 3 months old, weighing about 160 lbs	23	19.2	4.2	13.0	2.0	40,450	1: 4.17	1: 6.5
3 to 6 " " " " 330 "	24	17.8	3.5	12.8	1.5	36,650	1: 4.62	1: 8.5
6 to 12 " " " " 550 "	25	16.4	2.5	13.2	0.7	32,150	1: 5.91	1: 18.9
12 to 18 " " " " 750 "	24	15.0	2.0	12.5	0.5	29,100	1: 6.81	1: 25.0
18 to 24 " " " " 950 "	24	14.2	1.8	12.0	0.4	27,350	1: 7.17	1: 30.0
Growing sheep:								
Wool breeds—								
4 to 6 months old, weighing about 60 lbs	25	19.5	3.4	15.4	0.7	37,900	1: 4.99	1: 22.0
6 to 8 " " " " 75 "	25	17.2	2.8	13.8	0.6	33,400	1: 5.41	1: 23.0
8 to 11 " " " " 80 "	23	14.1	2.1	11.5	0.5	27,400	1: 6.01	1: 23.0
11 to 15 " " " " 90 "	22	13.4	1.8	11.2	0.4	25,850	1: 6.72	1: 28.0
15 to 20 " " " " 100 "	22	12.6	1.5	10.8	0.3	24,150	1: 7.65	1: 36.0
Mutton breeds—								
4 to 6 months old, weighing about 60 lbs	26	20.8	4.4	15.5	0.9	40,800	1: 3.98	1: 17.2
6 to 8 " " " " 80 "	26	19.2	3.5	15.0	0.7	37,350	1: 4.74	1: 21.4
8 to 11 " " " " 100 "	24	17.8	3.0	14.3	0.5	34,300	1: 5.14	1: 28.6
11 to 15 " " " " 120 "	23	15.3	2.2	12.6	0.5	29,650	1: 6.24	1: 25.0
15 to 20 " " " " 150 "	22	14.4	2.0	12.0	0.4	27,750	1: 6.45	1: 30.0
Growing swine:								
Breeding stock—								
2 to 3 months old, weighing about 50 lbs	44	36.6	7.6	28.0	1.0	70,450	1: 3.98	1: 28.0
3 to 5 " " " " 100 "	35	28.9	5.0	23.1	0.8	55,650	1: 4.98	1: 28.9
5 to 6 " " " " 120 "	32	25.4	3.7	21.3	0.4	48,190	1: 6.00	1: 53.5
6 to 8 " " " " 200 "	28	21.8	2.8	18.7	0.3	41,250	1: 6.92	1: 62.3
8 to 12 " " " " 250 "	25	17.6	2.1	15.3	0.2	33,200	1: 7.50	1: 76.5
Growing, fattening swine:								
2 to 3 months old, weighing about 50 lbs	44	36.6	7.6	28.0	1.0	70,450	1: 3.98	1: 28.0
3 to 5 " " " " 100 "	35	28.9	5.0	23.1	0.8	55,650	1: 4.98	1: 28.9
5 to 6 " " " " 150 "	33	27.2	4.3	22.3	0.6	52,000	1: 5.50	1: 37.2
6 to 8 " " " " 200 "	30	24.5	3.6	20.5	0.4	46,500	1: 5.94	1: 51.3
9 to 12 " " " " 300 "	26	21.6	3.0	18.3	0.3	40,900	1: 6.33	1: 61.0

essential to scientific feeding, and no arbitrary adoption of a feeding standard should be so inflexible as not to yield when a financial advantage would follow such a course. Feeding standards, then, are very useful guides, but must not be allowed unquestioned dictation. They are to be approximated as closely as the available feeds and the market prices of them will permit, and their study should suggest the direction that feed-production should take.

The table of feeding standards printed on pages 114 and 115 is taken by permission from Farmers' Bulletin No. 22, revised edition, to which have been added the columns showing the total digestible nutrients, the nutritive ratio and the ratio of the fat to the carbohydrates for each ration.

With the tables before us, let us now use them in the balancing of a ration consisting of alfalfa hay, Hungarian hay, corn, and wheat bran, making the nutritive ratio 1:5.65, and the ratio of the fat to the carbohydrates 1:26, this being the standard for cows giving 22 pounds of milk per day.

The following data are taken from the tables:

	Protein, per cent.	Carbohydrates, per cent.	Fast, per cent.	Nutritive ratio.	Protein-equating factor.
Hungarian	4.50	51.67	1.34	1:12.2	22.2
Alfalfa	10.58	37.33	1.38	1: 3.8	9.5
Corn	7.14	66.12	4.97	1:10.8	14
Wheat bran	12.01	41.23	2.87	1: 4	8.3

Balancing alfalfa by Hungarian, and corn by bran, and performing the operations indicated, we get the following:

		Second term of ratio.	Difference.		Protein-equating factor.		Relative quantities required.
A	(Hungarian,	12.20	1.85	×	22.2	=	41.07
	Proposed,	*5.65*					
	(Alfalfa,	3.80	6.55	×	9.5	=	62.23
B	(Corn,	10.80	1.65	×	14	=	23.10
	Proposed,	*5.65*					
	(Bran,	4	5.15	×	8.3	=	42.75

By this simple calculation, involving but two subtractions and two multiplications, the ratio in which Hungarian and alfalfa must be mixed to obtain the given nutritive ratio is determined with absolute accuracy, and is 41.07 to 62.23, respectively, or nearly as 2 to 3. By a parallel calculation, the ratio of corn to bran required to produce a mixture with the given nutritive ratio is 23.10 to 42.75, or somewhat more than 1 to 2. The mixture A constitutes the roughage of the ration; the other, B, the grain; and both mixtures having the correct nutritive ratio, each may be used in any quantity desired without affecting the nutritive ratio.

However, in order to have the ratio of the fat to the carbohydrates

1:26, it is necessary to use these two mixtures in definite relative amounts, which are ascertained as follows: Assuming the weights represented by the figures to be pounds, we must calculate the ratio of the fat to the carbohydrates in each mixture by multiplying the weight of each feed used by the percentage of fat and of carbohydrates that it contains, and then adding the corresponding products, thus:

	Feed.	Weight.		Per cent. fat.		Weight of fat.
A	Hungarian,	41.07	×	1.34	=	0.55
A	Alfalfa,	62.23	×	1.38	=	0.86
	Totals,	103.30 lbs. contain				1.41 lbs. fat.

	Feed.	Weight.		Per cent. carbohydrates.		Weight of carbohydrates.
A	Hungarian,	41.07	×	51.67	=	21.22
A	Alfalfa,	62.23	×	37.33	=	23.23
	Totals,	103.30 lbs. contain				44.45 lbs. carbohydrates.

The weight of the fat in a mixture of 41.07 pounds Hungarian and 62.23 pounds alfalfa is to the weight of carbohydrates in the same as 1.41 to 44.45, or 1:31.52.

Further, 103.3 pounds of the mixture contain 1.41 pounds of fat, from which we calculate the fat-equating factor, namely, the number of pounds necessary to take to get one pound of fat. 103.3 ÷ 1.41 = 73.26, the fat-equating factor for the mixture.

In a similar manner we must calculate the weights of fat and carbohydrates, the ratio between them, and the fat-equating factor for the mixture of corn and bran:

	Feed.	Weight.		Per cent. fat.		Weight of fat.
B	Corn,	23.10	×	4.97	=	1.15
B	Bran,	42.75	×	2.87	=	1.23
	Total,	65.85 lbs. contain				2.38 lbs. fat.

	Feed.	Weight.		Per cent. carbohydrates.		Weight of carbohydrates.
B	Corn,	23.10	×	66.12	=	15.27
B	Bran,	42.75	×	41.23	=	17.63
	Total,	65.85 lbs. contain				32.90 lbs. carbohydrates.

The weight of the fat in 23.10 pounds corn and 42.75 pounds bran is to the weight of the carbohydrates in the same as 2.38 is to 32.9, or 1:13.82. As 65.85 pounds of the mixture contain 2.38 pounds fat, 27.66 pounds would contain 1 pound; 65.85 ÷ 2.38 = 27.66, which is, therefore, the fat-equating factor.

To determine the relative amounts of A and B to be taken to obtain a mixture in which the ratio of the fats to the carbohydrates is 1:26, we proceed by allegation precisely as in balancing in respect to the nutritive ratio, but using the fat-equating factors for the mixtures, and the second terms of the ratios of the fat to the carbohydrates in the mixtures and in the proposed compound mixture.

Feed.	Second term of ratio.	Differ- ence.		Fat- equating factor.		Relative quantities required.
Mixture A,	31.52	12.18	×	73.26	=	892.31
Proposed,	*26*					
Mixture B,	13.82	5.52	×	27.66	=	152.68

From this we see that if we wish to use these two mixtures in compounding a ration that will not only possess the nutritive ratio 1:5.65, but in which the ratio of fats to carbohydrates is 1:26, we must use 892.31 pounds of the Hungarian and alfalfa to 152.68 pounds of the corn and bran. To determine the amount of each single feed we must make still another calculation.

The 892.31 pounds of mixture A contain Hungarian and alfalfa in the ratio of 41.07 to 62.23. If we should take these amounts only we would have but 103.3 pounds. We must, therefore, take as many times each of these as 103.3 is contained times in 892.31; 892.31 ÷ 103.3 = 8.638, the number of units of each required.

41.07 × 8.638 = 354.76, the Hungarian required.
62.23 × 8.638 = 537.54, the alfalfa required.
892.30 lbs. mixture A required.

The 152.68 pounds of mixture B contain corn and bran in the ratio of 23.10 pounds of corn to 42.75 pounds of bran. Were we to take these amounts only, there would be but 65.85 pounds instead of 152.68. We must, therefore, take as many times as much of each as this sum is contained times in 152.68; 152.68 ÷ 65.85 = 2.319, the number of units of each required.

23.10 × 2.319 = 53.57, the corn required.
42.75 × 2.319 = 99.14, the bran required.
152.71 lbs. mixture B required.

Collecting the preceding results, we get the following statement of the quantities of each required to obtain a mixture that will have a nutritive ratio of 1:5.65, and the fat and the carbohydrates in the ratio 1:26:

Hungarian	354.76
Alfalfa	537.54
Corn	53.57
Bran	99.14
Total	1,045.01

These are the only proportions in which these feeds can be mixed and produce the ratios proposed.

It will be noted that the calculations necessary in order to bring the fat and carbohydrates into the ratio of the standard are much more laborious than those for obtaining the correct nutritive ratio. This is chiefly due to the fact that it is not practicable to prepare tables for use in this on account of the great number of possible combinations of feeds of the various nutritive ratios. Each case must be calculated for itself. In the examples given the figures have been carried out farther than necessary in ordinary practice, the object being to demonstrate the exactness of the method.

In calculating the amount to be fed to agree with the standard, any one of various methods may be used, if the ratio has been calculated to the exact standard in respect to composition. Thus, if the ratios are correctly determined, a calculation of the amount of the mixture to be taken to include the required quantity of protein, for example, will be all that is required, since the required quantity of protein will necessarily carry with it the required quantities of the other nutrients. The same result would be reached if the fat or the carbohydrates were taken as the basis of calculation. Probably the simplest method of making this calculation is by means of the energy required by the standard. This is given in the tables under the heading "Fuel value." Evidently enough of the ration must be taken to yield the required fuel value. This being done, if the ratio is correctly balanced, each constituent will be provided in the correct quantity. To make this calculation, it is only necessary to multiply the number of pounds of each feed used in the ration by the Calories yielded per pound by the respective feeds, add together the products, and divide the sum by the number of Calories required per day. The quotient will be the number of days for which the quantity of the ration will suffice, and dividing the quantity by the number of days will give the pounds per day required. Thus, in the example under calculation, we would have the following:

Feed.	Pounds per day.		Calories per pound.		Total Calories.	
Hungarian,	354.76	×	1,101.31	=	390,700.7	
Alfalfa,	537.54	×	949.36	=	510,319	
Corn,	53.57	×	1,572.37	=	84,231.9	
Bran,	99.14	×	1,111.38	=	110,282.2	
	1,045.01	lbs.	give		1,095,533.8	Calories.

The number of Calories required per day for cows giving twenty-two pounds of milk per day is 30,950 per thousand pounds live weight. Dividing 1,095,533.8 by 30,950, we get 35.4 as the number of days that the 1,045.01 pounds of the ration would last, and dividing 1,045.01 by 35.4, we ascertain the number of pounds to be fed per day to be 29.5.

SIMPLIFIED CALCULATIONS.

While the execution of the calculations described in the preceding pages requires much less time than is necessary to balance a ration by the cut-and-try method, it is still laborious if the attempt is made to bring the fat and carbohydrates to a definite ratio. Moreover, a clear head for mathematics is required to understand the process, or even to apply the formulated rules. The purpose of this section of the bulletin is to reduce the matter to its simplest terms, and it is hoped that any one with sufficient intelligence to understand their value will be able to balance rations with the facilities here afforded.

As previously stated, fats and carbohydrates contain the same elements, viz., carbon, hydrogen, and oxygen, and to a large extent perform the same functions in nutrition. Within reasonable limits, such as afforded by mixtures of ordinary feeds, it is not necessary that these should be in a definite ratio to each other. On the other hand, protein contains nitrogen and sulphur, in addition to carbon, oxygen, and hydrogen, and as these are essential to the animal body, protein can and does perform offices in nutrition that fats and carbohydrates cannot. A sufficient amount of protein is thus essential, and a proper proportion highly advantageous in feeding. The ratio of the energy yielded by protein to that yielded by non-protein is called the *nutritive ratio.* In the tables, these ratios are simplified by making the protein 1 in every case, the second term of the ratio being changed proportionately. When this second term is large it indicates a relatively large amount of fats and carbohydrates, and the nutritive ratio is said to be *wide;* when the second term is small, the fats and carbohydrates are in smaller relative amount, and the ratio is said to be *narrow.* If the nutritive ratio is adjusted to the standard, the most important balancing of the ration will be accomplished, assuming that ordinary feeds are used, and with due attention to provision for the roughage and the grain that the special case may demand. It is, in fact, a difficult matter to do more than this toward duplicating the German standards with our ordinary feeds, and in the opinion of the writer the ratio of the fats to the carbohydrates may as well be left out of consideration, except in special cases.

The first point to be clearly realized in balancing rations is that, essentially, this consists in offsetting the deficiency of one feed by excess in another, taking them in such amounts that the resulting mixture possesses the nutritive ratio desired. Of course, it may occasionally occur that a feed will possess the desired nutritive ratio, in which case it is itself a balanced ration for the purpose. In compounding a balanced ration, it is obvious that, if some are too poor in protein, at least one must be richer than the proposed ration, or there can be no possibility of mixing them so as to produce the desired nutritive ratio. For example, if one wishes to compound a ration for a dairy cow in which the nutritive ratio is to be 1:5.65, and to do this with sorghum fodder, timothy hay, corn, and turnips, he will be unable to do so, for, on examining the table, we find that the nutritive ratios of these feeds are as follows:

Sorghum fodder	1:21.9
Timothy hay	1:16.2
Corn	1:10.8
Turnips	1: 8.3

The proposed nutritive ratio being 1:5.65, it will be seen that each of these feeds is too rich in fats and carbohydrates, as shown by the greater size of the second term of the ratio. These feeds must be accompanied by at least one other in which the nutritive ratio is narrower; that is, in which the carbohydrates are in smaller amount compared with the protein, as shown by a smaller number as the second term of the nutritive ratio.

Now, in balancing a ration which includes a number of feeds that are too rich in fats and carbohydrates, it is necessary to offset the excess of each by a feed that is deficient in these substances. It is not necessary, however, that one of these should be balanced by one feed, another by another, and so on. All may be balanced by a single one, by two; three, or in fact any number. In case but one feed is used to balance two or more, while in the end we may sum up all the quantities, we must in the process of balancing, balance one at a time, thus arranging a number of pairs in each of which a feed deficient in protein is balanced by one having an excess, and in this pairing a given feed may be used any number of times, one portion balancing one feed and another portion another.

In the example under consideration, if we consult the table again to see what may be used in balancing the four feeds too rich in fats and carbohydrates, it is evident that we must select something that is much poorer in these substances; that is, in which the second term of the nutritive ratio, which represents them, is small. Under hays, we find that the leguminous crops are the only ones available that are sufficiently low in these substances. Even among these the red clover has a ratio of 1: 5.7; that is, practically, the proposed ratio, so that it cannot be used to balance other feeds in producing a ratio of 1:5.65. Soy-bean, cow-pea, alfalfa, crimson clover, alsike clover and white clover are all the hays that are available. Under the grains and mill products, we find none but pea-meal and soy-bean meal, but under the by-products obtained in various industries we find a considerable number of available feeds; for example, gluten-meal, gluten feed, bran, shorts, linseed-meal, and cottonseed-meal.

Let us illustrate the method of balancing rations by balancing each of the feeds under consideration. It will be best, perhaps, to balance the sorghum and timothy by some hay, and the corn and turnips by a concentrated feed. The reasons for the process of calculating have been given in detail in the previous section of this bulletin; at this point the rule will be given without explanation.

RULE FOR BALANCING FEEDS IN RESPECT TO NUTRITIVE RATIO.

To balance two feeds so that the resulting mixture shall have a definite nutritive ratio, it is essential that one of the two have a wider and the other a narrower nutritive ratio than that proposed for the mixture; that is, that in the *first* case the second term of the ratio is larger, and in the *second* case smaller than it is in the proposed ration.

To ascertain the relative amounts to be taken to balance two feeds, the *first* of which has a wider nutritive ratio, and the *second* of which has a narrower one than that to be produced:

Subtract the second term of the proposed nutritive ratio from the second term of the nutritive ratio of the *first* feed, and multiply the difference by the protein-equating factor of the *second* feed; the product will be the relative quantity of the *second* feed.

Subtract the second term of the nutritive ratio of the *second* feed from the second term of the proposed nutritive ratio; multiply the difference by the protein-equating factor of the *first* feed; the product will be the relative amount of the *first* feed.

Two or more mixtures having the same nutritive ratio may be used in any proportion, to produce a compound mixture for a ration of any composition desired, without altering the nutritive ratio.

Preceding in accordance with the foregoing rule to balance sorghum and alfalfa, so as to produce a mixture with the nutritive ratio of 1:5.65, making use of the preceding tables, we have:

Second term of nutritive ratio of sorghum (the “first” feed)	21.9
Second term of proposed nutritive ratio	5.65
Difference	16.25
Protein-equating factor of alfalfa (the “second” feed)	9.5
	8125
	14625
Relative amount of alfalfa required	154.375
Second term of proposed nutritive ratio	5.65
Second term of nutritive ratio of alfalfa (the “second” feed) . . .	3.8
	1.85
Protein-equating factor of sorghum (the “first” feed).	38.5
	925
	1480
	555
Relative quantity of sorghum required	71.225

The preceding calculation shows every figure that the balancing of these two feeds requires, when use is made of the tables furnished in this bulletin. It requires but a minute and one-half to do the work. It will pay to spend an hour learning how to do it. The results show exactly the relative amounts of sorghum and alfalfa that must be taken to obtain a mixture with the nutritive ratio 1:5.65. This may be rounded off to 7:15, or even if made 1:2 would not be far from the standard. That is, approximately one ton of sorghum fodder must be balanced by two tons of alfalfa hay. It is obvious that, so long as this proportion is maintained for these, the mixture may be used in any quantity desired, either alone or with other feeds or mixtures having the required nutritive ratio.

In a similar manner, we may balance the timothy by alfalfa, the corn by bran, and the turnips by bran. Without showing the details of subtraction and multiplication, the following table indicates the operations necessary:

Feed.	Second term of nutritive ratio.	Difference.		Protein-equating factor.		Relative quantity.
Timothy	16.2	1.85	×	34.6	=	64
Mixture	*5.65*					
Alfalfa	3.8	10.55	×	9.5	=	100.2
Corn	10.8	1.65	×	14	=	23.1
Mixture	*5.65*					
Bran	4	5.15	×	8.3	=	42.7
Turnips	8.3	1.65	×	123.5	=	203.8
Mixture	*5.65*					
Bran	4	2.65	×	8.3	=	22

These figures show the relative quantities required of each feed to balance it by another. Each pair is balanced independently of all the others, and the mixtures can be mixed with each other in any proportion. For example, 20 pounds of the timothy and alfalfa mixture might be used with 10 pounds of the mixture of corn and bran; or 25 pounds of the hay mixture might be taken with 9 pounds of the grain mixture; or, in short, any other quantities of either might be taken that the judgment of the feeder might dictate; or, with some of each of these, a quantity of the turnips and bran combination, or the sorghum and alfalfa mixture; or both might be used with either or both of the other mixtures. Each mixture being balanced within itself, any possible compound mixture of these mixtures will be balanced.

In balancing these six feeds, we might have balanced sorghum or timothy or both by bran, and corn or turnips or both by alfalfa, but, where possible, it is better to balance the bulky feeds among themselves, and the concentrated feeds among themselves. The feeder can then use the resulting mixtures in such quantities of each as he deems desirable to maintain a suitable relation between the grain and the roughage.

In respect to calculating the quantities to be fed to agree with the standard, reference must be made to a preceding page, as it is impossible to simplify the matter further, but for practical purposes the observation and judgment of the feeder will be all that is necessary.

In order to facilitate still further the selection of feeds for the several classes of domestic animals, and their compounding into rations, table III has been compiled. This is a combination of parts of tables I and II. The feeds have been arranged in the order of their nutritive ratios, the narrowest being given first and the widest last. In addition, the nutritive ratios of the rations required by animals when fed at different ages, and for the several purposes, have been incorporated in the same order, and with those of the feeds. For greater convenience in calculating, the protein-equating factors have also been repeated here. By finding the nutritive ratio of the ration of the class of animals to be fed, the feeder can see by looking upward in the table all of the feeds that possess narrower nutritive ratios than that of the ration, and by looking downward, all that have wider nutritive ratios. He can then select with the greatest facility such as are available to him, and proceed to balance them by means of the nutritive ratios and protein-equating factors.

Table III. Showing nutritive ratios and protein-equating factors for feeds, and nutritive ratios of rations required by the several classes of domestic animals named, all arranged according to nutritive ratio. All feeds named before a ration possess narrower nutritive ratios than the ration; all named after have wider nutritive ratios.

Feeds and Classes of Animals.	Approx. wt. in lbs.	Nutritive ratio, 1:(—)..	Protein-equating factor....
Dried blood (H)		0.1	1.9
Meat scrap		0.5	1.5
Cottonseed-meal		1.2	2.7
Gluten-meal, Chicago		1.5	3.0
Linseed-meal (new process)		1.5	3.3
Linseed-meal (old process)		1.7	3.5
Gluten-meal, cream		1.7	3.3
Milk, skim, separator		1.9	33.2
Milk, skim, by setting		2.1	32.3
Buttermilk		2.1	35.5
Soy-bean meal (K)		2.1	2.8
Buckwheat bran		2.2	5.2
Buckwheat middlings		2.3	4.5
Gluten-meal, King		2.3	3.3
Brewers' grains (dried)		2.4	5.3
Malt sprouts		2.5	5.3
Gluten feed, Buffalo		2.5	4.3
Gluten feed, Atlas		2.7	4.3
Gluten-meal, Hammond		2.8	4.0
Distillery grains (dried), corn		2.8	4.6
Sugar-beet leaves (H)		3.0	58.8
Alfalfa, green		3.1	25.7
Alfalfa hay, first stage (K)		3.1	7.6
Brewers' grains (wet)		3.1	25.0
Gluten feed, Rockford		3.1	4.9
Pea-meal		3.2	6.0
Gluten-meal, Buffalo		3.2	4.6
Gluten feed		3.3	5.0
Alfalfa hay, second stage (K)		3.5	8.4
Alfalfa hay		3.8	9.5
Crimson clover hay		3.9	9.5
White clover hay		3.9	8.7
Cow-pea hay		3.9	9.3
Soy-bean hay		3.9	9.3
Milk, whole		3.9	29.6
Sheep, mutton, growing	60.	3.98	
Swine, breeding stock, growing	50.	3.98	
Swine, fattening, growing	50.	3.98	
Wheat bran		4.0	8.3
Cattle, beef, growing	160.	4.17	
Alfalfa hay, third stage (K)		4.3	9.6
Rape, green		4.3	46.3
Cattle, beef, growing	330.	4.34	
Cattle, dairy, growing	150.	4.38	
Cows, 27½ lbs. milk a day		4.48	
Sheep, fattening, second period		4.53	
Soy-beans, green		4.7	35.8
Sheep, mutton, growing	80.	4.74	
Cottonseed feed		4.8	10.4
Crimson clover, green		4.8	46.3
Wheat shorts		4.8	8.2
Wheat middlings		4.8	7.8
Rye bran		4.9	8.7
Swine, breeding stock, growing	100.	4.98	
Swine, fattening, growing	100.	4.98	
Sheep, wool, growing	60.	4.99	
Cattle, dairy, growing	300.	5.02	
Cow-pea, green		5.1	59.5
Sheep, mutton, growing	100.	5.14	
Oxen, at heavy work		5.29	

Table III—*Concluded.*

Feeds and Classes of animals.	Approx. wt. in lbs.	Nutritive ratio. 1:(—)..	Protein-equating factor...	Feeds and Classes of Animals.	Approx. wt. in lbs.	Nutritive ratio, 1:(—)..	Protein-equating factor...
Red clover, green		5.3	32.6	*Sows*, brood		6.56	
Cattle, fattening, second period		5.36		*Cows*, 11 lbs. milk a day		6.67	
Sheep, fattening, first period		5.38		Cottonseed (whole)		6.7	9.0
Sheep, wool, growing	75.	5.41		*Sheep*, wool, growing	90.	6.72	
Swine, fattening, growing	150.	5.5		*Cattle*, dairy, growing	500.	6.81	
Alsike clover hay		5.5	12.3	*Cattle*, beef, growing	750.	6.81	
Distillery grains (dried) rye		5.5	9.6	*Swine*, breeding-stock, growing	200.	6.92	
Ewes, breeding, with lambs		5.56		*Horses*, light work		6.93	
Cows, 22 lbs. milk a day		5.65		*Swine*, fattening, third period		7.0	
Oatmeal		5 7	8.7	Wheat		7.1	9.8
Red clover hay		5.7	13.6	*Cattle*, beef, growing	950.	7.17	
Mangel wurzels		5.7	97.1	Buffalo-grass hay (K)		7.2	16.1
Swine, fattening, first period		5.9		Kentucky blue-grass, green		7.3	37.6
Cattle, beef, growing	550.	5.91		Rye fodder, green		7.4	48.8
Swine, fattening, growing	200.	5.94		Beets		7.4	82.6
Cows, 16½ lbs. milk a day		5.95		*Cattle*, dairy, growing	700.	7.44	
Swine, breeding stock, growing	120.	6.0		*Swine*, breeding stock, growing	250.	7.5	
Sheep, wool, growing	80.	6.01		Mixed grasses and clover, hay		7.5	16.2
Horses, heavy work		6.04		*Oxen*, at light work		7.63	
Beet molasses (H)		6.1	11.0	*Sheep*, wool, growing	100.	7.65	
Cattle, fattening, third period		6.14		Barley hay		7.7	19.6
Horses, medium work		6.18		Barley		7.9	11.5
Oats		6.2	10.8	Rye		8.0	11.0
Rowen (mixed), hay		6.2	13.9	Oat fodder, green		8.3	41.0
Sheep, mutton, growing	120.	6.24		Turnips		8.3	123.5
Swine, fattening, second period		6.28		*Sheep*, fine wool		8.45	
Oxen, at medium work		6.31		*Cattle*, dairy, growing	900.	8.45	
Swine, fattening, growing	300.	6.33		Hungarian grass, green		8.6	52.1
Cattle, fattening, first period		6.45		Kentucky blue-grass hay		8.8	21.0
Sheep, mutton, growing	150.	6.45		Kafir-corn meal (K)		8.9	16.3

Orchard-grass, green	....	9 0	52.4
Oats, hay from	....	9.1	24.6
Barley meal	....	9.1	13.6
Hominy chops	....	9.1	11 9
Rutabagas	......	9.1	112 5
Sheep, coarse wool	....	9.13	......
Whey	....	9 3	178 6
Orchard-grass hay	....	9.4	20.9
Beets, sugar (H)	....	9.5	90.9
Sugar-beet pulp, dry	....	9 6	14 7
Kafir-corn	......	9.8	17 3
Ground corn and oats, equal parts	....	10.0	14 3
Redtop hay	....	10.2	20.8
Carrots	....	10 3	123.5
Corn	... ..	10 8	14 0
Redtop, green	....	10.9	48 5
Mixed grasses, hay	....	11.0	23.7
Meadow fescue, hay	....	11 3	23 8
Sugar-beet pulp (fresh)	....	11 3	158.7
Timothy, green	....	11.3	49.8
Corn-fodder, green	....	11 7	90 9
Corn-meal	... ..	11 7	16 0
Oxen, at rest in stall	......	11.75	.. ....
Meadow fescue, green	......	11 9	67 1
Potatoes	......	12.1	73 5
Hungarian grass hay	....	12 2	22 2
Corn silage	......	13 7	82 6
Corn-and-cob meal	......	14.0	21 0
Corn-fodder, field cured	.... . .	14.9	42.7
Kafir-corn stover, field cured (K)	......	15 9	31.1
Timothy hay	......	16.2	34.6
Kafir-corn fodder, green	... ..	17.0	114 9
Corn-stover, field cured	......	17 4	50.5
Soy-bean straw	....	18 4	43 5
Sorghum fodder, cured	... ..	21 9	38 5
Sorghum fodder, green	......	22.0	166.7
Kafir-corn stover, field cured	......	24 0	55.0
Sorghum silage (H)	... ..	25 6	166 7
Oat straw	......	33 6	83 3
Cottonseed hulls	....	34 7	95 2
Rye straw	.... ..	65 8	158 7
Prairie hay (K)	......	84 2	163.9
Wheat straw	.... .	100.5	270.3

READY-CALCULATED RATIONS.

The number of feeds available is so large, and their possible combinations so as to produce the several nutritive ratios required by the standards so numerous, that it is impracticable to calculate them all in advance. In order to assist to some extent, and to encourage attention to the proper compounding of rations, the accompanying table of balanced mixtures has been prepared. Each pair of feeds, when taken in the proportions stated, will give a mixture having the nutritive ratio given at the head of the column. Where blanks are left, the two feeds cannot be used in obtaining a mixture of the nutritive ratio given at the head of the column, as both are either too narrow or too wide in their nutritive ratios. In compounding rations consisting of more than two feeds, any of the two-feed rations shown in the table may be mixed in any proportion with any other one or ones having the same nutritive ratio. In this way any complexity or variety desired may be obtained in the final compound mixture. Some of the mixtures balanced are included because of the probable usefulness of one of the constituents in small quantities, with no idea that the simple mixture there presented will be fed alone, but that it will be used in connection with one or more others in compounding a ration. The nutritive ratios selected to which the feeds are balanced are those required by important groups of animals, and are so distributed that the differences between the second terms of the nutritive ratios required by the other groups do not differ by more than 0.15 from that of those calculated, except in four instances, and in but one unimportant one is the difference more than 0.2.

The table is in three parts. In the first, forage crops are balanced among themselves. Alfalfa hay, red clover hay and soy-bean or cow-pea hay are each balanced with alfalfa hay, soy-bean hay, red clover hay, mangels, turnips, sugar-beet pulp, green corn-fodder, potatoes, Hungarian hay, corn silage, dry corn-fodder, timothy hay, green Kafir-corn fodder, corn stover, soy-bean straw, dry sorghum fodder, green sorghum fodder, dry Kafir-corn fodder, sorghum silage, oat straw, cottonseed hulls, prairie hay (K), and wheat straw, as far as their composition permits.

In the second part, grains, by-products and dairy products are balanced among themselves. Wherever possible, cottonseed-meal, old-process linseed-meal, wheat bran, Kafir-corn grain and corn have been balanced with cottonseed-meal, gluten-meal, old-process linseed-meal, new-process linseed-meal, separator skim-milk, buttermilk, soy-bean meal, pea-meal, gluten feed, whole milk, wheat bran, wheat shorts, oats, cottonseed, wheat, barley, rye, whey, Kafir-corn, and corn.

In the third part, grains, etc., are balanced with forage crops; cottonseed-meal, old-process linseed-meal, wheat bran, Kafir-corn and corn being balanced as far as possible with alfalfa hay, soy-bean hay, cow-pea hay, red clover hay, mangels, turnips, fresh sugar-beet pulp, potatoes, Hungarian hay, corn silage, corn-fodder, timothy hay, corn-stover, soy-bean straw, dry sorghum fodder, Kafir-corn stover, sorghum silage, oat straw, cottonseed hulls, prairie hay, and wheat straw; and bran with green alfalfa, green red clover, green corn-fodder, green Kafir-corn fodder and green sorghum fodder in addition.

In respect to the tables included in this bulletin, it is too much to believe that they are absolutely free from error, but no effort has been spared to make them so, all of the operations being proved or checked by duplication.

The author wishes at this time to acknowledge his especial indebtedness to Miss Florence Vail, B. S., for her interest and accuracy in making calculations for this bulletin. All of those for tables I, II and III were made by her, and a large portion of those for table IV, as well as others in the text.

Table IV. Balanced mixtures. The figures opposite a pair of feeds show the relative amounts by weight that must be taken of each in order to obtain a mixture having the nutritive ratio given at the head of the column in which the figures stand.

Feeds Balanced.	Nutritive Ratio, 1:(——)													
	3.98	4.48	5.00	5.36	5.65	6.00	6.28	6.45	6.81	7.17	7.50	8 45	9.13	11.75
Alfalfa hay	16.3	11.6	6.7	3.2	0.5	....	....	....	....	....	....	....	....	....
Red clover hay	2.4	9.2	16.3	21.2	25.2	....	....	....	....	....	....	....	....	....
Alfalfa hay	16.3	11.6	6.7	3.2	0.5	....	....	....	....	....	....	....	....	....
Mangels	17.5	66.0	116.5	151.5	179.6	....	....	....	....	....	....	....	....	....
Alfalfa hay	41.0	36.3	31.4	27.9	25.2	21.9	19.2	17.6	14.2	10.7	7.6	....	....	....
Turnips	22.2	84.0	148.2	192.7	228.5	271.7	306.3	327.3	371.7	416.2	457.0	....	....	....
Alfalfa hay	69.5	64.8	59.9	56.4	53.7	50.4	47.7	46.1	42.7	39.2	36.1	27.1	20.6	....
Sugar-beet pulp, fresh	28.6	107.9	190.4	247.6	293.6	349.1	393.6	420.6	477.7	534.8	587.2	738 0	845.9	....
Alfalfa hay	73.3	68.6	63.7	60.2	57.5	54.2	51.5	49.9	46.5	43.0	39.9	30.9	24.4	....
Corn-fodder, green	16.4	61.8	109.1	141.8	168.2	200.0	225.4	240.9	273.6	306.3	336.3	422.7	484.5	....
Alfalfa hay	77.1	72.4	67.5	64.0	61.3	58.0	55.3	53.7	50.3	46.8	43.7	34.7	28.2	3.3
Potatoes	13.2	50.0	88.2	114.7	136.0	161.7	182.3	194.8	221.2	247.7	272.0	341.8	391.8	584.3
Alfalfa hay	78.1	73.3	68.4	65.0	62.2	58.9	56.2	54.6	51.2	47.8	44.7	35.6	29.2	4.3
Hungarian hay	4.0	15.1	26.6	34.6	41.1	48.8	55.1	58.8	66.8	74.8	82.1	103.2	118.3	176.5
Alfalfa hay	92.3	87.6	82.7	79.2	76.5	73.2	70.5	68.9	65.5	62.0	58.9	49.9	43.4	18.5
Corn silage	14.9	56.2	99.1	128.9	152.8	181.7	204.8	218.9	248.6	278.4	305.6	384.1	440.3	656.7
Alfalfa hay	103.7	99.0	94.1	90.6	87.9	84.6	81.9	80.3	76.9	73.4	70.3	61.3	54.8	29.9
Corn-fodder, field cured	7.7	29.0	51.2	66.6	79.0	93.9	105.9	113.2	128.5	143.9	158.0	198.6	227.6	339.5
Alfalfa hay	116.1	111.3	106.4	103.0	100.2	96.9	94.2	92.6	89.2	85.8	82.7	73.6	67.2	42.3
Timothy hay	6.2	23.5	41.5	54.0	64.0	76.1	85.8	91.7	104.1	116.6	128.0	160.9	184.4	275.1
Alfalfa hay	123.7	118.9	114.0	110.6	107.8	104.5	101.8	100.2	96.8	93.4	90.3	81.2	74.8	49.9
Kafir-corn fodder, green	20.7	78.1	137.9	179.2	212.6	252.8	285.0	304.5	345.8	387.2	425.1	534.3	612.4	913.5
Alfalfa hay	127.5	122.7	117.8	114.4	111.6	108.3	105.6	104.0	100.6	97.2	94.1	85.0	78.6	53.7
Corn-stover	9.1	34.3	60.6	78.8	93.4	111.1	125.2	133.8	152.0	170.2	186.9	234.8	269.2	401.5
Alfalfa hay	137.0	132.2	127.3	123.9	121.1	117.8	115.1	113.5	110.1	106.7	103.6	94.5	88.1	63.2
Soy-bean straw	7.8	29.6	52.2	67.9	80.5	95.7	107.9	115.3	130.9	146.6	161.0	202.3	231.9	345.8
Alfalfa hay	170.2	165.5	160.6	157.1	154.4	151.1	148.4	146.8	143.4	139.9	136.8	127.8	121.3	96.4
Sorghum fodder, dry	6.9	26.2	46.2	60.1	71.2	84.7	95.5	102.0	115.9	129.7	142.5	179.0	205.2	3[illegible]6.1

Alfalfa hay	171.2	166.4	161.5	158.1	155.3	152.0	149.3	147.7	144.3	140.9	137.8	128.7	122.3	97.4
Sorghum fodder, green	30.0	113.4	200.0	260.1	308.4	366.7	413.4	441.8	501.8	561.8	616.8	775.2	888.5	1325.3
Alfalfa hay	190.2	185.4	180.5	177.1	174.3	171.0	168.3	166.7	163.3	159.9	156.8	147.7	141.3	116.4
Kafir-corn stover, field cured	9.9	37.4	66.0	85.8	101.8	121.0	136.4	145.8	165.6	185.4	203.5	255.8	293.2	437.3
Alfalfa hay	205.4	200.6	195.7	192.3	189.5	186.2	183.5	181.9	178.5	175.1	172.0	162.9	156.5	131.6
Sorghum silage	30.0	113.4	200.0	260.1	308.4	366.7	413.4	441.8	501.8	561.8	616.8	775.2	888.5	1325.3
Alfalfa hay	281.4	276.6	271.7	268.3	265.5	262.2	259.5	257.9	254.5	251.1	248.0	238.9	232.5	207.6
Oat straw	15.0	56.6	100.0	129.9	154.1	183.3	206.6	220.7	250.7	280.7	308.2	387.3	444.0	662.2
Alfalfa hay	291.8	287.0	282.2	278.7	276.0	272.7	270.0	268.4	265.0	261.5	258.4	249.4	242.9	218.0
Cottonseed hulls	17.1	64.7	114.2	148 5	176.1	209.4	236.1	252.3	286.6	330.3	352.2	442.7	507.4	756.8
Alfalfa hay	762.1	757.3	752.4	749.0	746.2	742.9	740.2	738.6	735.2	731.8	728.7	719.6	713.2	688.3
Prairie hay (K)	29.5	111.5	196.7	255.7	303.2	360.8	406.5	414.3	493.3	552.3	606.4	762.1	873.6	1303.0
Alfalfa hay	916.9	912.2	907.3	903.8	901.1	897.8	895.1	893.5	890.1	886.6	883.5	874.5	868.0	843.1
Wheat straw	48.7	183.8	324.4	421.7	500.1	594.7	670.3	716.3	813 6	910.9	1000.1	1256.9	1440.7	2148.9
Soy-bean or cow-pea hay	16.0	11.3	6.5	3.2	0.5	....	....	....	....	....	....	....	....	....
Red clover hay	1.1	7.9	15.0	19.9	23.8	....	....	....	....	....	....	....	....	....
Soy-bean or cow-pea hay	16.0	11.3	6.5	3.2	0.5	....	....	....	....	....	....	....	....	....
Mangels	7.8	56.3	106.8	141.8	169.9	....	....	....	....	....	....	....	....	....
Soy-bean or cow-pea hay	40.2	35.5	30.7	27.3	24.6	21.4	18.8	17.2	13.9	10.5	7.4	....	....	....
Turnips	9.9	71.6	135.8	180.3	216.1	259.3	293.9	314.9	359.4	403.8	444.6	....	....	....
Soy-bean or cow-pea hay	68.1	63.4	58.6	55.2	52.5	49.3	46.7	45.1	41.8	38.4	35.3	26.5	20.2	....
Sugar-beet pulp, fresh	12.7	92.1	174.6	231.7	277.7	333.3	377.7	404.7	461.8	518.9	571.3	722.1	830.0	....
Soy-bean or cow-pea hay	71.8	67.1	62.3	59.0	56.3	53.0	50.4	48.8	45.5	42.1	39.1	30.2	23.9	....
Corn-fodder, green	7.3	52.7	100.0	132.7	159.1	190.9	216.3	231.8	264.5	297.2	327.2	413.6	475.4	....
Soy-bean or cow-pea hay	75.5	70.9	66.0	62.7	60.0	56.7	54.1	52.5	49.2	45.8	42.8	33.9	27.6	3.3
Potatoes	5.9	42.6	80.8	107.3	128.6	154.3	174.9	187.4	213.9	240.3	264.6	334.4	384.4	577.0
Soy-bean or cow-pea hay	76.4	71.8	67.0	63.6	60.9	57.7	55.1	53.5	50.1	46.8	43.7	34.9	28.6	4.2
Hungarian hay	1.8	12.9	24.4	32.4	38.9	46.6	52.8	56.6	64.6	72.6	79.9	101.0	116.1	174.3
Soy-bean or cow-pea hay	90.4	85.7	80.9	77.6	74.9	71.6	69.0	67.4	64.1	60.7	57.7	48.8	42.5	18.1
Corn silage	6.6	47.9	90.9	120.6	144.6	173.5	196.6	210.6	240.4	270.1	297.4	375.8	432.0	648.4
Soy-bean or cow-pea hay	101.6	96.9	92.1	88.7	86.0	82.8	80.2	78.6	75.2	71.9	68.8	60.0	53.7	29.8
Corn-fodder, field cured	3.4	24.8	47.0	62.3	74.7	89.7	101.6	108.9	124.3	139.6	153.7	194.3	223.3	335.2
Soy-bean or cow-pea hay	113.6	109.0	104.2	100.8	98.1	94.9	92.3	90.7	87.3	84.0	80.9	72.1	65.8	41.4
Timothy hay	2.8	20.1	38.1	50.5	60.6	72.7	82.3	88.2	100.7	113.1	124.6	157.4	181.0	271.6

Table IV—*Continued.*

Feeds Balanced.	Nutritive Ratio, 1 : (——)													
	3.98	4.48	5.00	5.36	5.65	6.00	6.28	6.45	6.81	7.17	7.50	8.45	9.13	11.75
Soy-bean or cow-pea hay	121.1	116.4	111.6	108.3	105.6	102.3	99.7	98.1	94.8	91.4	88.2	79.5	73.2	48.8
Kafir-corn fodder, green	9.2	66.6	126.4	167.8	201.1	241.3	273.5	293.0	334.4	375.7	413.6	522.8	600.9	902.0
Soy-bean or cow-pea hay	124.8	120.2	115.3	112.0	109.3	106.0	103.4	101.8	98.5	95.1	92.1	83.2	76.9	52.5
Corn-stover	4.0	29.3	55.6	73.7	88.4	106.1	120.2	128.8	147.0	165.1	181.8	229.8	264.1	396.4
Soy-bean or cow-pea hay	134.1	129.5	124.6	121.3	118.6	115.3	112.7	111.1	107.8	104.4	101.4	92.5	86.2	61.8
Soy-bean straw	3.5	25.2	47.9	63.5	76.1	91.4	103.5	110.9	126.6	142.2	156.6	197.9	227.5	341.5
Soy-bean or cow-pea hay	166.7	162.0	157.2	153.8	151.1	147.9	145.3	143.7	140.3	137.0	133.9	125.1	118.8	94.4
Sorghum fodder, dry	3.1	22.3	42.4	55.2	67.4	80.9	91.6	98.2	111.9	125.9	138.6	175.2	201.4	302.2
Soy-bean or cow-pea hay	167.6	162.9	158.1	154.8	152.1	148.8	146.2	144.6	141.3	137.9	134.9	126.0	119.7	95.3
Sorghum fodder, green	13.3	96.7	183.4	243.4	291.7	350.1	396.7	425.1	485.1	545.1	600.1	758.5	871.8	1308.6
Soy-bean or cow-pea hay	186.2	181.5	176.7	173.4	170.7	167.4	164.8	163.2	159.9	156.5	153.5	144.6	138.3	113.9
Kafir-corn stover, field cured	4.4	31.9	60.5	80.3	96.3	115.5	130.9	140.3	160.1	179.9	198.0	250.3	287.7	431.8
Soy-bean or cow-pea hay	201.1	196.4	191.6	188.2	185.5	182.3	179.7	178.1	174.7	171.4	168.3	159.5	153.2	128.8
Sorghum silage	13.3	96.7	183.4	243.4	291.7	350.1	396.7	425.1	485.1	545.1	600.1	758.5	871.8	1308.6
Soy-bean or cow-pea hay	275.5	270.8	266.0	262.6	259.9	256.7	254.1	252.5	249.1	245.8	242.7	233.9	227.6	203.2
Oat straw	6.7	48.3	91.6	121.6	145.8	174.9	198.3	212.4	242.4	272.4	299.9	379.0	435.7	653.9
Soy-bean or cow-pea hay	285.7	281.0	276.2	272.9	270.2	266.9	264.3	262.7	259.4	256.0	253.0	244.1	237.8	213.4
Cottonseed hulls	7.6	55.2	104.7	139.0	166.6	199.9	226.6	242.8	277.0	311.3	342.7	433.2	497.9	747.3
Soy-bean or cow-pea hay	746.0	741.4	736.6	733.2	730.5	727.3	724.7	723.1	719.7	716.4	713.3	704.5	698.2	673.8
Prairie hay (K)	13.1	95.1	180.3	239.3	286.8	344.2	390.1	417.9	476.9	536.0	590.0	745.7	857.2	1286.6
Soy-bean or cow-pea hay	897.6	893.0	888.2	884.8	882.1	878.9	876.2	874.7	871.3	868.0	864.9	856.1	849.7	825.4
Wheat straw	21.6	156.8	297.3	394.6	473.0	567.6	643.3	689.3	786.6	883.9	973.1	1229.9	1413.7	2121.9
Red clover hay	2.4	9.2	16.3	21.2	25.2	......	......	......	......	......	......	......	......	......
Alfalfa hay	16.3	11.6	6.7	3.2	0.5	......	......	......	......	......	......	......	......	......
Red clover hay	1.1	7.9	15.0	19.9	23.8	......	......	......	......	......	......	......	......	......
Soy-bean or cow-pea hay	16.0	11.3	6.5	3.2	0.5	......	......	......	......	......	......	......	......	......
Red clover hay	......	......	......	......	......	31.3	27.5	25.2	20.3	15.4	10.9	......	......	......
Turnips	......	......	......	......	......	37.1	71.6	92.6	137.1	181.5	222.3	......	......	......

Red clover hay Sugar-beet pulp, fresh	....	....	....	....	....	72.1 47.6	68.3 92.0	66.0 119.0	61.1 176.2	56.2 233.3	51.7 285.7	38.8 436.4	29.5 544.3	....
Red clover hay Corn-fodder, green	....	....	....	....	....	77.5 27.3	73.7 52.7	71.4 68.2	66.5 100.9	61.6 133.6	57.1 163.6	44.2 250.0	35.0 311.8	....
Red clover hay Potatoes	....	....	....	....	....	83.0 22.1	79.2 42.6	76.8 55.1	71.9 81.6	67.0 108.0	62.6 132.3	49.6 202.1	40.4 252.1	4.8 444.7
Red clover hay Hungarian hay	....	....	....	....	....	84.3 6.7	80.5 12.9	78.2 16.7	73.3 24.6	68.4 32.6	63.9 40.0	51.0 61.1	41.8 76.1	6.1 134.3
Red clover hay Corn silage	....	....	....	....	....	104.7 24.8	100.9 47.9	98.6 62.0	93.7 91.7	88.8 121.4	84.3 148.7	71.4 227.2	62.2 283.3	26.5 499.7
Red clover hay Corn-fodder, field cured	....	....	....	....	....	121.0 12.8	117.2 24.8	114.9 32.0	110.0 47.4	105.1 62.8	100.6 76.9	87.7 117.4	78.5 146.5	42.8 258.3
Red clover hay Timothy hay	....	....	....	....	....	138.7 10.4	134.9 20.1	132.6 26.0	127.7 38.4	122.8 50.9	118.3 62.3	105.4 95.2	96.2 118.7	60.5 209.3
Red clover hay Kafir-corn fodder, green	....	....	....	....	....	149.6 34.5	145.8 66.6	143.5 86.2	138.6 127.5	133.7 168.9	129.2 206.8	116.3 316.0	107.0 394.1	71.4 695.1
Red clover hay Corn-stover	....	....	....	....	....	155.0 15.2	151.2 29.3	148.9 37.9	144.0 56.1	139.1 74.2	134.6 90.9	121.7 138.9	112.5 173.2	76.8 305.5
Red clover hay Soy-bean straw	....	....	....	....	....	168.6 13.1	164.8 25.2	162.5 32.6	157.6 48.3	152.7 63.9	148.2 78.3	135.3 119.6	126.1 149.2	90.4 263.2
Red clover hay Sorghum fodder, dry	....	....	....	....	....	216.2 11.6	212.4 22.3	210.1 28.9	205.2 42.7	200.3 56.6	195.8 69.3	182.9 105.9	173.7 132.1	138.0 232.9
Red clover hay Sorghum fodder, green	....	....	....	....	....	217.6 50.0	213.8 96.7	211.5 125.0	206.6 185.0	201.7 245.0	197.2 300.1	184.3 458.4	175.0 571.7	139.4 1008.5
Red clover hay Kafir-corn stover, field cured	....	....	....	....	....	244.8 16.5	241.0 31.9	238.7 41.3	233.8 61.1	228.9 80.9	224.4 99.0	211.5 151.3	202.2 188.7	166.6 332.8
Red clover hay Sorghum silage	....	....	....	....	....	266.6 50.0	262.8 96.7	260.4 125.0	255.5 185.0	250.6 245.0	246.2 300.1	233.2 458.4	224.0 571.8	188.4 1008.5
Red clover hay Oat straw	....	....	....	....	....	375.4 25.0	371.6 48.3	369.2 62.5	364.3 92.5	359.4 122.5	355.0 149.9	342.0 229.1	332.8 285.7	297.2 504.0
Red clover hay Cottonseed hulls	....	....	....	....	....	390.3 28.6	386.5 55.2	384.2 71.4	379.3 105.7	374.4 140.0	370.0 171.4	357.0 261.8	347.8 326.5	312.1 576.0
Red clover hay Prairie hay (K)	....	....	....	....	....	1063.5 49.2	1059.7 95.1	1057.4 122.9	1052.5 181.9	1047.6 240.9	1043.1 295.0	1030.2 450.7	1021.0 562.2	985.3 991.6

Table IV—*Continued.*

Feeds Balanced.	Nutritive Ratio, 1: (—)													
	3.98	4.48	5.00	5.36	5.65	6.00	6.28	6.45	6.81	7.17	7.50	8.45	9.13	11.75
Red clover hay	......	......	......	......	......	1285.2	1281.4	1279.1	1274.2	1269.3	1264.8	1251.9	1242.6	1207.0
Wheat straw	......	......	......	......	......	81.1	156.8	202.7	300.0	397 3	486.5	743.3	927.1	1635.3
Cottonseed-meal	0.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	23.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Cottonseed-meal	2.2	0.9	......	......	......	......	......	......	......	......	......	......	......	......
Wheat shorts	22.8	26.9	......	......	......	......	......	......	......	......	......	......	......	......
Cottonseed-meal	6.0	4.6	3.2	2.3	1.5	0.5	......	......	......	......	......	......	......	......
Oats	30.0	35.4	41.0	44.9	48.1	51.8	......	......	......	......	......	......	......	......
Cottonseed-meal	7.3	6.0	4.6	3.6	2.8	1.9	1.1	0.7	......	......	......	......	......	......
Cottonseed	25.0	29.5	34.2	37.4	40.1	43.2	45.7	47.3	......	......	......	......	......	......
Cottonseed-meal	8.4	7.1	5.7	4.7	3.9	3.0	2.2	1.8	0.8	......	......	......	......	......
Wheat	27.2	32.1	37.2	40.8	43.6	47.0	49.8	51.5	55.0	......	......	......	......	......
Cottonseed-meal	10.6	9.2	7.8	6.9	6.1	5.1	4.4	3.9	2.9	2.0	1.1	......	......	......
Barley	32.0	37.7	43.7	47.8	51.2	55.2	58.4	60.4	64.5	68.7	72.5	......	......	......
Cottonseed-meal	10.9	9.5	8.1	7.1	6.4	5.4	4.6	4.2	3.2	2.2	1.4	......	......	......
Rye	30.6	36.1	41.8	45.8	49.0	52.8	55.9	57.8	61.7	65.7	69.3	......	......	......
Cottonseed-meal	14.4	13.0	11.6	10.6	9.9	8.9	8.2	7.7	6.7	5.8	4.9	2.3	0.5	......
Whey	496.5	585.8	678.7	743.0	794.8	857.3	907.3	937.7	1002.0	1066.2	1125.2	1294.9	1416.3	......
Cottonseed-meal	15.7	14.4	13.0	12.0	11.2	10.3	9.5	9.0	8.1	7.1	6.2	3.7	1.8	......
Kafir-corn	48.1	56.7	65.7	72.0	77.0	83.0	87.9	90.8	97.1	103.3	109.0	125.4	137.2	......
Cottonseed-meal	18.4	17.1	15.7	14.7	13.9	13.0	12.2	11.8	10.8	9.8	8.9	6.4	4.4	......
Corn	38.9	45.9	53.2	58.2	62.3	67.2	71.1	73.5	78.5	83.6	88.2	101.5	111.0	......
Oil-meal, O. P.	0.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	20.6	......	......	......	......	......	......	......	......	......	......	......	......	......
Oil-meal, O. P.	2.7	1.1	......	......	......	......	......	......	......	......	......	......	......	......
Wheat shorts	20.3	24.4	......	......	......	......	......	......	......	......	......	......	......	......
Oil-meal, O. P.	7.3	5.7	4.0	2.8	1.8	0.7	......	......	......	......	......	......	......	......
Oats	26.8	32.2	37.8	41.7	44.8	48.6	......	......	......	......	......	......	......	......

Oil-meal, O. P.	9.0	7.3	5.6	4.4	3.5	2.3	1.4	0.8	......	......	......	......	......	......
Cottonseed-meal	22.3	26.8	31.5	34.7	37.4	40.5	43.0	44.6	......	......	......	......	......	......
Oil-meal, O. P.	10.8	8.6	6.9	5.7	4.8	3.6	2.7	2.1	1.0	......	......	......	......	......
Wheat	24.3	29.2	34.3	37.8	40.7	44.1	46.8	48.5	52.0	......	......	......	......	......
Oil-meal, O. P.	12.9	11.3	9.6	8.4	7.4	6.3	5.3	4.8	3.6	2.4	1.3	......	......	......
Barley	28.5	34.3	40.3	44.4	47.7	51.8	55.0	56.9	61.1	65.2	69.0	......	......	......
Oil-meal, O. P.	13.3	11.6	9.9	8.7	7.8	6.6	5.7	5.1	3.9	2.7	1.7	......	......	......
Rye	27.3	32.8	38.5	42.5	45.7	49.5	52.6	54.5	58.4	62.4	66.0	......	......	......
Oil-meal, O. P.	17.6	15.9	14.2	13.0	12.0	10.9	10.0	9.4	8.2	7.0	5.9	2.8	0.6	......
Whey	442.9	532.2	625.1	689.4	741.2	803.7	853.7	884.1	948.4	1012.7	1071.6	1241.3	1362.7	......
Oil-meal, O. P.	19.2	17.6	15.8	14.7	13.7	12.5	11.6	11.1	9.9	8.7	7.6	4.5	2.2	......
Kafir-corn	42.9	51.6	60.6	66.8	71.8	77.9	82.7	85.6	91.9	98.1	103.8	120.2	132.0	......
Oil-meal, O. P.	22.5	20.9	19.1	18.0	17.0	15.8	14.9	14.4	13.2	12.0	10.9	7.8	5.5	......
Corn	34.7	41.7	49.0	54.0	58.1	63.0	66.9	69.3	74.3	79.4	84.0	97.3	106.8	......
Wheat bran	23.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Cottonseed-meal	0.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	20.6	......	......	......	......	......	......	......	......	......	......	......	......	......
Gluten-meal	0.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	20.6	......	......	......	......	......	......	......	......	......	......	......	......	......
Oil-meal, O. P.	0.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	18.9	......	......	......	......	......	......	......	......	......	......	......	......	......
Oil-meal, N. P.	0.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	17.3	......	......	......	......	......	......	......	......	......	......	......	......	......
Skim-milk, separator	0.7	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	15.6	......	......	......	......	......	......	......	......	......	......	......	......	......
Buttermilk	0.7	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	15.6	......	......	......	......	......	......	......	......	......	......	......	......	......
Soy-bean meal	0.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	6.5	......	......	......	......	......	......	......	......	......	......	......	......	......
Pea-meal	0.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	5.6	......	......	......	......	......	......	......	......	......	......	......	......	......
Gluten feed	0.1	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	0.7	......	......	......	......	......	......	......	......	......	......	......	......	......
Whole milk	0.6	......	......	......	......	......	......	......	......	......	......	......	......	......

Table IV — *Continued.*

Feeds Balanced.	Nutritive Ratio, 1: (—)													
	3.98	4.48	5.00	5.36	5.65	6.00	6.28	6.45	6.81	7.17	7.50	8.45	9.13	11.75
Wheat bran	......	2.7	......	......	......	......	......	......	......	......	......	......	......	......
Wheat shorts	......	3.9	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	......	14.3	10.0	7.0	4.6	1.7	......	......	......	......	......	......	......	......
Oats	......	5.2	10.8	14.7	17.8	21.6	......	......	......	......	......	......	......	......
Wheat bran	......	18.4	14.1	11.1	8.7	5.8	3.5	2.1	......	......	......	......	......	......
Cottonseed	......	4.3	9.0	12.2	14.9	18.0	20.5	22.1	......	......	......	......	......	......
Wheat bran	......	21.7	17.4	14.4	12.0	9.1	6.8	5.4	2.4	......	......	......	......	......
Wheat	......	4.7	9.8	13.3	16.2	19.6	22.3	24.0	27.5	......	......	......	......	......
Wheat bran	......	28.4	24.1	21.1	18.7	15.8	13.5	12.0	9.1	6.1	3.3	......	......	......
Barley	......	5.5	11.5	15.6	19.0	23.0	26.2	28.2	32.3	36.5	40.3	......	......	......
Wheat bran	......	29.2	24.9	21.9	19.5	16.6	14.3	12.9	9.9	6.9	4.2	......	......	......
Rye	......	5.3	11.0	15.0	18.2	22.0	25.1	27.0	30.9	34.9	38.5	......	......	......
Wheat bran	......	40.0	35.7	32.7	30.3	27.4	25.1	23.7	20.7	17.7	14.9	7.1	1.4	......
Whey	......	85.7	178.6	242.9	294.7	357.2	407.2	437.6	501.9	566.2	625.1	794.8	916.2	......
Wheat bran	......	44.2	39.8	36.9	34.4	31.5	29.2	27.8	24.8	21.8	19.1	11.2	5.6	......
Kafir-corn	......	8.3	17.3	23.5	28.5	34.6	39.4	42.4	48.6	54.8	60.6	77.0	88.7	......
Wheat bran	......	52.5	48.1	45.2	42.7	39.8	37.5	36.1	33.1	30.1	27.4	19.5	13.9	......
Corn	......	6.7	14.0	19.0	23.1	28.0	31.9	34.3	39.3	44.4	49.0	62.3	71.8	......
Kafir-corn	48.1	56.7	65.7	72.0	77.0	83.0	87.9	90.8	97.1	103.3	109.0	125.4	137.2	......
Cottonseed-meal	15.7	14.4	13.0	12.0	11.2	10.3	9.5	9.0	8.1	7.1	6.2	3.6	1.8	......
Kafir-corn	42.9	51.6	60.6	66.8	71.8	77.9	82.7	85.6	91.9	98.1	103.8	120.2	132.0	......
Gluten-meal	17.5	16.0	14.4	13.3	12.5	11.4	10.6	10.1	9.0	7.9	6.9	4.1	2.0	......
Kafir-corn	42.9	51.6	60.6	66.8	71.8	77.9	82.7	85.6	91.9	98.1	103.8	120.2	132.0	......
Oil-meal, O. P.	19.2	17.6	15.8	14.7	13.7	12.5	11.6	11.1	9.9	8.7	7.6	4.5	2.2	......
Kafir-corn	39.4	48.1	57.1	63.3	68.3	74.4	79.2	82.2	88.4	94.6	100.3	116.8	128.5	......
Oil-meal, N. P.	20.4	18.6	16.8	15.5	14.5	13.3	12.3	11.7	10.5	9.2	8.1	4.7	2.3	......
Kafir-corn	36.0	44.6	53.6	59.9	64.9	70.9	75.8	78.7	84.9	91.2	96.9	113.3	125.1	......
Skim-milk, separator	193.2	176.6	159.4	147.4	137.8	126.2	116.9	111.2	99.3	87.3	76.4	44.8	22.2	......

Kafir-corn	32.5	41.2	50.2	56.4	61.4	67.5	72.3	75.3	81.5	87.7	93.4	109.9	121.6	....
Buttermilk	206.6	188.9	170.4	157.6	147.3	134.9	125.0	118.9	106.1	93.4	81.7	47.9	23.8	....
Kafir-corn	32.5	41.2	50.2	56.4	61.4	67.5	72.3	75.3	81.5	87.7	93.4	109.9	121.6	....
Soy-bean meal	16.3	14.9	13.4	12.4	11.6	10.6	9.9	9.4	8.4	7.4	6.4	3.8	1.9	....
Kafir-corn	13.5	22.1	31.1	37.4	42.4	48.4	53.3	56.2	62.5	68.7	74.4	90.8	102.6	....
Pea-meal	34.9	31.9	28.8	26.6	24.9	22.8	21.1	20.1	17.9	15.8	13.8	8.1	4.0	....
Kafir-corn	11.8	20.4	29.4	35.6	40.7	46.7	51.6	54.5	60.7	67.0	72.7	89.1	100.9	....
Gluten feed	29.1	26.6	24.0	22.2	20.8	19.0	17.6	16.8	15.0	13.2	11.5	6.8	3.4	....
Kafir-corn	1.4	10.0	19.0	25.3	30.3	36.3	41.2	44.1	50.3	56.6	62.3	78.7	90.5	....
Whole milk	172.3	157.5	142.1	131.4	122.8	112.5	104.2	99.2	88.5	77.8	68.1	40.0	19.8	....
Kafir-corn	....	8.3	17.3	23.5	28.5	34.6	39.4	42.4	48.6	54.8	60.6	77.0	88.7	....
Wheat bran	....	44.2	39.8	36.9	34.4	31.5	29.2	27.8	24.8	21.8	19.1	11.2	5.6	....
Kafir-corn	....	....	3.5	9.7	14.7	20.8	25.6	28.5	34.8	41.0	46.7	63.1	74.9	....
Wheat shorts	....	....	39.4	36.4	34.0	31.2	28.9	27.5	24.5	21.6	18.9	11.1	5.5	....
Kafir-corn	....	....	....	....	....	....	1.4	4.3	10.6	16.8	22.5	38.9	50.7	....
Oats	....	....	....	....	....	....	38.0	36.2	32.3	28.4	24.8	14.6	7.2	....
Kafir-corn	....	....	....	....	....	....	....	....	1.9	8.1	13.8	30.3	42.0	....
Cottonseed	....	....	....	....	....	....	....	....	26.9	23.7	20.7	12.2	6.0	....
Kafir-corn	....	....	....	....	....	....	....	....	....	1.2	6.9	23.4	25.1	....
Wheat	....	....	....	....	....	....	....	....	....	25.8	22.5	13.2	6.6	....
Kafir-corn	....	....	....	....	....	....	....	....	....	....	....	9.5	21.3	....
Barley	....	....	....	....	....	....	....	....	....	....	....	15.5	7.7	....
Kafir-corn	....	....	....	....	....	....	....	....	....	....	....	7.8	19.5	....
Rye	....	....	....	....	....	....	....	....	....	....	....	14.9	7.4	....
Corn	38.9	45.9	53.2	58.2	62.3	67.2	71.1	73.5	78.5	83.6	88.2	101.5	111.0	....
Cottonseed-meal	18.4	17.1	15.7	14.7	13.9	13.0	12.2	11.7	10.8	9.8	8.9	6.3	4.5	....
Corn	34.7	41.7	49.0	54.0	58.1	63.0	66.9	69.3	74.3	79.4	84.0	97.3	106.8	....
Gluten-meal	20.5	19.0	17.4	16.3	15.5	14.4	13.6	13.1	12.0	10.9	9.9	7.1	5.0	....
Corn	34.7	41.7	49.0	54.0	58.1	63.0	66.9	69.3	74.3	79.4	84.0	97.3	106.8	....
Oil-meal, O. P.	22.5	20.9	19.1	18.0	17.0	15.8	14.9	14.4	13.2	12.0	10.9	7.8	5.5	....
Corn	31.9	38.9	46.2	51.2	55.3	60.2	64.1	66.5	71.5	76.6	81.2	94.5	104.0	....
Oil-meal, N. P.	23.9	22.1	20.3	19.0	18.0	16.8	15.8	15.2	14.0	12.7	11.6	8.2	5.8	....

Table IV—*Continued.*

Feeds Balanced.	Nutritive Ratio, 1: (—)													
	3.98	4.48	5.00	5.36	5.65	6.00	6.28	6.45	6.81	7.17	7.50	8.45	9.13	11.75
Corn	29.1	36.1	43.4	48.4	52.5	57.4	61.3	63.7	68.7	73.8	78.4	91.7	101.2	....
Skim-milk, separator	226.4	209.8	192.6	180.6	171.0	159.4	150.1	144.4	132.5	120.5	109.6	78.0	55.4	....
Corn	26.3	33.3	40.6	45.6	49.7	54.6	58.5	60.9	65.9	71.0	75.6	88.9	98.4	....
Buttermilk	242.1	224.4	205.9	193.1	182.8	170.4	160.5	154.4	141.7	128.9	117.2	83.4	59.3	....
Corn	26.3	33.3	40.6	45.6	49.7	54.6	58.5	60.9	65.9	71.0	75.6	88.9	98.4	....
Soy-bean meal	19.1	17.7	16.2	15.2	14.4	13.4	12.7	12.2	11.2	10.2	9.2	6.6	4.7	....
Corn	10.9	17.9	25.2	30.2	34.3	39.2	43.1	45.5	50.5	55.6	60.2	73.5	83.0	....
Pea-meal	40.9	37.9	34.8	32.6	30.9	28.8	27.1	26.1	23.9	21.8	19.8	14.1	10.0	....
Corn	9.5	16.5	23.8	28.8	32.9	37.8	41.7	44.1	49.1	54.2	58.8	72.1	81.6	....
Gluten feed	34.1	31.6	29.0	27.2	25.8	24.0	22.6	21.8	20.0	18.2	16.5	11.8	8.4	....
Corn	1.1	8.1	15.4	20.4	24.5	29.4	33.3	35.7	40.7	45.8	50.4	63.7	73.2	....
Whole milk	201.9	187.1	171.7	161.0	152.4	142.1	133.8	128.8	118.1	107.4	97.7	69.6	49.4	....
Corn	....	6.7	14.0	19.0	23.1	28.0	31.9	34.3	39.3	44.4	49.0	62.3	71.8	....
Wheat bran	....	52.5	48.1	45.2	42.7	39.8	37.5	36.1	33.1	30.1	27.4	19.5	13.9	....
Corn	....	....	2.8	7.8	11.9	16.8	20.7	23.1	28.1	33.2	37.8	51.1	60.6	....
Wheat shorts	....	....	47.6	44.6	42.2	39.4	37.1	35.7	32.7	29.8	27.1	19.3	13.7	....
Corn	....	....	....	....	....	....	1.1	3.5	8.5	13.6	18.2	31.5	41.0	....
Oats	....	....	....	....	....	....	48.8	47.0	43.1	39.2	35.6	25.4	18.0	....
Corn	....	....	....	....	....	....	....	....	1.5	6.6	11.2	24.5	34.0	....
Cottonseed	....	....	....	....	....	....	....	....	35.9	32.7	29.7	21.2	15.0	....
Corn	....	....	....	....	....	....	....	....	....	1.0	5.6	18.9	28.4	....
Wheat	....	....	....	....	....	....	....	....	....	35.6	32.3	23.0	16.4	....
Corn	....	....	....	....	....	....	....	....	....	....	....	7.7	17.2	....
Barley	....	....	....	....	....	....	....	....	....	....	....	27.0	19.2	....
Corn	....	....	....	....	....	....	....	....	....	....	....	6.3	15.8	....
Rye	....	....	....	....	....	....	....	....	....	....	....	25.9	18.4	....

Cottonseed-meal	4.6	3.3	1.9	0.9	0.1	....	....	....	....	....	....	....	....	....
Red clover hay	37.8	44.6	51.7	56.6	60.5	....	....	....	....	....	....	....	....	....
Cottonseed-meal	4.6	3.3	1.9	0.9	0.1	....	....	....	....	....	....	....	....	....
Mangels	269.9	318.5	369.0	403.9	432.1	....	....	....	....	....	....	....	....	....
Cottonseed-meal	11.7	10.3	8.9	7.9	7.2	6.2	5.5	5.0	4.0	3.1	2.2	....	....	....
Turnips	343.3	405.1	469.3	513.8	549.6	592.8	627.4	648.4	692.8	737.3	778.1	....	....	....
Cottonseed-meal	19.8	18.4	17.0	16.0	15.3	14.3	13.6	13.1	12.1	11.2	10.3	7.7	5.9	....
Sugar-beet pulp, fresh	441.2	520.5	603.1	660.2	706.2	761.8	806.2	833.2	890.3	947.4	999.8	1150.6	1258.5	....
Cottonseed-meal	21.9	20.6	19.2	18.2	17.4	16.5	15.7	15.3	14.3	13.3	12.4	9.9	8.0	1.0
Potatoes	204.3	241.1	279.3	305.8	327.1	352.8	373.4	385.9	412.3	438.8	463.1	532.9	582.9	775.4
Cottonseed-meal	22.2	20.8	19.4	18.5	17.7	16.7	16.0	15.5	14.6	13.6	12.7	10.1	8.3	1.2
Hungarian hay	61.7	72.8	84.4	92.4	98.8	106.6	112.8	116.6	124.5	132.5	139.9	161.0	176.0	234.2
Cottonseed-meal	26.2	24.9	23.5	22.5	21.7	20.8	20.0	19.6	18.6	17.6	16.7	14.2	12.3	5.3
Corn silage	229.6	270.9	313.9	343.6	367.6	396.5	419.6	433.7	463.4	493.1	520.4	598.9	655.0	871.4
Cottonseed-meal	29.5	28.1	26.7	25.8	25.0	24.0	23.3	22.8	21.8	20.9	20.0	17.4	15.6	8.5
Corn-fodder	118.7	140.1	162.3	177.6	190.0	205.0	216.9	224.2	239.6	254.9	269.0	309.6	338.6	450.5
Cottonseed-meal	33.0	31.6	30.2	29.3	28.5	27.5	26.8	26.3	25.4	24.4	23.5	20.9	19.1	12.0
Timothy hay	96.2	113.5	131.5	143.9	154.0	166.1	175.8	181.7	194.1	206.6	218.0	250.9	274.4	365.0
Cottonseed-meal	36.2	34.9	33.5	32.5	31.7	30.8	30.0	29.6	28.6	27.6	26.7	24.2	22.3	15.3
Corn-stover	140.4	165.6	191.9	210.1	224.7	242.4	256.5	265.1	283.4	301.5	318.2	366.1	400.5	532.8
Cottonseed-meal	38.9	37.6	36.2	35.2	34.4	33.5	32.7	32.3	31.3	30.3	29.4	26.9	25.0	18.0
Soy-bean straw	120.9	142.7	165.3	181.0	193.6	208.8	221.0	228.4	244.0	259.7	274.1	315.4	345.0	458.9
Cottonseed-meal	48.4	47.0	45.6	44.7	43.9	42.9	42.2	41.7	40.7	39.8	38.9	36.3	34.5	27.4
Sorghum fodder, dry	107.0	126.3	146.3	160.2	171.3	184.8	195.6	202.1	216.0	229.8	242.6	279.1	305.3	406.2
Cottonseed-meal	54.1	52.7	51.3	50.3	49.5	48.6	47.8	47.4	46.4	45.4	44.6	42.0	40.1	33.1
Kafir-corn stover	152.9	180.4	209.0	228.8	244.8	264.0	279.4	288.8	308.6	328.4	346.5	398.8	436.2	580.3
Cottonseed-meal	58.4	57.0	55.6	54.6	53.9	52.9	52.2	51.7	50.7	49.8	48.9	46.3	44.5	37.4
Sorghum silage	463.4	546.8	633.5	693.5	741.8	800.2	846.8	875.2	935.2	995.2	1050.2	1208.6	1321.9	1758.7
Cottonseed-meal	80.0	78.6	77.2	76.2	75.5	74.5	73.8	73.3	72.3	71.4	70.5	67.9	66.1	59.0
Oat straw	231.6	273.2	316.5	346.5	370.7	399.8	423.2	437.3	467.3	497.3	524.8	603.9	660.6	878.8
Cottonseed-meal	82.9	81.6	80.2	79.2	78.4	77.5	76.7	76.3	75.3	74.3	73.4	70.9	69.0	62.0
Cottonseed hulls	264.7	312.3	361.8	396.0	423.6	457.0	483.6	499.9	534.1	568.3	599.8	690.2	754.9	1004.4
Cottonseed-meal	216.6	215.2	213.8	212.9	212.1	211.1	210.4	209.9	209.0	208.0	207.1	204.5	202.7	195.6
Prairie hay (K)	455.6	537.6	622.8	681.8	729.4	786.7	832.6	860.5	919.5	978.5	1032.6	1188.3	1299.7	1729.2

Table IV—*Continued.*

Feeds Balanced.	Nutritive Ratio, 1: (—)													
	3.98	**4.48**	**5.00**	**5.36**	**5.65**	**6.00**	**6.28**	**6.45**	**6.81**	**7.17**	**7.50**	**8.45**	**9.13**	**11.75**
Cottonseed-meal	260.6	259.3	257.9	256.9	256.1	255.1	254.4	253.9	253.0	252.0	251.1	248.5	246.7	239.6
Wheat straw	751.4	886.6	1027.1	1124.4	1202.8	1297.4	1373.1	1419.1	1516.4	1613.7	1702.9	1959.7	2143.5	2851.7
Oil-meal, O. P.	5.7	4.0	2.3	1.1	0.2	....	....	....	....	....	....	....	....	....
Red clover hay	33.7	40.5	47.6	52.5	56.4	....	....	....	....	....	....	....	....	....
Oil-meal, O. P.	5.7	4.0	2.3	1.1	0.2	....	....	....	....	....	....	....	....	....
Mangels	240.8	289.4	339.9	374.8	403.0	....	....	....	....	....	....	....	....	....
Oil-meal, O. P.	14.3	12.6	10.9	9.7	8.7	7.6	6.7	6.1	4.9	3.7	2.6	....	....	....
Turnips	306.3	368.0	432.3	476.7	512.5	555.8	590.3	611.3	655.8	700.2	741.0	....	....	....
Oil-meal, O. P.	24.2	22.5	20.8	19.6	18.6	17.5	16.6	16.0	14.8	13.6	12.5	9.4	7.2	....
Sugar-beet pulp, fresh	393.6	472.9	555.5	612.6	658.6	714.2	758.6	785.6	842.7	899.8	952.2	1103.0	1210.9	....
Oil-meal, O. P.	26.8	25.1	23.4	22.2	21.3	20.1	19.2	18.6	17.5	16.3	15.2	12.0	9.8	1.2
Potatoes	182.3	219.0	257.3	283.7	305.0	330.8	351.3	363.8	390.3	416.7	441.0	510.8	560.8	753.4
Oil-meal, O. P.	27.1	25.5	23.8	22.6	21.6	20.5	19.5	19.0	17.8	16.6	15.5	12.4	10.1	1.5
Hungarian hay	55.1	66.2	77.7	85.7	92.1	99.9	106.1	109.9	117.9	125.9	133.2	154.3	169.4	227.6
Oil-meal, O. P.	32.1	30.4	28.7	27.5	26.6	25.4	24.5	23.9	22.7	21.5	20.5	17.3	15.1	6.4
Corn silage	204.8	246.1	289.1	318.8	342.8	371.7	394.8	408.9	438.6	468.3	495.6	574.1	630.2	846.7
Oil-meal, O. P.	36.0	34.4	32.7	31.5	30.5	29.4	28.4	27.9	26.7	25.5	24.4	21.3	19.0	10.4
Corn-fodder	105.9	127.2	149.5	164.8	177.2	192.2	204.1	211.4	226.7	242.1	256.2	296.8	325.8	437.7
Oil-meal, O. P.	40.3	38.7	37.0	35.8	34.8	33.7	32.7	32.2	31.0	29.8	28.7	25.6	23.3	14.7
Timothy hay	85.8	103.1	121.1	133.6	143.6	155.7	165.4	171.3	183.7	196.2	207.6	240.5	264.0	354.7
Oil-meal, O. P.	44.3	42.6	40.9	39.7	38.8	37.6	36.7	36.1	34.9	33.8	32.7	29.5	27.3	18.6
Corn-stover	125.2	150.5	176.8	194.9	209.6	227.3	241.4	250.0	268.2	286.3	303.0	351.0	385.3	517.6
Oil-meal, O. P.	47.6	45.9	44.2	43.0	42.1	40.9	40.0	39.4	38.2	37.1	36.0	32.8	30.6	21.9
Soy-bean straw	107.9	129.6	152.3	167.9	180.5	195.8	207.9	215.3	231.0	246.6	261.0	302.3	331.9	445.9
Oil-meal, O. P.	59.1	57.5	55.8	54.6	53.6	52.5	51.5	51.0	49.8	48.6	47.5	44.4	42.1	33.5
Sorghum fodder, dry	95.5	114.7	134.8	148.6	159.8	173.3	184.0	190.6	204.4	218.3	231.0	267.6	293.8	394.6
Oil-meal, O. P.	66.1	64.4	62.7	61.5	60.6	59.4	58.5	57.9	56.7	55.5	54.5	51.3	49.1	40.4
Kafir-corn stover	136.4	163.9	192.5	212.3	228.3	247.5	262.9	272.3	292.1	311.9	330.0	382.3	419.7	563.8

Oil-meal, O. P.	71.3	69.7	68.0	66.8	65.8	64.7	63.8	63.2	62.0	60.8	59.7	56.6	54.4	45.7
Sorghum silage	413.4	496.8	583.5	643.5	691.8	750.2	796.8	825.2	885.2	945.2	1000.2	1158.6	1271.9	1708.7
Oil-meal, O. P	97.7	96.1	94.4	93.2	92.2	91.1	90.2	89.6	88.4	87.2	86.1	83.0	80.8	72.1
Oat straw	206.6	248.2	291.6	321.5	345.7	374.9	398.2	412.3	442.3	472.3	499.8	578.9	635.6	853.8
Oil-meal, O. P	101.4	99.7	98.0	96.8	95.9	94.7	93.8	93.2	92.0	90.8	89.8	86.6	84.4	75.7
Cottonseed hulls	236.1	283.7	333.2	367.5	395.1	428.4	455.1	471.2	505.5	539.8	571.2	661.6	726.4	975.8
Oil-meal, O. P	264.7	263.1	261.4	260.2	259.2	258.1	257.1	256.6	255.4	254.2	253.1	250.0	247.7	239.1
Prairie hay (K)	406.5	488.4	573.7	632.7	680.2	737.6	783.4	811.3	870.3	929.3	983.4	1139.1	1250.6	1680.0
Oil-meal, O. P.	318.5	316.9	315.2	314.0	313.0	311.9	310.9	310.4	309.2	308.0	306.9	303.8	301.5	292.9
Wheat straw	670.3	805.5	946.1	1043.4	1121.7	1216.4	1292.0	1338.0	1435.3	1532.6	1621.8	1878.6	2062.4	2770.6
Wheat bran	7.3	......	......	......	......	......	......	......	......	......	......	......	......	......
Alfalfa, green	0.5	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	1.5	......	......	......	......	......	......	......	......	......	......	......	......	......
Alfalfa hay	0.2	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	0.7	......	......	......	......	......	......	......	......	......	......	......	......	......
Soy-bean or cow-pea hay	0.2	......	......	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	......	6.8	2.5	......	......	......	......	......	......	......	......	......	......	......
Red clover, green	......	15.6	32.6	......	......	......	......	......	......	......	......	......	......	......
Wheat bran	......	10.1	5.8	2.8	0.4	......	......	......	......	......	......	......	......	......
Red clover hay	......	6.5	13.6	18.5	22.4	......	......	......	......	......	......	......	......	......
Wheat bran	......	10.1	5.8	2.8	0.4	......	......	......	......	......	......	......	......	......
Mangels	......	46.6	97.1	132.1	160.2	......	......	......	......	......	......	......	......	......
Wheat bran	......	31.7	27.4	24.4	22.0	19.1	16.8	15.4	12.4	9.4	6.6	......	......	......
Turnips	......	59.3	123.5	168.0	203.8	247.0	281.6	302.6	347.0	391.5	432.3	......	......	......
Wheat bran	......	56.6	52.3	49.3	46.9	44.0	41.7	40.3	37.3	34.3	31.5	23.7	18.0	......
Sugar-beet pulp, fresh	......	76.2	158.7	215.8	261.9	317.4	361.8	388.8	445.9	503.1	555.5	706.2	814.1	......
Wheat bran	......	59.9	55.6	52.6	50.2	47.3	45.0	43.6	40.6	37.6	34.9	27.0	21.3	......
Corn-fodder, green	......	43.6	90.9	123.6	150.0	181.8	207.3	222.7	255.4	288.2	318.2	404.5	466.3	......
Wheat bran	......	63.2	58.9	55.9	53.5	50.6	48.3	46.9	43.9	40.9	38.2	30.3	24.7	2.9
Potatoes	......	35.3	73.5	100.0	121.3	147.0	167.6	180.1	206.5	233.0	257.3	327.1	377.1	569.6
Wheat bran	......	64.1	59.8	56.8	54.4	51.5	49.1	47.7	44.7	41.7	39.0	31.1	25.5	3.7
Hungarian hay	......	10.7	22.2	30.2	36.6	44.4	50.6	54.5	62.4	70.4	77.7	98.8	113.9	172.1
Wheat bran	......	76.5	72.2	69.2	66.8	63.9	61.6	60.2	57.2	54.2	51.5	43.6	37.9	16.2
Corn silage	......	39.6	82.6	112.3	136.3	165.2	188.3	202.4	232.1	261.8	289.1	367.6	423.7	640.2

Table IV—*Continued.*

Feeds Balanced.	Nutritive Ratio, 1: (—)													
	3.98	4.48	5.00	5.36	5.65	6.00	6.28	6.45	6.81	7.17	7.50	8.45	9.13	11.75
Wheat bran	....	86.5	82.2	79.2	76.8	73.9	71.5	70.1	67.1	64.2	61.4	53.5	47.9	26.1
Corn-fodder	....	20.5	42.7	58.1	70.5	85.4	97.4	104.6	120.0	135.4	149.5	190.0	219.1	330.9
Wheat bran	....	97.3	93.0	90.0	87.6	84.7	82.3	80.9	77.9	74.9	72.2	64.3	58.7	36.9
Timothy hay	....	16.6	34.6	47.1	57.1	69.2	78.9	84.8	97.2	109.7	121.1	154.0	177.5	268.2
Wheat bran	....	103.9	99.6	96.6	94.2	91.3	89.0	87.6	84.6	81.6	78.9	71.0	65.3	43.6
Kafir-corn fodder, green	....	55.2	114.9	156.3	189.6	229.8	262.0	281.5	322.9	364.2	402.2	511.3	589.4	890.5
Wheat bran	....	107.2	102.9	99.9	97.5	94.6	92.3	90.9	87.9	84.9	82.2	74.3	68.6	46.9
Corn-stover	....	24.2	50.5	68.7	83.3	101.0	115.1	123.7	141.9	160.1	176.8	224.7	259.1	391.4
Wheat bran	....	115.5	111.2	108.2	105.8	102.9	100.6	99.2	96.2	93.2	90.5	82.6	76.9	55.2
Soy-bean straw	....	20.9	43.5	59.2	71.8	87.0	99.2	106.6	122.2	137.9	152.3	193.6	223.2	337.1
Wheat bran	....	144.5	140.3	137.3	134.9	132.0	129.6	128.2	125.2	122.3	119.5	111.6	106.0	84.2
Sorghum fodder, dry	....	18.5	38.5	52.4	63.5	77.0	87.8	94.3	108.2	122.0	134 8	171.3	197.5	298.4
Wheat bran	....	145.4	141.1	138.1	135.7	132.8	130.5	129.1	126.1	123.1	120.4	112.5	106.8	85.1
Sorghum fodder, green	....	80.0	166.7	226.7	275.1	333.4	380.0	408.4	468.4	528.4	583.5	741.8	855.2	1291.9
Wheat bran	....	162.0	157.7	154.7	152.3	149.4	147.1	145.7	142.7	139.7	137.0	129.1	123.4	101.7
Kafir-corn stover	....	26.4	55.0	74.8	90.8	110.0	125.4	134.8	154.6	174.4	192.5	244.8	282.2	426.3
Wheat bran	....	175.3	171.0	168.0	165.6	162.7	160.4	158.9	156.0	153.0	150.2	142.3	136.7	115.0
Sorghum silage	....	80.0	166.7	226.7	275.1	333.4	380.0	408.4	468.4	528.4	583.5	741.8	855.2	1291.9
Wheat bran	....	241.7	237.4	234.4	232.0	229.1	226.8	225.3	222.4	219.4	216.6	208.7	203.1	181.4
Oat straw	....	40.0	83.3	113.3	137.4	166.6	189.9	204.1	234.1	264.1	291.6	370.7	427.3	645.6
Wheat bran	....	250.8	246.5	243.5	241.1	238.2	235.9	234.5	231.5	228.5	225.8	217.9	212.2	190.5
Cottonseed hulls	....	45.7	95.2	129.5	157.1	190.4	217.1	233.2	267.5	301.8	333.2	423.6	488.4	737.8
Wheat bran	....	661.7	657.4	654.4	652.0	649.1	646.7	645.3	642.3	639.3	636.6	628.7	623.1	601.3
Prairie hay (K)	....	78.7	163.9	222.9	270.4	327.8	373.7	401.6	460.6	519.6	573.7	729.4	840.8	1270.2
Wheat bran	....	797.0	792.7	789.7	787.3	784.4	782.0	780.6	777.6	774.6	771.9	764.0	758.4	736.6
Wheat straw	....	129.7	270.3	367.6	446.0	540.6	616.3	662.2	759.5	856.9	946.1	1202.8	1386.6	2094.8
Kafir-corn	3.1	11.8	20.8	27.0	32.0	38.1	42.9	45.8	52.1	58.3	64.0	80.4	92.2	....
Alfalfa hay	55.3	50.5	45.6	42.2	39.4	36.1	33.4	31.8	28.4	25.0	21.9	12.8	6.4	....

Kafir-corn Soy-bean or cow-pea hay	1.4 54.1	10.0 49.5	19.0 44.6	25.3 41.3	30.3 38.6	36.3 35.3	41.2 32.7	44.1 31.2	50.3 27.8	56.6 24.5	62.3 21.4	78.7 12.6	90.5 6.2	
Kafir-corn Red clover hay						5.2 51.7	10.0 47.9	13.0 45.6	19.2 40.7	25.4 35.8	31.1 31.3	47.6 18.4	59.3 9.1	
Kafir-corn Mangels						5.2 369.0	10.0 341.8	13.0 325.3	19.2 290.3	25.4 255.5	31.1 223.3	47.6 131.1	59.3 65.1	
Kafir-corn Turnips												2.6 166.7	14.4 82.7	
Kafir-corn Potatoes														6.1 143.3
Kafir-corn Hungarian hay														7.8 43.3
Kafir-corn Corn silage														33.7 161.1
Kafir-corn Corn-fodder														54.5 83.3
Kafir-corn Timothy hay														77.0 67.5
Kafir-corn Corn-stover														97.7 98.5
Kafir-corn Soy-bean straw														115.0 84.8
Kafir-corn Sorghum-fodder, dry														175.6 75.1
Kafir-corn Kafir-corn stover														211.9 107.3
Kafir-corn Sorghum silage														239.6 325.1
Kafir-corn Oat straw														378.0 162.4
Kafir-corn Cottonseed hulls														397.0 185.6
Kafir-corn Prairie hay (K)														1253.4 319.6

Table IV—*Concluded.*

Feeds Balanced.	Nutritive Ratio, 1 : (——)													
	3.98	4.48	5.00	5.36	5.65	6.00	6.28	6.45	6.81	7.17	7.50	8.45	9.13	11.75
Kafir-corn..	......	......	......	......	......	......	......	......	......	......	......	......	......	1535.4
Wheat straw.	......	......	......	......	......	......	......	......	......	......	......	......	......	527.1
Corn..	2.5	9.5	16.8	21.8	25.9	30.8	34.7	37.1	42.1	47.2	51.8	65.1	74.6	......
Alfalfa hay	64.8	60.0	55.1	51.7	48.9	45.6	42.9	41.3	37.9	34.5	31.4	22.3	15.9	......
Corn	1.1	8.1	15.4	20.4	24.5	29.4	33.3	35.7	40.7	45.8	50.4	63.7	73.2	......
Soy-bean or cow-pea hay	63.4	58.8	53.9	50.6	47.9	44.6	42.0	40.5	37.1	33.8	30.7	21.9	15.5	......
Corn..	......	......	......	......	......	4.2	8.1	10.5	15.5	20.6	25.2	38.5	48.0	......
Red clover hay	......	......	......	......	......	65.3	61.5	59.2	54.3	49.4	44.9	32.0	22.7	......
Corn..	......	......	......	......	......	4.2	8.1	10.5	15.5	20.6	25.2	38.5	48.0	......
Mangels.	......	......	......	......	......	466.1	438.9	422.4	387.4	352.5	320.4	228.2	162.2	......
Corn..	......	......	......	......	......	......	......	......	......	......	......	2.1	11.6	......
Turnips	......	......	......	......	......	......	......	......	......	......	......	290.2	206.2	......
Corn..	......	......	......	......	......	......	......	......	......	......	......	......	......	4.9
Potatoes.	......	......	......	......	......	......	......	......	......	......	......	......	......	69.8
Corn..	......	......	......	......	......	......	......	......	......	......	......	......	......	6.3
Hungarian hay	......	......	......	......	......	......	......	......	......	......	......	......	......	21.1
Corn..	......	......	......	......	......	......	......	......	......	......	......	......	......	27.3
Corn silage	......	......	......	......	......	......	......	......	......	......	......	......	......	78.5
Corn..	......	......	......	......	......	......	......	......	......	......	......	......	......	44.1
Corn-fodder.	......	......	......	......	......	......	......	......	......	......	......	......	......	40.6
Corn..	......	......	......	......	......	......	......	......	......	......	......	......	......	62.3
Timothy hay.	......	......	......	......	......	......	......	......	......	......	......	......	......	32.9
Corn..	......	......	......	......	......	......	......	......	......	......	......	......	......	79.1
Corn-stover	......	......	......	......	......	......	......	......	......	......	......	......	......	48.0
Corn..	......	......	......	......	......	......	......	......	......	......	......	......	......	93.1
Soy-bean straw	......	......	......	......	......	......	......	......	......	......	......	......	......	41.3
Corn..	......	......	......	......	......	......	......	......	......	......	......	......	......	142.1
Sorghum fodder, dry	......	......	......	......	......	......	......	......	......	......	......	......	......	36.6

Corn														171.5
Kafir-corn stover														52.3
Corn														193.9
Sorghum silage														158.4
Corn														305.9
Oat straw														79.1
Corn														321.3
Cottonseed hulls														90.4
Corn														1014.3
Prairie hay (K)														155.7
Corn														1242.5
Wheat straw														256.8

SUMMARY.

This bulletin, combating the statements of text-books and bulletins on computing rations, demonstrates that rations of any degree of complexity may be balanced with absolute exactness by simple arithmetical processes if feeds are available of the necessary composition. The greater the number of points in which it is desired that the ration shall meet a certain standard, the greater the number and variety of feeds that must be available. If efforts are limited to a mixing of feeds so as to produce a definite nutritive ratio, the necessary calculations for balancing two feeds can be made in ten minutes, using the data given in any table showing the percentage of digestible nutrients in the feeds.

To materially abridge the labor of balancing a ration and to bring the arithmetical process within easier reach of all, the nutritive ratio for each of a large number of the more common feeds has been calculated and included in tables showing the composition of feeds and rations. Another factor has also been calculated for each feed, which is called the protein-equating factor. This factor shows the number of pounds of a feed that must be taken to get one pound of protein. By using the nutritive ratios and protein-equating factors provided in the tables, a ration of two feeds can be balanced to any intermediate nutritive ratio in one and one-half minutes or less.

The bulletin maintains, and the method of calculation is based upon the fact, that, reduced to a final analysis, the balancing of a ration consists in balancing the feeds used in it two by two. In this pairing, any one of the feeds may be used more than once, and the several quantities of a feed so used are finally added together to obtain the total sum. Recognition of the compound nature of this sum is essential to an understanding of the theory of the balancing of rations.

After giving in detail the method of exactly balancing rations in respect to protein, fat, and carbohydrates, a simplified procedure is suggested as ample for practical requirements with ordinary feeds, in which the ration is balanced in respect to protein and non-protein merely.

Finally, a table of over 2100 balanced mixtures is given, showing the relative amounts of certain feeds to be used to at least approximate the nutritive ratios required by the feeding standards for the domestic animals. Figures are given for fourteen different ratios. The mixtures given may in many cases constitute a ration; in others, a ration may be compounded by using, in any proportion desired, any of the various mixtures having the same nutritive ratio.