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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
College Station, Brazos County, Texas

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DIVISION OF CHEMISTRY

Productive Energy of Feeds Calculated from Feeding Experiments with Sheep

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The productive energy of feeds for ruminants was calculated for 336 tests in 81 feeding experiments with sheep made by various Experiment Stations. Feeding experiments can be used for this purpose when feeds are compared with a standard feed in a check ration, with few or no other variables. Many feeding experiments examined could not be used for this calculation on account of the presence of two or more variables. The productive energy calculated from the feeding experiments agreed reasonably well with the productive energy calculated from analyses and production coefficients previously published, for alfalfa hay, corn, corn silage, corn gluten feed, native hay, hominy feed, kafir, oats, oat and pea silage, peanut meal, roots, rutabagas, soy bean oil meal, soy bean hay, sugar beets, and timothy hay. Revised production coefficients, based upon the feeding experiments, are given for alfalfa hay, bean straw, dried beet pulp, clover hay, corn fodder, corn stover, emmer or spelt, molasses, oat straw, rye, soy bean straw, sunflower silage, whole wheat, ground wheat, and wheat bran. The productive values of corn fodder and of oat straw were greater in balanced than in unbalanced rations. Cottonseed meal and linseed meal had higher productive values, which was 50 per cent higher with cottonseed meal, when they were added to and compared with an unbalanced ration, than when compared with another protein feed fed in a balanced ration.

CONTENTS

BULLETIN NO. 436 NOVEMBER, 1931

PRODUCTIVE ENERGY OF FEEDS CALCULATED FROM FEEDING EXPERIMENTS WITH SHEEP

By G. S. FRAPS

Exact methods for estimating the feeding values of feeds are needed for agricultural and for commercial purposes. For agricultural purposes they are needed in formulating standards for feeding animals, in deciding on rations to be used for feeding purposes, and in studies of the relative economy of various feeding stuffs. For commercial purposes they are needed for aid in comparing the values of different lots of the same feed, or different kinds of feeds with one another, for compounding commercial mixed feeds of the highest possible nutritive value at the lowest possible cost, and for comparing different kinds of commercial mixed feeds with one another.

A number of factors enter into the value of a feed for animal production; these include the productive energy, the digestible protein, the constituents of the proteins, the vitamins A, B, C, D, E, G, the minerals, especially lime and phosphoric acid, and the bulk, or volume. The palatability also appears to be an important factor in inducing the animal to eat liberally of the mixture. The relative importance of these factors in the individual feed depends upon the kind of feed, the kind of animals, and the possible deficiency of the ration to be fed. For ruminants it may be said that the productive energy, the digestible protein, and the bulk, or volume, are the most important factors in the feeding value of the feed. The commercial value of unmixed feeds is measured by other factors, presumably closely related to the feeding value, but perhaps assigned commercial significance out of proportion to the feeding value.

The only one of the factors mentioned above which will be discussed in this Bulletin is the productive energy.

PRODUCTIVE ENERGY

It was formerly assumed that the digestible nutrients of one feed were as good as those of another, pound for pound; thus, one pound of digestible nutriment in straw was assumed to be equal in feeding value to one pound of digestible nutriment in corn. It has been shown by Kellner, Armsby, and others, that this assumption is not correct. The losses consequent on digestion are much greater for each unit of digestible nutrient in straw, than in corn, so that the net energy which the animal could secure from a pound of digestible material in corn is much greater than that which it could secure from a pound of digestible material in straw. Kellner (14) determined the quantities of fat which could be put on a fattening steer, fed on a slightly fattening ration, by additions of protein, of fat, of starch, of crude fiber, and of sugar. Using the values so secured, he calculated the values of certain feeds from the digestible constituents, and compared the calculated value with the actual quantity of fat put on a fattening steer, by additions of the feed to the ration. With cottonseed meal, peanut oil meal, palm oil meal, and linseed oil meal, the experimental values were practically the same as those calculated, but with other feeds the value found by actual test was decidedly below that calculated. Some of these results are given in Table 1. It is seen from this table that the assumption of equal value for the digestible nutrients would be only about 20 per cent correct in case of wheat straw, 63 per cent correct in case of meadow hay, 69 per cent correct for clover hay, and 77 per cent correct for wheat bran. To put it another way, the assumption of equal value for digestible nutrients would be five times the actual value found by experiment with the wheat straw, nearly 50 per cent too high with meadow hay or clover hay, and 30 per cent too high for wheat bran.

Table 1. Productive value in calories per 100 grams of food found by experiment compared with productive value calculated on the assumption that digestible nutrients have equal value. (Kellner)

	Calculated from digestible nutrients	Found on experiment	Per cent found of calculated
Cottonseed meal	190.4	186.9	98
Peanut oil meal	179.5	179.8	100
Wheat straw	98.9	20.1	20
Oat straw	103.6	40.8	61
Meadow hay	122.8	77.1	63
Clover hay	118.3	81.1	69
Wheat bran	146.5	113.3	77
Brewers grains, dried	146.9	123.9	84
Beet pulp, dried	172.6	135.3	78

After establishing the diversity in the feeding value of the digestible nutrients of different classes of feeds, Kellner (14, 15) devised methods for estimating and for calculating the productive values of feeds, and proposed feeding standards based upon them. Kellner expressed productive value in terms of starch. Armsby (1) also proposed standards and devised methods for estimating the productive values of feeds, expressing the value in terms of therms, a therm being 1,000 large calories. Kellner's system has been extensively used in Europe, but the system based on equal value of digestible nutrients is still used in this country. Forbes and associates (2, 3, 4, 16) have continued the work of Armsby.

It has been objected that the data on which the systems of Kellner or of Armsby are based are too limited to permit the general application of the results. If one examines the evidence, however, he will find that in spite of the data being not as extensive as might be desired, they are not so limited after all but are sufficient to serve the basis of the system, and that the productive energy comes much nearer to expressing the correct nutritive value of the energy of the feed, than does the content of the digestible nutrients.

Disposition of energy of feed. A portion of the material and energy fed to an animal appears as undigested materials in the solid excrement. Some metabolic products (waste material of the animal body) also appear in the excrement. The difference between the amount of each nutrient fed and the corresponding amount in the excrement, is said to be digested.

Quantity fed — quantity excreted = quantity digested.

However, this is not strictly correct, both on account of the presence of metabolic products in the excrement, and for the further reason that fermentation takes place in the stomach or intestines of some animals, producing in addition to marsh gas and carbon dioxide, soluble products which may be absorbed and utilized by the animal. This fermentation is especially noticeable with horses, and with ruminants, such as sheep and cows. It does not occur to a large extent with chickens, hogs, or dogs.

Quantity digested (so-called) — quantity lost as gases = quantity absorbed.

A portion of the energy in the nutrients absorbed by the body is not utilized but is excreted in the urine, some of it in compounds of nitrogen, and some in other compounds and some also is evolved as marsh gas. After the energy in the urine and the energy in the gases are subtracted from the energy absorbed, the remainder is termed the metabolizable energy.

Energy of food eaten — energy in solid excrement — energy in gases — energy in liquid excrement = metabolizable energy.

The metabolizable energy does not, however, represent the net energy available to the animal from the food. There must be deducted from it the loss of energy in the fermentation in the intestines, in addition to that contained in the marsh gas, and the energy used up in the processes of digestion, including chewing of the feed, moving the material through the body, and all other energy required to place the material of the food in condition for use by the animal. When the consumption of energy is deducted from the metabolizable energy, the result is the net energy or productive energy available for the use of the animal body.

The energy consequent on the digestion of food is evolved as heat. Whether or not this heat is of any service to the animal depends upon conditions. If the animal receives a ration near or below its maintenance requirements and if the temperature is below that of the animal body, the heat of digestion may aid in maintaining the temperature of the animal, thereby taking the place of food or body material which would otherwise be oxidized to provide heat and permitting it to be used for other purposes. At higher planes of nutrition or at higher stall temperatures, the heat of digestion is of no value to the animal, and with heavy rations, the disposal of the heat of digestion may be a burden to the animal in hot weather, and may cause the animal to go off feed.

MEASUREMENTS OF PRODUCTIVE ENERGY

Measurements of the productive energy of feeds have been made by Kellner, in Germany, and by Armsby, Forbes and associates, in this country. The method of Kellner consisted in first measuring the production of fat and flesh on a fattening steer, fed a basal ration sufficiently above maintenance to avoid any possible utilization of heat of digestion. The food or material to be studied was then added to the basal ration, and the production of flesh and fat again measured. The difference between the two experiments gave the gain in flesh and fat due to the additional feed, and from this the productive value of the feed tested was calculated. Corrections were made for any change in weight of the animal, conversion of flesh to fat, or differences in the amount of the basal ration eaten.

It is to be noted that Kellner measures the productive energy of the food by the additional quantity of fat secured, and makes no allowance for the energy used in the chemical changes involved in the transformation of the productive energy in the nutrients into the form of fat or flesh. It is hardly conceivable that the transformation occurs without consumption of energy. The productive energy measured by Kellner is not, therefore, the actual productive energy but should be approximately in proportion to it. The actual productive energy is the productive energy of the fat stored up, plus the energy involved in the transformation. Likewise, the percentage of the productive energy used for work, or milk, may be different from that used for fat. Since, however, there is at present no method of measuring the energy consumed in transforming the material of the food to flesh and fat, we can do no better than to take the energy in the fat and flesh stored up as a measure of the productive energy of the feed.

The method of Armsby and of Forbes and associates (1, 2) for net energy is based upon the increased elimination of heat due to the ingestion of the food. As pointed out by them (3, 4), the net energy varies with the conditions of the test. The productive energy must be estimated under standard conditions, as was done by Kellner.

Based upon the methods referred to above, Kellner (14, 15) and Armsby (1) have devised feeding standards for various classes of animals, calculated the productive values of feeds, and discussed the theoretical aspects of the problem.

The term productive energy as used in this Bulletin is confined entirely to the amount of net energy which can be used for the production of fat and flesh. If measured in terms of maintenance or milk, it may have a different value.

PRODUCTION COEFFICIENTS

The procedure for calculating the productive energy of feeds used by Kellner (15) is somewhat complicated. That proposed by Armsby (1) is not closely related to the chemical composition of the feed. The calculation of the digestible nutrients (except the digestible protein) is not necessary if the productive energy is to be used. By combining the different calculations (including the coefficients of digestibility) it is possible to secure factors by means of which the productive energy may be calculated directly from the chemical composition of the feed. The Texas Agricultural Experiment Station has published some factors for ruminants (5, 6, 8) and for poultry (7).

CALCULATIONS FROM FEEDING EXPERIMENTS

The respiration or calorimetric experiments to ascertain the productive energy of feeds referred to above require expensive apparatus, including respiration chambers or animal calorimeters, involving considerable expenditures of time and money, and are difficult to carry out. For this reason the data regarding the productive energy of feeds and of their constituents are limited in amount.

It should, however, be possible to calculate productive energy from feeding experiments. That this can be done has already been shown (10, 11, 12, 13), and productive values for ground kafir, kafir heads, ground milo and ground feterita heads have been corrected by means of these feeding experiments (6).

METHOD OF CALCULATION HERE USED

The method of calculation used for the work here reported is outlined in Tables 2 and 3. In Table 2, the comparison is made for a roughage; in Table 3, for a concentrate. One of the rations in the lot (Lot 2 in Table 2, Lot 1 in Table 3) which comes the nearest to containing feeds of standard feeding value, was selected as a standard. The productive energy fed in the standard ration was calculated from the productive values of the various feeds contained in it (Total T for Lot 2 in Table 2). The productive energy used in the calculations, in therms per pound, is given after the name of each feed. The weights of the animals at the beginning and at the end were added and divided by 2, and the result was assumed to represent the average weight during the experiment (W). The average weight was multiplied by the maintenance requirement for one pound (H) using Armsby's values) to secure the total productive energy used for maintenance. The total productive energy fed in the ration less the energy for maintenance gave the energy left for production (B), and this divided by the gain in weight gave the therms required for one pound of gain in weight, on the standard ration ($B \div G = K$).

One of the feeds was selected as the unknown in each of the other rations. The productive energy of the remainder (T) was calculated from the other ingredients. The energy for maintenance (M) was calculated as stated above ($W \times H = M$). The energy in the gain in weight (L) was calculated from the therms per one pound of gain as found in the standard ration ($K \times G = L$). The value of the ration was the energy required for maintenance added to that required by the gain

Table 2. Productive energy of feeds calculated from feeding experiments, Bulletin 143, South Dakota Experiment Station.

	Siberian alfalfa hay	Standard	Sweet clover	Pea hay	Corn fodder	Prairie hay	Corn silage
Lot No.	1	2	3	4	5	6	7
Average weight, pounds (W)	99.0	100.4	99.2	95.5	102.6	95.8	83.1
Average daily gain, pounds (G)	.48	.56	.43	.35	.32	.36	—.013
Daily feed, pounds, corn	.953	.953	.955	.955	.925	.925	....
Oats	.953	.953	.955	.955	.925	.925	....
Alfalfa hay	....	1.71	....	....	....	....	....
Siberian alfalfa hay	1.42	....	....	....	....	....	....
Sweet clover	....	....	1.38	....	....	....	....
Canadian field pea hay	....	....	....	1.12	....	....	....
Shredded corn fodder	....	....	....	....	1.14	....	....
Prairie hay	....	....	....	....	....	.853	....
Corn silage	....	....	....	....	....	....	3.76
Productive value, therms, corn—(.822)	.783	.783	.785	.785	.760	.760	....
Oats—(.546)	.520	.520	.521	.521	.505	.505	....
Alfalfa hay—(.345)	....	.590	....	....	....	....	....
Total therms T	1.303	1.893	1.306	1.306	1.265	1.265	0
Maintenance therms, W × .0079 = M	.782	.793	.784	.754	.811	.757	.656
Productive value of gain, T—M = B	....	1.100	....	....	....	....	....
Therms for 1 lb. gain in standard B ÷ G = K	....	1.964	....	....	....	....	....
Productive energy of gain, K × G = L	.943	....	.845	.687	.628	.707	—.026
Productive energy of ration, M + L = O	1.725	....	1.629	1.441	1.439	1.464	.630
Productive energy of supplement fed, O—T = E	.422	....	.323	.135	.174	.199	.630
Productive energy of 100 lbs. supplement = E ÷ wt. feed × 100	29.7	....	23.4	12.1	15.3	23.3	16.8

in weight (M+L=O). The productive energy (E) of the feed considered was the productive energy of the ration, as measured by gain in weight of the animal (O) less the productive value of the ration (T) fed in addition to the feed tested (O—T=E). The productive value of the feed in therms for 100 pounds is E divided by the weight fed multiplied by 100.

The method does not measure the absolute productive value of the feed tested, but compares it with a standard feed of known feeding value. There is no more objection to this method of calculation than to the other methods used for stating the results of feeding experiments.

If the feeding experiment is well planned and properly conducted, so that all variables are eliminated except those due to a single feed being studied, there is no reason to believe it will not give reasonably accurate results. Chemical analyses of the feeds used are desirable on account of the variable character of feeds and the necessity of calculating their productive values from the analysis. Errors in the assumed productive energy of the supplementary feeds would be eliminated if practically the same quantities of these feeds are fed to each lot. The same applies to the assumed maintenance requirements of the animals and to the calculated energy requirements for one pound of gain in weight, if the animals average nearly the same in weight and make nearly the same gains. If there is much difference in the average weights of the animals, an error in the assumed maintenance requirements could affect the results of the calculation. If there is much difference in gain in weight in the several lots of animals on experiment, there may be differences in the energy required to make the gain, for it has been shown that the energy stored up for each pound of gain increases as the animal becomes fatter.

The composition of the gain in weight in fattening depends upon the kind of animal and the degree of fatness attained. The percentage of fat in the gain is much larger near the end of the fattening process than at the beginning. The composition of the gain near the beginning of the fattening depends upon the condition of the animal at that time and also on the stage of growth. Thin animals will put on material of lower fat content than those in better condition. The gains of young animals contain more water than those of mature animals. According to Armsby (1), the energy per pound of increases in weight (excluding some doubtful results) may vary from 2.49 to 4.00 therms with an average of 3.25 (page 362) for various animals. For sheep the energy content of the gain (page 352) varied from 1.4 to 4.0 therms.

The therms required per pound of gain, as found in the calculations of the standard lot in the experiments, are tabulated and summarized in Table 3. The average is 2.60 therms per pound, which is somewhat lower than the average for various animals (3.25) given above. It varies from 1.124 to 4.136, which is a wide distribution, and there is a somewhat even spread in the distribution. Variations in maintenance requirements and in the fill taken in by the animal, of course, affect

Table 3. Productive energy of feeds calculated from experiments, Bulletin 185, Washington Experiment Station.

	Standard	Wheat	Barley	Oats
Lot No.	1	2	3	4
Average weight, pounds (W)	84.50	83.25	83.90	81.25
Average daily gain, pounds (G)	.326	.279	.283	.287
Daily feed, pounds, corn	1.17			
Wheat		1.17		
Barley			1.17	
Oats				1.17
Alfalfa hay	1.86	1.86	1.89	1.87
Productive values, therms, corn—(.863)	1.010			
Alfalfa, therms—(.355)	.660	.660	.671	.664
Total therms, T	1.670	.660	.671	.664
Maintenance therms, W × .0085 = M	.718	.708	.713	.691
Productive energy of gain, T—M = B	.952			
Therms for 1 lb. gain in standard B ÷ G = K	2.920			
Productive energy of gain, K × G = L		.815	.826	.838
Productive energy of ration, M + L = O		1.523	1.539	1.529
Productive energy of supplement fed, O—T = E		.863	.868	.865
Productive energy of 100 pounds supplement = E ÷ wt. feed × 100		73.8	74.2	73.9

the therms required for a pound of gain. These tables are of interest in connection with the establishment of economical rations, but this Bulletin deals with the productive energy of the feeds.

Table 4. Therms required for one pound gain.

Number of tests	Therms
2	1.1 — 1.5
2	1.6 — 1.8
8	1.8 — 2.1
10	2.1 — 2.3
12	2.3 — 2.5
17	2.5 — 2.7
8	2.7 — 2.9
10	2.9 — 3.1
6	3.1 — 3.3
4	3.3 — 3.7
2	3.8 — 4.2
Total 81 .... Average	2.6

SELECTION OF THE FEEDING EXPERIMENTS USED

A large number (over 168) of feeding experiments were studied in connection with the work here reported. It was found that many of the experiments were unsuited for calculating the productive energy for one particular feed, for various reasons, some of which will be mentioned.

The method of calculation involves comparing the productive energy of a feed of known productive energy, with the unknown, as illustrated in Tables 2, 3, and others and as already described. In addition to the assumed productive value of the standard feed, productive energy must be assumed for the other feeds fed with it in the ration, and for the maintenance requirements of the animals. These assumed values are necessarily not exactly correct, even when chemical analyses of the feeds were made. If the quantities of the supplemental feeds eaten by the different lots of sheep are the same in each lot, if the sheep average the same in weight at the beginning of the experiment, and make the same gain, any error in the assumed productive energy of the supplemental feeds, or in the assumed maintenance requirements, would be canceled out. The result would be a direct comparison between the standard feed and the feeds studied, expressed as therms. The only variable would be the two feeds being compared.

The number of experiments which exactly meet the requirements given above is low, especially with regard to an equal gain in weight. Experiments were selected which were reasonably close to the requirements, and all the experiments were carefully scrutinized. Experiments were excluded when there were too wide variations in the quantities of feed eaten in the supplemental ration or when no direct comparison could be made of any particular feed with a standard feed on account of the presence of two or more large variables. Many experiments which make comparisons of the effect of mixtures or rations or other conditions upon the growth of animals, cannot be used to compare individual feeds used in the ration on account of the many variables between rations fed the different lots. Some experiments were used in which there were wide variations in the gain in weight of the animals, although this condition is not desirable; these variations must be considered in connection with the conclusions.

Feeding experiments in which a standard feed is compared with several other feeds, in rations in which the quantity of all other feeds is kept constant (as illustrated in Tables 2 and 3) are few in number. The usual procedure is to make several comparisons in the same experiment, instead of comparing all the lots with a single one. For example, Lot 1 may be compared with Lot 2, Lot 2 with Lots 3 and 6, Lot 4 with Lots 5 and 6. The same method of procedure, of course, could be used in comparing the productive energy of the variables, but the use of a single standard is preferable.

Another procedure involves the use of one of the roughages or concentrates in two or three of the rations, but not in the others. It is sometimes possible to calculate the productive energy of the variable addition from one of the experiments and use this calculated value in calculating the others.

Experiments in which two or more new feeds are introduced into one ration, or in which there are decided variations in the quantities eaten of two or more of the feeds, or into which two or more variables are introduced, are unsuitable for comparing the productive values of individual feeds, or estimating the productive energy. They may give information regarding the value of the ration as a whole, or the palatability of the mixture but all the effect of the ration cannot be ascribed to one variable selected from two or more variables.

Experiments in which two feeds are fed in variable quantities are not well suited to calculate productive energy. In the first place, one of the two variables must be selected from which to calculate the productive energy. In the second place, an error in the assumed productive value in the other feed will result in too high or too low a productive value for the feed calculated. This is illustrated in Table 5, in which the calculated productive energy of the alfalfa increases from 32.8 to 45.7 therms per hundred pounds as the quantity fed increases.

PRODUCTIVE VALUES USED

When analyses of the feed used were given, the productive values were calculated from the analyses, using the production coefficients already published (6, 8), and these values were used in the calculations. In many cases the analyses were not given, and for these, average productive values were used, calculated from the production coefficients and the ordinary analysis of the feed, either of the Texas Station or of Henry and Morrison (9). Many of the productive values used are given in Table 6. These values no doubt deviate in many cases from the productive values of the feeds actually used, but since the experiments were conducted and conclusions drawn with no knowledge of the com-

Table 5. The calculated productive energy may be different when the same feed is fed in different quantities.

	Standard	Alfalfa	Alfalfa	Alfalfa	Alfalfa
Lot No.	1	5	6	8	13
Average weight, pounds	73.00	73.59	72.26	69.89	70.20
Daily gain, pounds	.246	.352	.299	.218	.220
Daily feed—corn, pounds	.745	1.345	.960	.500	.277
Alfalfa, pounds	2.078	1.833	1.919	2.210	2.412
Productive value therms per 100 pounds alfalfa	....	31.6	38.5	39.2	44.7
Therms for 1 pound gain	3.321	3.594	3.211	3.078	2.459

Table 6. Productive energy of feeds used in calculating feeding experiments—Therms per pound.

Feed	Therms per pound	Feed	Therms per pound	Feed	Therms per pound
Alfalfa	.345	Cottonseed meal	.717	Oat and pea silage	.150
Ajax	.740	Cowpea hay	.347	Oats	.546
Barley	.760	Darso	.820	Oat straw	.219
Barley, chopped	.800	Darso silage	.119	Oil meal	.780
Bean fodder	.330	Gluten feed	.740	Pea hay	.380
Beet pulp, dry	.610	Gluten meal	.700	Pea meal	.750
Beets, sugar	.070	Hay, Minne. + clover	.350	Potatoes	.260
Blue grass hay	.360	Hay, rowen	.350	Prairie hay	.220
Buffalo gluten feed	.700	Hominy feed	.850	Rutabagas	.060
Cane silage	.103	June grass	.340	Rye, chopped	.830
Clover, Alsike	.360	Kafir, ground	.800	Shorts	.740
Clover hay	.354	Kafir heads	.680	Soybean oil meal	.760
Clover hay, sweet	.380	Kafir, shelled	.800	Soybean, whole	.850
Clover rowen hay	.350	Kafir, silage	.100	Sorghum silage	.103
Clover silage	.150	Linseed meal	.780	Speltz	.780
Corn	.822	Maize feed	.780	Sudan hay	.330
Corn fodder	.380	Mangels	.063	Timothy hay	.320
Corn and kafir silage	.150	Mangels and carrots	.070	Turnips	.063
Corn meal	.860	Millet hay	.360	Wheat	.840
Corn silage	.155	Milo heads, ground	.724	Wheat bran	.489
Corn and soja bean silage	.150	Molasses	.057	Wheat, chopped	.860
Corn stover	.340	Oat hay	.350	Wheat salvage	.800
Corn stover, uncut	.300	Oat hay, cut	.330	Wheat straw	.240
		Oat hay, whole	.330	Wisconsin hay	.360
				Wyoming hay	.360

position of the feeds tested, it was considered permissible to study the results in the same way; but of course the matter must be considered in the final interpretation of the results. These assumptions are not greater than the assumptions made by those who originally carried out the experiment.

COMPARISON OF PRODUCTIVE ENERGY WITH FEED FOR 100 POUNDS OF GAIN

The results of feeding experiments are frequently compared in terms of pounds of feed required to make 100 pounds of gain. The feed used by the animal for maintenance and for fattening are both included, so that the greater the cost of maintenance, the greater the number of pounds of feed required per hundred pounds of gain in weight. The chief items entering into the cost of maintenance are the weight of the animal and the length of the period of the experiment, which vary in different experiments. The proportion of the total ration used for gain in weight materially affects the weight of the feed required for 100 pounds of gain; if one lot uses one-fourth of the ration for production, while another lot uses one-third, it is obvious that the pounds of gain for 100 pounds of feed could be correspondingly influenced.

The largest gains in weight are secured when the animal eats daily a ration containing the largest amount of productive energy which it can handle to advantage. The quantity of productive energy consumed depends upon the proportion of concentrates to roughages, the adequacy of the ration, and the appetite of the animal, influenced by palatability. If the ration is deficient in any respect, the appetite of the animal is likely to fall off. The palatability of the mixture is an important factor, since heavy rations must be especially attractive. Different amounts of the same ration would cause differences in gain in weight; consequently a difference in the pounds of feed for 100 pounds of gain is thus not a measure of any particular factor or feed in the ration, but it is the measure of the ration as a unit, and is especially related to the palatability of the mixture.

The calculation of the productive energy, on the other hand, attempts to eliminate the other factors, and confine the results entirely to the therms of productive energy in a unit of feed.

Variations in the composition of the gain in weight, uncertainty with respect to the composition or feeding value of the feeds used, and the presence of several variables, affect the interpretation of results by means of feed required for 100 pounds of gain, just as they affect the results of the calculation of productive energy.

CALCULATION OF DIGESTIBLE NUTRIENTS FOR A POUND OF GAIN

The same method of calculation used for productive energy could be applied to digestible nutrients, provided they were of equal value to the animal. A comparison of such a calculation with that of productive

Table 7. Comparison of therms per pound gain with digestible nutrients per pound gain and feed per 100 pounds gain. Experiment from Illinois Bull. 167.

Lot No.	1	2	3	4	1	2	3
Average weight, pounds (W)	83.0	81.0	78.7	78.0	81.3	80.6	78.8
Average daily gain (G)	.30	.27	.22	.20	.33	.32	.29
Daily feed—corn C (.822)	1.24	1.05	.71	.54	1.36	1.14	.88
Alfalfa A (.345)	1.23	1.42	1.71	1.87	1.17	1.49	1.78
Productive value—corn	1.019	.863	.584	.444	1.118	.937	.723
Alfalfa	.459	.490	.590	.645	.404	.514	.614
Total T	1.478	1.353	1.174	1.089	1.522	1.451	1.337
Maintenance W × .0085 = M	.706	.689	.669	.663	.691	.685	.670
Productive value T—M = B	.772	.664	.505	.426	.831	.766	.667
Therms for 1 lb. gain B ÷ G = K	2.573	2.459	2.295	2.130	2.518	2.394	2.300
Digestible nutrients, pounds—							
Corn (.799)	.991	.839	.567	.431	1.087	.911	.703
Alfalfa hay (.505)	.621	.717	.864	.944	.591	.752	.899
Total digestible nutrients T	1.612	1.556	1.431	1.375	1.678	1.663	1.602
Maintenance W × .0091 = M	.755	.737	.716	.710	.740	.733	.717
Digestible nutrients for gain made B	.857	.819	.715	.665	.938	.930	.885
Nutrients for 1 pound gain B ÷ G = K	2.857	3.033	3.250	3.325	2.842	2.906	3.052
Corn for 100 pounds gain	413	389	323	270	413	357	303
Alfalfa for 100 pounds gain	410	526	777	935	354	466	614

energy is given in Table 7. The requirements for maintenance are based upon the figures of Max Kriss (16). The experiment used was selected because the animals were fed variable amounts of roughages and concentrates, between which there are wide differences in the productive energy per pound of digestible nutrients.

In both the experiments, it is seen that the therms of productive energy for each pound of gain decreases as the gain in weight decreases. This is in accordance with the fact that the thinner animals put on material containing less heat units than do the fatter animals. On the other hand, the total of digestible nutrients required for a pound of gain increases as the gain in weight decreases and as the quantity fed of alfalfa increases, and of corn decreases. This shows clearly that the digestible nutrients of alfalfa have lower values than those of corn. It is in accord with the evidence that the productive energy of the digestible nutrients of alfalfa is lower than that for corn.

THE PRODUCTIVE ENERGY CALCULATED FROM THE FEEDING EXPERIMENTS

A summary of the results of the calculation of the productive energy from the feeding experiments with sheep is given in Table 8. Detailed calculations of a number of the experiments are given in Tables 2, 3, and 9 to 38, inclusive. The calculations were made by the method already described. In Table 8 the feeds are listed in alphabetical order.

In Table 8 the productive energy calculated from the feeding experiments is given in the column headed "Therms productive energy from feeding experiments". The column headed "Therms calculated from analysis" contains the productive energy calculated from the analysis of the feed used in the particular experiment, where such analysis is given, by means of the production coefficients (6, 8). The column headed "Gain in weight" shows whether the average gain in weight was 10 per cent or more higher (H) or lower (L) than the gain in the lot used for the standard.

Two columns give references to the bulletins or reports in which the experiments were published. The last column gives the numbers of the tables in which the experiments are given in detail in this Bulletin, if they are given.

In general it may be said that the results of the feeding experiments agree with the productive energy calculated from the production coefficients. There are some unusually high results secured from protein supplements, especially cottonseed meal. Some of the calculations indicate the need for correcting the production coefficients previously given for some of the feeds, such as corn fodder, in which case the production coefficients seem to give too high a productive value. On the whole, the results show that the productive values coincide reasonably well with the results of the feeding experiments, and show the usefulness of the method.

Table 8. Productive energy in therms per hundred pounds calculated from feeding experiments with sheep

Name of feed	Therms productive energy from feeding experiments	Therms calculated from analysis	Gain in weight	State	Bulletin or report	Table No.
Alfalfa hay, Siberian (alfalfa 34.5)......	29.7	29.7	L	S. D.	143	2
Alfalfa hay, second cutting (first cutting 36.8)............	30.4	35.3	L	Wash.	170	9
Alfalfa hay, second cutting (first cutting 35.3)............	31.3	35.3	M	Wash.	185	....
Alfalfa hay, third cutting (first 36.8)....	32.4	29.9	M	Wash.	170	9
Alfalfa hay, third cutting (first 35.5)....	32.8	29.9	M	Wash.	185	....
Alfalfa (clover hay 38.0)..............	36.4	0	M	Ind.	179	....
Alfalfa (clover hay 35.4)..............	37.0	0	M	Mich.	136	29
Alfalfa hay (timothy hay 34.0)........	42.9	0	H	Ohio	245	25
Alfalfa hay (timothy hay 34.0)........	45.1	0	H	Ohio	245	25
Alfalfa hay, long (compared with cut, 35.4)........................	34.0	0	H	Idaho	Cir. 19	10
Alfalfa hay, long (cut 35.4)..........	37.5	0	H	Idaho	Cir. 19	10
Average (11)..................	35.4	32.0	....	....	....	....
Alfalfa, chopped (long 34.5)...........	36.8	0	M	Ohio	179	....
Alfalfa meal (hay 35.4)...............	39.0	0	H	Idaho	Cir. 19	10
Alfalfa meal (hay 35.4)...............	41.7	0	H	Idaho	Cir. 19	10
Alfalfa meal (native hay 42.0).........	42.2	39.6	M	Wyo.	89	12
Alfalfa and molasses.................	35.7	0	M	Neb.	197	....
Mangel beet........................	9.4	0	H	Iowa	110	33
Mangel beet, calculated.............	....	6.6	....	....	....	....
Bean straw.........................	22.4	0	M	Mich.	136	29
Bean straw.........................	29.6	0	M	Mich.	136	29
Bean straw, calculated, coefficient soy-bean straw......................	....	17.8	....	....	....	....
Barley............................	48.9	79.8	L	Wyo.	109	....
Barley, Scotch.....................	57.4	81.7	L	Wyo.	89	12
Barley, whole......................	61.4	0	M	Iowa	210	....
Barley............................	63.3	80.3	L	Wyo.	85	....
Barley............................	65.6	0	L	S. D.	86	32
Barley, cracked....................	66.4	82.4	L	Wyo.	103	11
Barley, whole......................	66.7	76.0	M	Colo.	266	....
Barley............................	68.0	0	M	Colo.	75	....
Barley, soaked.....................	70.5	82.4	M	Wyo.	103	11
Barley............................	70.8	0	M	Mont.	59	....
Barley, whole......................	71.1	0	L	Kan.	Cir. 88	....
Barley............................	72.2	0	M	Neb.	211	27
Barley............................	74.2	79.8	M	Wash.	185	3
Barley............................	74.2	0	L	Okla.	146	....
Barley, whole......................	75.9	0	M	Iowa	210	....
Barley............................	77.5	0	M	Ore.	195	34
Barley............................	77.6	82.4	M	Wyo.	103	11
Barley............................	79.4	0	M	Mont.	47	....
Barley............................	79.8	0	M	S. D.	86	32
Barley............................	80.4	77.5	M	Wyo.	73	....
Barley............................	80.7	0	H	Neb.	211	27
Barley, whole......................	82.2	82.0	M	Iowa	210	....
Barley............................	86.8	79.5	M	Wyo.	73	....
Barley, Scotch.....................	88.3	0	L	Wyo.	81	....
Barley............................	129.3	0	M	Mont.	47	....
Average (25)................	74.7	80.3	....	....	....	....
Barley meal........................	69.2	82.4	M	Wyo.	103	11
Bald barley........................	51.2	84.3	L	Wyo.	89	12
Bald barley........................	86.7	84.7	L	Wyo.	79	....
Beet pulp, wet.....................	8.0	0	L	Colo.	75	....
Beet pulp, wet.....................	13.0	7.8	M	Colo.	266	....
Beet pulp, wet, average.............	....	5.8	....	....	....	....

Table 8. Productive energy in therms per hundred pounds calculated from feeding experiments with sheep —Continued.

Name of feed	Therms productive energy from feeding experiments	Therms calculated from analysis	Gain in weight	State	Bulletin or report	Table No.
Beet pulp, dried	77.7	66.2	M	Mich.	220	13
Beet pulp, dried	81.8	66.2	M	Wis.	1906	....
Beet pulp, dried	85.6	66.2	M	Mich.	220	13
Beet pulp, dried	89.7	66.2	M	Mich.	220	13
Average (4)	83.7	66.2	....	....	....	....
Beet pulp average	....	63.0	....	....	....	....
Molasses beet pulp, dried	68.5	61.9	M	Colo.	266	....
Molasses beet pulp, dried	80.0	61.9	M	Colo.	266	....
Molasses beet pulp, dried	83.6	61.7	M	Mich.	220	13
Molasses beet pulp, dried	98.1	61.9	M	Colo.	261	....
Average (4)	82.6	61.9	....	....	....	....
Cottonseed cake, cold-pressed	100.0	0	H	Neb.	173	20
Clover hay, sweet	20.3	0	M	Kan.	Cir. 109	24
Clover, sweet	23.4	38.2	L	S. D.	143	2
Clover hay, sweet	23.8	0	M	Kan.	Cir. 109	24
Clover hay	25.0	29.9	L	Ohio	245	16
Clover hay, sweet	26.0	0	M	Kan.	Cir. 109	24
Clover hay	26.8	0	H	Ind.	179	....
Clover hay	27.2	37.1	L	Wyo.	79	....
Clover hay, red	28.6	29.9	M	Ohio	245	17
Clover hay	28.7	0	M	Ind.	192	21
Clover hay	31.2	0	M	Ind.	202	23
Clover, sweet	32.5	0	L	Kan.	1921	....
Clover hay, sweet, first cutting	32.8	35.4	M	Wash.	185	....
Clover hay	35.9	0	M	Ind.	179	19
Clover hay	36.7	38.1	M	Ohio	245	18
Clover hay	37.8	0	M	Ind.	184	22
Clover, sweet	41.1	34.5	H	Wash.	170	9
Average (16)	29.9	34.7	....	....	....	....
Corn, ground	79.7	0	M	Kan.	Cir. 88	....
Corn, ground (.82 whole)	79.3	0	M	Neb.	257	38
Corn, ear	69.6	0	M	Idaho	196	....
Corn silage	3.0	0	M	Idaho	Cir. 19	10
Corn silage	4.1	0	L	Kan.	Cir. 79	26
Corn silage	7.4	0	M	Ohio	179	....
Corn silage	9.6	0	M	Neb.	197	14
Corn silage	10.4	0	M	Iowa	110	33
Corn silage	11.1	0	M	N. Y.	47	....
Corn silage	11.3	0	M	Neb.	211	27
Corn silage	11.6	0	M	Ind.	162	....
Corn silage	11.6	0	M	Ind.	162	....
Corn silage	11.7	13.9	M	Neb.	197	14
Corn silage	11.9	13.9	M	Neb.	197	....
Corn silage	12.0	0	L	Ind.	202	23
Corn silage	12.3	0	L	Ind.	202	23
Corn silage	12.7	13.9	L	Neb.	197	....
Corn silage	13.8	0	M	Neb.	197	....
Corn silage	14.0	0	M	Neb.	197	....
Corn silage	14.4	0	M	Ind.	162	....
Corn silage	14.6	0	M	Ind.	162	15
Corn silage (barn)	15.2	0	M	Ind.	179	19
Corn silage	16.1	0	M	Neb.	197	....
Corn silage (barn)	16.4	0	L	Ind.	192	21
Corn silage	16.8	0	M	Ind.	162	....
Corn silage	16.8	17.1	L	S. D.	143	2
Corn silage	18.5	0	M	Ind.	192	21
Corn silage	18.6	0	L	Mich.	107	....
Corn silage	19.4	0	M	Ind.	162	15

Table 8. Productive energy in therms per hundred pounds calculated from feeding experiments with sheep —Continued.

Name of feed	Therms productive energy from feeding experiments	Therms calculated from analysis	Gain in weight	State	Bulletin or report	Table No.
Corn silage	20.2	0	M	Ind.	168	....
Corn silage	20.4	0	M	Ohio	179	....
Corn silage	20.5	0	M	Ind.	168	....
Corn silage	20.9	17.0	M	Wash.	185	....
Corn silage	21.4	0	H	Ind.	162	....
Corn silage	21.6	0	H	Neb.	173	20
Corn silage	21.7	0	M	Ind.	179	19
Corn silage	21.7	0	L	Kan.	1921	....
Corn silage	22.3	0	M	Ind.	179	....
Corn silage	24.6	0	M	Ind.	162	15
Corn silage	25.4	0	H	Ind.	102	....
Corn silage	25.9	0	H	Ind.	184	22
Corn silage	26.7	0	H	Ind.	184	22
Corn silage	30.9	0	M	Ind.	162	....
Corn silage	33.2	15.1	H	Wash.	170	9
Corn silage	35.9	0	H	Mo.	115	....
Corn silage	36.8	15.1	H	Wash.	170	....
Corn silage	41.8	15.1	H	Wash.	170	9
Average (44)	18.4	15.1	....	....	....	....
Calculated immature	....	11.0	....	....	....	....
Calculated well matured	....	15.5	....	....	....	....
Corn stalks	25.3	0	M	Mich.	136	29
Corn stalks	32.9	0	M	Mich.	136	29
Corn stover	4.4	27.9	L	Ohio	245	17
Corn stover	12.0	27.9	L	Ohio	245	16
Corn stover	15.9	27.9	L	Ohio	245	17
Corn stover	17.1	27.9	L	Ohio	245	18
Corn stover	18.5	27.9	L	Ohio	245	16
Corn stover	34.6	0	M	Okla.	78	....
Average (6)	17.2	27.9	....	....	....	....
Shredded corn fodder	15.3	37.0	L	S. D.	143	2
Corn gluten feed	75.6	75.5	M	Iowa	210	....
Corn gluten feed	80.0	0	L	Kan.	Cir. 79	26
Corn gluten feed	80.2	74.4	M	Iowa	185	....
Average (3)	78.6	75.0	....	....	....	....
Cottonseed meal	47.4	0	M	Ind.	102	....
Cottonseed meal	66.7	0	L	Ind.	184	22
Cottonseed meal	68.5	0	M	Ind.	162	15
Cottonseed meal	72.7	0	M	Ind.	168	....
Cottonseed meal	78.5	0	L	Ind.	192	21
Cottonseed meal	79.2	0	M	Ind.	168	....
Cottonseed meal	81.2	0	M	Mo.	115	....
Cottonseed meal	85.2	0	H	Ind.	179	19
Cottonseed meal	85.2	73.7	H	Wyo.	130	....
Cottonseed meal	94.2	0	L	Ind.	179	19
Cottonseed meal	97.0	0	M	Ind.	162	....
Cottonseed meal	97.3	0	M	Ind.	168	....
Cottonseed meal	101.0	0	L	Ind.	168	....
Cottonseed meal	106.0	0	M	Ind.	192	21
Cottonseed meal	107.0	0	M	Ind.	202	23
Cottonseed meal	107.2	0	M	Ind.	202	23
Cottonseed meal	108.6	0	H	Ind.	179	19
Cottonseed meal	109.5	73.1	M	Wash.	185	....
Cottonseed meal	110.2	0	H	Ind.	184	22
Cottonseed meal	116.0	71.5	H	Wash.	170	9
Cottonseed meal	116.9	0	H	Ind.	184	22
Cottonseed meal	117.2	0	L	Ind.	202	23
Cottonseed meal	123.0	0	L	Kan.	Cir. 79	26
Cottonseed meal	123.0	0	H	Neb.	173	20

Table 8. Productive energy in therms per hundred pounds calculated from feeding experiments with sheep —Continued.

Name of feed	Therms productive energy from feeding experiments	Therms calculated from analysis	Gain in weight	State	Bulletin or report	Table No.
Cottonseed meal	149.3	0	L	Ind.	162	15
Cottonseed meal	170.0	0	H	Ind.	162	....
Average (26)	100.7	72.8	....	....	....	....
Cow pea hay	37.4	0	M	Okla.	78	....
Darso	86.0	0	....	Okla.	146	....
Darso silage	12.0	0	....	....	....	....
Hay, native, Wyoming	19.4	43.2	L	Wyo.	85	....
Hay, prairie, South Dakota	23.3	25.5	L	S. D.	143	2
Hay, native, Wyoming	26.7	37.7	L	Wyo.	79	....
Hay, native, Wyoming	27.1	0	L	Wyo.	51	....
Hay, native, Wyoming	27.7	36.7	L	Wyo.	73	....
Hay, prairie, Oklahoma	28.1	0	L	Okla.	78	....
Hay, prairie, Nebraska	31.1	0	L	Neb.	66	35
Hay, native, Wyoming	31.8	37.7	L	Wyo.	79	....
Hay, native, Wyoming	39.1	0	L	Wyo.	47	....
Average (9)	28.3	36.2	....	....	....	....
Hominy feed	83.6	0	L	Kan.	Cir. 79	26
Hominy meal	85.4	0	M	Ind.	221	....
Hominy feed	87.5	0	M	Neb.	173	20
Hominy feed	87.5	87.2	M	Iowa	210	....
Average (4)	86.0	87.2	....	....	....	....
Kafir heads	51.7	0	M	Kan.	Cir. 109	24
Kafir, whole	77.6	0	M	Kan.	Cir. 109	24
Kafir, whole	77.8	0	M	Kan.	1921	....
Kafir	84.1	0	M	Okla.	146	....
Kafir, ground	74.3	0	L	Okla.	146	....
Kafir, ground	76.8	0	M	Kan.	Cir. 109	24
Average (5)	78.1	0	....	....	....	....
Average Texas Feed Control samples	....	79.8	....	....	....	....
Linseed meal	46.9	73.9	M	Neb.	197	....
Linseed meal	52.3	72.2	L	Ohio	245	17
Linseed meal	57.1	....	M	Neb.	197	....
Linseed meal	63.1	73.9	M	Neb.	197	....
Linseed meal	63.1	73.9	H	Neb.	197	14
Linseed meal	71.9	0	L	Neb.	66	35
Linseed meal	76.8	72.2	L	Ohio	245	16
Linseed meal	77.2	72.2	M	Ohio	245	16
Linseed meal	80.7	0	M	Ind.	221	....
Linseed meal	80.7	73.2	H	Iowa	185	....
Linseed meal	80.9	76.5	L	Ill.	260	31
Linseed meal	81.3	71.4	L	Ill.	260	30
Linseed meal	83.2	0	L	Wyo.	73	....
Linseed meal	83.8	72.2	M	Ohio	245	17
Linseed meal	84.7	0	H	Neb.	211	27
Linseed cake	85.0	76.8	M	Wyo.	89	12
Linseed meal	87.8	0	H	Neb.	211	27
Linseed meal	93.2	0	L	Kan.	Cir. 79	26
Linseed meal	96.7	73.9	H	Neb.	197	14
Linseed meal	122.0	0	H	Neb.	173	20
Linseed meal	123.2	0	H	Ohio	245	25
Linseed meal	124.0	0	M	Mo.	115	....
Linseed meal	234.0	0	M	Kan.	Cir. 79	26
Average (23)	89.1	73.5	....	....	....	....

Table 8. Productive energy in therms per hundred pounds calculated from feeding experiments with sheep —Continued.

Name of feed	Therms productive energy from feeding experiments	Therms calculated from analysis	Gain in weight	State	Bulletin or report	Table No.
Millet hay	22.0	0	L	Mich.	136	29
Millet hay	40.9	0	M	Mich.	136	29
Millet (grain)	79.5	0	M	S. D.	86	32
Molasses, corn	43.6	0	H	Iowa	215	28
Molasses, cane	46.0	0	M	Iowa	215	28
Molasses	49.5	0	M	Neb.	197	....
Molasses	49.5	0	M	Neb.	197	14
Molasses, beet	53.5	0	H	Iowa	215	28
Molasses, beet	59.2	0	M	Iowa	215	28
Molasses, cane	65.9	0	H	Iowa	215	28
Molasses, beet	76.7	0	H	Idaho	Cir. 19	10
Molasses, beet	80.2	0	H	Iowa	215	28
Molasses, cane	84.9	0	M	Ind.	192	21
Molasses, beet	92.0	51.7	M	Colo.	266	....
Average (11)	63.7	....	....	....	....	....
Molasses, cane, calculated	....	54.7	....	....	....	....
Molasses, beet, calculated	....	52.9	....	....	....	....
Oats	60.9	0	L	Neb.	66	35
Oats	63.5	0	L	Mont.	47	....
Oats	66.0	0	L	Ind.	168	....
Oats	66.0	0	M	Ind.	179	19
Oats	66.5	0	M	Mich.	107	....
Oats (whole)	67.4	0	M	Mich.	107	....
Oats (whole)	67.6	70.9	M	Colo.	266	....
Oats	67.6	0	L	Ind.	168	....
Oats (whole)	69.2	0	M	Iowa	210	....
Oats (whole)	70.1	0	M	Iowa	210	....
Oats	71.8	0	M	Mich.	59	....
Oats	71.9	75.4	L	Wyo.	73	....
Oats	73.5	0	M	S. D.	86	32
Oats	73.9	74.3	L	Wash.	185	3
Oats	74.3	75.4	L	Wyo.	73	....
Oats	81.5	0	M	Ore.	198	34
Oats (whole)	85.7	71.9	M	Iowa	210	....
Oats	88.8	0	M	Neb.	66	35
Oats	89.4	0	M	Ind.	184	22
Oats	91.2	0	M	Mich.	107	....
Average (20)	73.3	73.6	....	....	....	....
Oat and pea silage	13.8	15.8	M	Wyo.	130	....
Oat and pea silage	14.1	15.1	L	Wyo.	109	....
Oat and pea silage	16.6	15.1	M	Wyo.	109	....
Oat and pea silage	16.8	15.8	L	Wyo.	130	....
Oat and pea silage	18.5	15.8	M	Wyo.	130	....
Average (5)	16.0	15.5	....	....	....	....
Oat straw	0	24.2	L	Ohio	245	17
Oat straw	3.8	0	M	Ind.	179	....
Oat straw	8.7	0	L	Ind.	192	21
Oat straw	10.8	25.8	L	Ohio	245	16
Oat straw	11.4	25.8	L	Ohio	245	17
Oat straw	13.7	25.8	L	Ohio	245	16
Oat straw	15.1	0	L	Ind.	179	19
Oat straw	18.4	26.3	L	Ill.	260	30
Oat straw	20.8	0	L	Mich.	136	29
Oat straw	26.2	0	M	Mich.	136	29
Oat straw	26.6	0	M	Ind.	184	22
Average (10)	15.6	25.6	....	....	....	....
Peas	55 8	0	L	Idaho	89	....

Table 8. Productive energy in therms per hundred pounds calculated from feeding experiments with sheep —Continued.

Name of feed	Therms productive energy from feeding experiments	Therms calculated from analysis	Gain in weight	State	Bulletin or report	Table No.
Pea hay (Canadian field)	12.0	42.0	L	S. D.	143	2
Pea hay	38.9	0	L	Wyo.	79	....
Pea hay	40.3	0	L	Wyo.	79	....
Pea and barley silage	14.2	0	M	Ore.	184	....
Pea and bald barley silage	16.1	0	M	Ore.	198	....
Peanut meal	85.7	71.6	M	Iowa	185	....
Roots	5.3	0	M	Mich.	113	....
Roots	8.7	0	M	Mich.	113	....
Rutabagas	0	0	....	Mich.	107	....
Rutabagas	8.7	0	L	Mich.	107	....
Calculated	....	8.3	....	....	....	....
Rye, whole	77.3	0	M	Neb.	256	37
Rye, whole	74.1	0	M	Neb.	256	37
Average, calculated	....	84.8	....	....	....	....
Soy bean oil meal	80.5	79.0	L	Ill.	260	31
Soy bean oil meal	88.0	0	M	Ill.	296	....
Soy bean hay	25.9	41.7	M	Ill.	260	31
Soy bean hay	26.0	0	M	Ind.	296	....
Soy bean hay	31.7	34.5	M	Ill.	260	30
Average (3)	27.9	38.1	....	....	....	....
Soy bean straw	13.0	5.5	L	Ill.	260	31
Soy bean straw	15.0	8.3	L	Ill.	260	30
Soy bean straw	22.7	11.9	L	Ohio	245	18
Average (3)	16.9	8.6	....	....	....	....
Soy beans, whole	49.4	0	M	Ill.	296	....
Soy beans	72.4	0	L	Wis.	1904	....
Soy beans, ground	74.0	0	M	Ind.	221	....
Soy beans, ground	76.4	85.2	L	Ill.	260	31
Soy beans, ground	84.2	0	M	Ind.	192	21
Soy beans, whole	88.0	0	M	Ill.	296	....
Soy beans, whole	89.1	85.2	L	Ill.	260	30
Soy beans, ground	141.1	0	M	Ind.	202	23
Average (8)	84.4	85.2	....	....	....	....
Stock tonic	0	0	....	Kan.	Cir. 88	....
Emmer	53.0	0	L	Wyo.	81	....
Emmer	53.8	78.9	L	Wyo.	85	....
Emmer or spelt	61.5	80.8	L	Wyo.	79	....
Emmer or spelt	65.6	0	L	S. D.	86	32
Emmer or spelt	73.4	0	M	S. D.	86	32
Emmer or spelt	76.0	0	H	Colo.	75	....
Average (6)	63.9	79.9	....	....	....	....
Sugar beets	9.8	0	L	Mich.	128	....
Sugar beets	12.5	0	H	Iowa	110	33
Sugar beets	13.0	0	L	Colo.	75	....
Sugar beets	13.7	0	M	Neb.	173	20
Average (4)	12.3	0	....	....	....	....
Calculated	....	12.6	....	....	....	....

Table 8. Productive energy in therms per hundred pounds calculated from feeding experiments with sheep —Continued.

Name of feed	Therms productive energy from feeding experiments	Therms calculated from analysis	Gain in weight	State	Bulletin or report	Table No.
Sunflower silage	9.7	8.3	H	Wyo.	130	....
Sunflower silage	12.5	0	M	Ore.	198	....
Sunflower silage	13.4	0	M	Ore.	184	....
Sunflower silage	13.6	8.5	M	Mont.	131	....
Sunflower silage	15.2	9.0	L	Wyo.	130	....
Sunflower silage	23.7	8.3	M	Wyo.	130	....
Average (6)	14.7	8.5	....	....	....	....
Tankage	48.3	0	M	Neb.	211	27
Timothy hay	23.4	0	L	Ind.	162	....
Timothy hay	29.3	0	L	Ind.	....	
Timothy hay	30.6	0	L	Ind.	162	15
Timothy hay	30.9	0	L	Ind.	162	....
Timothy hay	32.3	0	L	Ind.	162	....
Timothy hay	37.7	0	L	Ind.	162	....
Timothy hay	40.5	0	M	Mo.	115	....
Average (7)	32.1	....	....	....	....	....
Velvet bean feed meal	42.8	70.0	M	Iowa	185	....
Wheat screenings	70.8	0	M	Mont.	59	....
Wheat screenings	82.7	0	M	Mont.	47	....
Wheat screenings	88.3	0	M	Mont.	47	....
Wheat (macaroni)	66.3	0	L	S. D.	86	32
Wheat (macaroni)	85.3	0	M	S. D.	86	32
Wheat (bread)	85.9	0	M	S. D.	86	32
Wheat, whole	67.4	0	M	Neb.	257	....
Wheat	70.7	0	M	Mich.	128	....
Wheat, whole	71.1	0	L	Neb.	257	36
Wheat, whole	72.2	0	L	Neb.	257	38
Wheat	73.0	0	M	Colo.	75	....
Wheat	73.8	86.0	M	Wash.	185	3
Wheat, whole	75.2	0	M	Neb.	256	37
Wheat, ground	75.8	0	L	Neb	275	36
Wheat	76.3	0	M	Mich.	128	....
Wheat	77.0	0	M	Mich.	128	....
Wheat, ground	77.0	0	M	Neb.	257	38
Wheat	77.1	0	M	Ore.	198	34
Wheat, whole	77.4	0	M	Neb.	256	37
Wheat	79.0	0	L	Mich.	113	....
Wheat, ground	78.5	0	M	Neb.	257	....
Wheat	83.3	0	M	Mich.	128	....
Wheat, ground	84.6	0	M	Neb.	257	....
Average (20)	76.3	86.0	....	....	....	....
Calculated	....	89.8	....	....	....	....
Wheat bran	48.3	0	M	Mich.	128	....
Wheat bran	51.7	0	L	Mich.	113	....
Wheat bran	51.9	0	L	Mich.	113	....
Wheat bran	52.2	0	L	Mich.	107	....
Wheat bran	54.5	0	L	Neb.	66	35
Wheat bran	58.9	0	M	Mich.	107	....
Wheat bran	61.3	0	L	Idaho	89	....
Wheat bran	65.4	0	M	Neb.	66	35
Wheat bran	71.7	0	M	Neb.	66	35
Average (9)	57.4	....	....	....	....	....
Calculated	....	49.1	....	....	....	....

EFFECT OF BALANCING THE RATION WITH PROTEID FEEDS

When the productive energy of a carbonaceous feed is calculated in a ration low in protein, and the calculation is also made for a corresponding ration high in protein, the results are higher in the latter case. Thus, corn stover (Table 16) has a productive energy of 12.0 therms when fed with corn, 18.5 therms when fed with corn and linseed oil meal, 4.4 therms (Table 17) when fed with corn, and 15.9 therms per 100 pounds when fed with corn and linseed oil meal. Millet hay in a ration without clover (Table 29) had a productive energy of 22.0 therms; with clover it was 40.9 therms. Oat straw likewise gave higher results with linseed oil meal (Tables 16, 17) or clover hay (Table 29), than in rations containing less protein. Cottonseed meal and linseed oil meal, when used in such a way as to supply protein to a ration otherwise deficient in protein, have higher productive values than calculated ordinarily, as can be seen by reference to the discussion in connection with these feeds.

The addition of a proteid feed to an unbalanced ration increases the utilization of the energy of the entire ration. The productive energy of a feed in an unbalanced ration is lower than it is in a balanced ration. The measurement should be made in a balanced ration, since in an unbalanced ration, another factor than the productive energy of the feed is depressing the results.

A proteid feed added to an unbalanced ration has an effect greater than its own productive energy, since it increases the utilization of the other feeds to which it is added.

The productive energy of a proteid feed will be higher when it is compared in a balanced ration with an unbalanced ration, than when it is compared in another ration with a ration balanced with some other proteid feed. The excess productive energy of the supplemental proteid feed is a real benefit, which should be taken into consideration when supplemental protein is added. The quantity of the excess will depend upon conditions, such as the extent of the deficiency of the ration to which it was added.

DISCUSSION OF THE INDIVIDUAL FEEDS

The feeds are listed in alphabetical order in Table 8. Detailed calculations are given in tables referred to in Table 8 and mentioned in the text.

Alfalfa hay. A number of experiments were made with alfalfa hay, but it was usually used as the standard. Table 8 contains the results of a few comparisons of second and third cuttings of alfalfa with the first cutting, and of alfalfa hay with clover or timothy hay. Some detailed calculations are given in Tables 2, 9, 10, 20, 25, and 29, as shown in Table 8. The results are about what could be expected, and agree quite well with the calculated values.

The high productive energy of alfalfa hay (42.9 and 45.1) obtained

Table 9.—Productive energy calculated from feeding experiments, Bulletin 170, Wyoming Experiment Station.

	Standard	Alfalfa hay (2nd cutting)	Alfalfa hay (3rd cutting)	Sweet clover	Alfalfa hay	Alfalfa hay	Alfalfa hay	Alfalfa hay	Corn silage	Cotton seed meal	Corn silage	Corn silage
Lot No	1	2	3	4	5	6	8	13	10	11	12	9
Average weight, pounds (W)	73.00	69.02	72.49	71.73	73.59	72.26	69.89	70.20	72.45	75.48	72.18	75.05
Average daily gain, pounds (G)	.246	.214	.235	.294	.352	.299	.218	.220	.332	.392	.278	.404
Daily feed, pounds—corn	.745	.745	.745	.745	1.345	.960	.500	.277	.745	1.185	.652	1.354
Alfalfa hay (1st cutting)	2.078				1.833	1.919	2.210	2.412	1.302	.514	1.173	.702
Alfalfa hay (2nd cutting)		2.056										
Alfalfa hay (3rd cutting)			2.230									
Cottonseed meal										.169	.093	
Corn silage									1.355	1.355	1.355	1.355
Sweet clover				2.220								
Productive value, therms—corn (.904)	.673	.673	.673	.673	1.216	.868	.452	.250	.673	1.071	.589	1.224
Alfalfa hay (1st cutting) (.368)	.765								.479	.189	.432	.258
Cottonseed meal (.715)											.066	
Corn silage (.360)										.488		
Total therms T	1.438	.673	.673	.673	1.216	.868	.452	.250	1.152	1.748	1.087	1.482
Maintenance therms W×.0085=M	.621	.587	.616	.610	.626	.614	.594	.597	.616	.642	.614	.638
Productive value of gain T—M=B	.817											
Therms for 1 lb. gain in standard B÷G=K	3.321											
Productive energy of gain K×G=L		.711	.780	.976	1.169	.993	.724	.731	1.103	1.302	.923	1.342
Productive energy of ration M+L=O		1.298	1.396	1.586	1.795	1.607	1.318	1.328	1.719	1.944	1.537	1.980
Productive energy of supplement fed O—T=E		.625	.723	.913	.579	.739	.866	1.078	.567	.196	.450	.498
Productive energy of 100 lbs. supplement = E÷wt. feed × 100		30.4	32.4	41.1	31.6	38.5	39.2	44.7	41.8	116.0	33.2	36.8

in two tests (Table 25) may have been due to the fact that too high a productive value (34.0) was assigned to the timothy hay with which it is compared. The average productive energy calculated from the eleven feeding experiments is what would be expected.

In the experiment calculated in Table 9, corn to alfalfa were fed in four ratios, and these were calculated for the productive value of alfalfa. As previously pointed out, tests of this kind are likely to give inaccurate values for productive energy, on account of error in the estimated productive energy of the other feed. In this case, the comparison can be made only against alfalfa itself; so these results were omitted from Table 8.

Chopped alfalfa and alfalfa meal. Long alfalfa compared with cut alfalfa, gave in two tests 4 and 8 per cent higher productive energy; in another experiment it gave 8 per cent less. Detailed calculations for one experiment are given in Table 10.

Table 10.—Productive energy calculated from feeding experiments, Circular 19, Idaho Experiment Station.

	Standard	Corn silage	Alfalfa meal	Long alfalfa	Long alfalfa	Alfalfa meal	Beet syrup
Lot No.	1	2	3	4	5	6	7
Average weight, pounds (W)	82.46	82.22	87.45	83.79	83.17	87.04	85.69
Average daily gain, pounds (G)	.2211	.2380	.2683	.2970	.2979	.2518	.3052
Daily feed, pounds, barley	.362	.357	.357	.357	.357	.362	.368
Long alfalfa hay				3.76	4.17		
Cut alfalfa	3.26	3.40					
Alfalfa meal			3.23			3.32	2.66
Corn silage		.264	.256	.256			
Beet syrup							.666
Productive value, therms, barley (.760)	.275	.271	.271	.271	.271	.275	.280
Cut alfalfa (.354)	1.154	1.204					
Alfalfa meal (.354)							.942
Corn silage (.030)			.008	.008			
Total therms T	1.429	1.475	.279	.279	.271	.275	1.222
Maintenance therms, W×.0085=M	.701	.699	.743	.712	.707	.740	.728
Productive value of gain T—M=B	.728						
Therms for 1 lb. gain in standard B÷G=K	3.293						
Productive energy of gain K×G=L		.784	.884	.978	.981	.829	1.005
Productive energy of ration M+L=O		1.483	1.627	1.690	1.688	1.569	1.733
Productive energy of supplement fed O—T=E		.008	1.348	1.411	1.417	1.294	.511
Productive energy of 100 lbs. supplement =E÷wt. feed×100		3.0	41.7	37.5	34.0	39.0	76.7

Alfalfa meal gave in one test 3.6 therms, or about 11 per cent higher value (Table 10) than alfalfa hay; in another test, 6.3 therms, or about 17 per cent (Table 10); in the third test, the comparison is made with native hay and not alfalfa (Table 12). Some uncertainty (Table 10) is introduced by the use of corn silage in one of the tests, though the productive value of the corn silage is that calculated from this particular experiment. If the average of the two tests is accepted, grinding to a meal would add 14 per cent to the productive energy of alfalfa hay.

Table 11. Productive energy of feeds calculated from feeding experiments, Bulletin 103, Wyoming Experiment Station.

	Standard	Barley	Soaked barley	Cracked barley	Barley meal
Lot No	1	2	3	4	5
Average weight, pounds (W)	62.95	64.9	62.3	61.7	61.2
Average daily gain, pounds (G)	.36	.34	.33	.32	.33
Daily feed, pounds—corn	.72				
Barley		.72			
Soaked barley			.72		
Cracked barley				.72	
Barley meal					.72
Alfalfa hay	2 70	2.70	2.70	2.70	2.70
Productive value, therms—corn (.822)	.592				
Alfalfa hay (.345)	.932	.932	.932	.932	.932
Total therms T	1.524	.932	.932	.932	.932
Maintenance therms W×.00933=M	.587	.606	.581	.576	.571
Productive value of gain T—M=B	.937				
Therms for 1 lb. gain in standard B÷G=K	2.603				
Productive energy of gain K×G=L		.885	.859	.834	.859
Productive energy of ration M+L=O		1.491	1.440	1.410	1.430
Productive energy of supplement fed O—T=E		.559	.508	.478	.498
Productive energy of 100 pounds supplement =E÷wt. feed × 100		77.6	70.6	66.4	69.2

Table 12. Productive energy calculated from feeding experiments, Bulletin 89, Wyoming Experiment Station.

	Standard	Bald barley	Scotch barley	Linseed oil cake	Alfalfa meal
Lot No	1	2	3	4	5
Average weight, pounds (W)	89.4	85.9	85.3	89.2	87.7
Average daily gain, pounds (G)	.25	.17	.19	.27	.23
Daily feed, pounds—native hay	1.89	1.88	1.88	1.94	1.92
Corn	.92			.72	.69
Bald barley		.93			
Scotch barley			.93		
Linseed oil cake				.24	
Alfalfa meal					.23
Productive value, therms—native hay (.423)	.799	.795	.795	.821	.812
Corn (.822)	.756			.592	.567
Total therms T	1.555	.795	.795	1.413	1.379
Maintenance therms W×.0085=M	.760	.730	.725	.758	.745
Productive value of gain T—M=B	.795				
Therms for 1 lb. gain in standard B÷G=K	3.180				
Productive energy of gain K×G=L		.541	.604	.859	.731
Productive energy of ration M+L=O		1.271	1.329	1.617	1.476
Productive energy of supplement fed O—T=E		.476	.534	.204	.097
Productive energy of 100 lbs. supplement=E÷wt. feed × 100		51.2	57.4	85.0	42.2

Table 13. Productive energy calculated from feeding experiments, Bulletin 220, Michigan Experiment Station.

	Standard	Beet pulp	Beet pulp	Dried molasses beet pulp	Beet pulp
Lot No.	1	2	3	4	5
Average weight, pounds (W)	80.13	82.92	81.68	81.53	82.25
Average daily gain, pounds (G)	.330	.348	.329	.343	.332
Daily feed, pounds—clover hay	1.539	1.403	1.505	1.300	1.400
Corn	.728	.366	....	....	....
Bran	.364	.185	.364	....	....
Linseed meal	.182	.913	.182	.319	.319
Beet pulp	....	.640	.728	....	.955
Dried molasses beet pulp	....	....	....	.955	....
Productive value, therms—clover hay (.354)	.545	.497	.533	.460	.496
Corn (.822)	.600	.301	....	....	....
Bran (.489)	.178	.090	.178	....	....
Linseed meal (.780)	.142	.070	.142	.250	.250
Total therms T	1.465	.958	.853	.710	.746
Maintenance therms W × .0085 = M	.681	.705	.694	.693	.699
Productive value of gain T—M = B	.784	....	....	....	....
Therms for 1 lb. gain in standard B ÷ G = K	2.376	....	....	....	....
Productive energy of gain K × G = L	....	.827	.782	.815	.789
Productive energy of ration M + L = O	....	1.532	1.476	1.508	1.488
Productive energy of supplement fed O—T = E	....	.574	.623	.798	.742
Productive energy of 100 lbs. supplement = E ÷ wt. feed × 100	....	89.7	85.6	83.6	77.7

The correction of the productive energy for grinding used in previous work was 0.318 therms for each per cent of crude fiber (6). The results of the feeding experiment with sheep would indicate that the correction is too high, and should be about 0.488 therms instead of 0.318. According to Henry and Morrison, page 271 (9), chopping alfalfa hay may increase its value for fattening cattle or sheep 15 to 25 per cent. This probably includes the reduction in loss by waste.

Beets—mangels. The value (Table 33) secured from the feeding experiment is about 50 per cent greater than the value calculated from the average analysis of Henry and Morrison (9) and the previous production coefficients, but one experiment is not sufficient to justify correction of the production coefficients, especially as the comparison had to be made with mixed hay, of uncertain productive energy.

Bean straw. The value secured from the feeding experiment is much higher than the value calculated from the average analysis (9) with the production coefficients for soy bean straw previously used (8). The production coefficients for soy bean straw are probably low. To judge from the experiments (Table 29) the comparison is correctly made. Corrected coefficients are given in Table 39.

Barley. Detailed calculations with experiments with barley are given in Tables 3, 11, 12 and others as shown in Table 8. The productive value of barley as found in the various tests varies widely, from 48.9 to 129.3. The average productive energy from 25 tests is 74.7 therms compared with 80.3 therms calculated from analyses made for eleven tests using the previous production coefficients. This is a deficiency of 7 per cent. In view of the many experiments, a change in the production coefficients appears justified and is given in Table 39.

Beet pulp, wet. The results secured with the feeding experiments are variable, and somewhat higher than those calculated.

Table 14. Productive energy calculated from feeding experiments, **Bulletin 197, Nebraska Experiment Station.**

	Standard	Corn silage	Molasses	Corn silage	Linseed oil meal	Linseed oil meal
Lot No	1	2	3	4	5	6
Average weight, pounds (W)	67.71	68.21	69.46	68.58	71.50	70.32
Average daily gain, pounds (G)	.331	.347	.367	.357	.403	.397
Daily feed, pounds—shelled corn	1.20	1.18	1.23	1.16	1.31	1.21
Molasses			.095	.095		
Alfalfa			.095	.095		
Linseed oil meal					.16	.15
Corn silage		1.15		1.14		1.21
Alfalfa hay	1.11	.87	1.08	.81	1.11	.79
Productive value, therms—shelled corn (.822)	.986	.970	1.011	.954	1.077	.995
Molasses (.570)				.054		
Alfalfa (.345)			.033	.033		
Corn silage (.100)						.121
Alfalfa hay (.332)	.369	.289	.359	.269	.369	.262
Total therms T	1.355	1.259	1.403	1.310	1.446	1.378
Maintenance therms W×.00933=M	.632	.636	.648	.640	.667	.656
Productive value of gain T—M =B	.723					
Therms for 1 lb. gain in standard B÷G=K	2.184					
Productive energy of gain K×G=L		.758	.802	.780	.880	.867
Productive energy of ration M÷L=O		1.394	1.450	1.420	1.547	1.523
Productive energy of supplement fed O—T =E		.135	.047	.110	.101	.145
Productive energy of 100 lbs. supplement= E÷wt. feed × 100		11.7	49.5	9.7	63.1	96.7

Beet pulp, dried. Detailed calculations of one of the experiments with beet pulp is given in Table 13. Other variables than the dried beet pulp are present and in this respect the experiment is not a good basis for calculating the productive energy. The four results in Table 8 are all higher than those calculated from the production coefficients. The average calculated from the feeding experiments is 83.7 therms per hundred pounds while that calculated from the production coefficient is 66.2. This is a deficiency of 26 per cent. The results appear to justify a change in the production coefficients but more tests are needed in which beet pulp is the only variable. The corrected production coefficients are given in Table 30.

Molasses beet pulp, dried. This feed is composed of dried beet pulp and molasses. Like the dried beet pulp, the productive energy calculated from the feeding experiments are higher than those calculated from the production coefficients. One calculation is given in Table 13, in which test there are too many variables.

Clover hay. The productive energy for clover hay calculated from the feeding experiments varies from 20.3 to 41.7 with an average of 30.7 therms per 100 pounds for the nineteen tests. Detailed calculations are given in Tables 18, 19, 22, and others cited in Table 8. The variations are wide but there are no doubt wide variations in the composition and quality of clover hay. The results are about what might be expected, considering the variations in the composition of the hay, and the sources of error in the feeding experiments. The average productive energy in the seventeen tests is lower in seven tests than that calculated from the analysis and previous production coefficients, and with one exception, the value found is lower than that calculated in the individual tests. The average values would indicate that the production coefficients may be about 10 per cent too high. (See corrected coefficients, Table 39.)

Table 15—Productive energy calculated from feeding experiments, Bulletin 162, Indiana Experiment Station.

	Timothy hay	Cotton-seed meal	Stand-ard	Cotton-seed meal	Corn silage	Corn silage (once daily)	Corn silage (twice daily)
Lot No.	1	2	3	4	5	6	7
Average weight, pounds (W)	64.4	68.9	70.8	71.6	71.5	71.2	71.7
Average daily gain, pounds (G)	.198	.294	.327	.343	.342	.334	.339
Daily feed, pounds—shelled corn	1.008	1.055	1.118	1.055	1.118	1.055	1.055
Oats	.066	.066	.066	.066	.066	.066	.066
Cottonseed meal	....	.146	....	.146	....	.146	.146
Clover hay	....	....	1.39	1.39	.96	.97	.76
Timothy hay	.81	.91	....	....	....	....	....
Corn silage	....	....	....	....	.80	.80	1.07
Productive value, therms—shelled corn (.822)	.829	.867	.919	.867	.919	.867	.867
Oats (.546)	.036	.036	.036	.036	.036	.036	.036
Cottonseed meal (.717)	....	....	....	....	....	.105	.105
Clover hay (.354)	....	....	.492	.492	.340	.343	.269
Timothy hay (.310)	....	.282	....	....	....	....	....
Total therms T	.865	1.185	1.447	1.395	1.295	1.351	1.277
Maintenance therms W×.0085=M	.547	.586	.602	.609	.608	.605	.609
Productive value of gain T—M=B	....	....	.845	....	....	....	....
Therms for 1 lb. gain in standard B÷G=K	....	....	2.584	....	....	....	....
Productive energy of gain K×G=L	.512	.760	....	.886	.884	.863	.876
Productive energy of ration M+L=O	1.059	1.346	....	1.495	1.492	1.468	1.485
Productive energy of supplement fed O—T=E	.194	.161	....	.100	.197	.117	.208
Productive energy of 100 lbs. supplement = E÷wt. feed×100	24.0	110.3	....	68.5	24.6	14.6	19.4

Ground corn. The evidence of these two tests (Table 8) is that grinding the corn did not increase its productive energy for sheep.

Corn silage. The productive energy of corn silage, calculated from the feeding experiments, varies from 3.0 to 41.8, with an average of 18.4 therms per 100 pounds for the 44 tests. Many of these experiments given

Table 16. Productive energy calculated from feeding experiments, Bulletin 245, Ohio Experiment Station.

	Clover hay	Standard	Oat straw	Corn stover	Linseed oil meal	Linseed oil meal	Oat straw	Corn stover
Lot No	1	2	3	4	5	6	7	8
Average weight, pounds (W)	70.04	77.04	68.03	68.43	76.67	77.95	72.04	72.73
Average daily gain, pounds (G)	.332	.372	.220	.258	.339	.387	2.47	.308
Daily feed, pounds, corn	1.24	1.22	1.13	1.17	1.035	1.035	1.035	1.035
Linseed oil meal	....	....	....	....	.207	.206	.207	.207
Alfalfa hay	....	1.35	....	....	....	1.48	....	....
Clover hay	1.27	....	....	....	1.39	....	....	....
Corn stover	....	....	....	1.19	....	....	....	1.36
Oat straw	....	....	1.07	....	....	....	1.04	....
Productive value, therms, corn (.860)	1.066	1.049	.972	1.006	.890	.890	.890	.890
Linseed oil meal (.737)	....	....	....	....	....	....	.153	.153
Alfalfa hay (.314)	....	.424	....	....	....	.465	....	....
Clover hay (.250)	....	....	....	....	.348	....	....	....
Total therms T	1.066	1.473	.972	1.006	1.238	1.355	1.043	1.043
Maintenance therms, W ×.0085 = M	.595	.655	.578	.582	.652	.663	.612	.618
Productive value of gain T—M = B	....	.818	....	....	....	....	....	....
Therms for 1 lb. gain in standard B ÷ G = K	....	2.199	....	....	....	....	....	....
Productive energy of gain K × G = L	.730	....	.484	.567	.745	.851	.543	.677
Productive energy of ration M + L = O	1.325	....	1.062	1.149	1.397	1.514	1.155	1.295
Productive energy of supplement fed O—T = E	.259	....	.090	.143	.159	.159	.112	.252
Productive energy of 100 lbs. supplement = E ÷ wt. feed × 100	20.4	....	8.4	12.0	76.8	77.2	10.8	18.5

in Table 8 have a productive value near the average. A few give very low values, while a few others give very high values. Some details are given in Tables 2, 10, 14, and others. In some of the experiments with corn silage, the animals seemed to take a greater fill than on the roughage, which would, of course, increase the apparent gain in weight and give too high a productive value. There is also a wide variation in the composition of corn silage. The calculated productive energy per 100 pounds of immature corn silage, Henry and Morrison's average, is 11.03 and for well matured corn silage it is 15.48, but the maximum and minimum vary considerably from these figures. The Iowa Experiment Station (Bull. 210) gives an analysis which calculates to a productive energy of 29.93. No change in the production coefficient for corn silage seems to be necessary.

Corn stalks. These have a higher productive energy in the one experiment (Table 29) than would be expected. The comparison was made with alfalfa. The production energy was higher in the test in which it was fed with clover hay (32.9) than when it was fed alone (25.3).

Corn stover and corn fodder. Seven calculations from feeding tests with these materials are given in Table 8. Detailed calculations are given in Tables 2, 16, 17, and 18. With one exception, the productive energy for corn fodder or corn stover, calculated from the feeding test, is much less than that calculated from the analysis and production coefficients previously used. The average calculated from the six feeding tests is 17.2 therms compared with 27.9 calculated from production coefficients, a deficiency of about 38 per cent. It is a question how much of this difference is due to a low productive value of the feed consumed, and how much due to waste in feeding, or refusal of the animal to eat the feed. The production coefficients are based upon the digestion coefficients for feed eaten. Waste in feeds is a separate consideration, and should be allowed for separately. The calculated productive energy is higher when it is fed with linseed oil meal and corn than when it is fed with corn alone (see Tables 16, 17), increasing from 12.0 to 18.5 in one case, and 4.4 to 15.9 in the other. Corrected production coefficients for corn stover and corn fodder are given in Table 39. Since some of the tests were in unbalanced rations, the factor 0.75 was used instead of 0.62.

Corn gluten feed. The productive energy calculated from the feeding tests was about what was expected. A detailed calculation is given in Table 26.

Cottonseed meal. The productive energy of cottonseed meal was calculated from 26 tests with sheep, as given in Table 8. Details of some of the calculations are given in Tables 9, 15, 22, and others, as listed in Table 8.

One of the tests gave a low productive value, and a number gave values about what would be expected, but most of the experiments gave

Table 17. Productive energy calculated from feeding experiments, Bulletin 245, Ohio Experiment Station.

	Clover hay	Standard	Oat straw	Corn stover	Linseed oil meal	Linseed oil meal	Oat straw	Corn stover
Lot No.	1	2	3	4	5	6	7	8
Average weight, pounds (W)	78.50	78.82	71.83	71.75	77.86	79.65	74.20	74.40
Average daily gain, pounds (G)	.318	.343	.182	.225	.293	.338	.236	.259
Daily feed, pounds, corn	1.29	1.30	1.29	1.29	1.084	1.084	1.084	1.084
Linseed oil meal	.....	.....	.....	.....	.216	.216	.216	.216
Alfalfa hay	.....	1.29	.....	.....	.....	1.29	.....	.....
Clover hay	1.22	.....	.....	.....	1.21	.....	.....	.....
Corn stover	.....	.....	.....	1.38	.....	.....	.....	1.16
Oat straw	.....	.....	1.06	.....	.....	.....	1.11	.....
Productive value, therms, corn (.860)	1.109	1.118	1.109	1.109	.932	.932	.932	.932
Linseed oil meal (.737)	.....	.....	.....	.....	.....	.....	.159	.159
Alfalfa hay (.314)	.....	.405	.....	.....	.....	.405	.....	.....
Clover hay (.286)	.....	.....	.....	.....	.346	.....	.....	.....
Total therms T	1.109	1.523	1.109	1.109	1.278	1.337	1.091	1.091
Maintenance therms W ×.0085 = M	.667	.670	.611	.610	.662	.677	.631	.632
Productive value of gain T—M = B	.....	.853	.....	.....	.....	.....	.....	.....
Therms for 1 lb. gain in standard B ÷ G = K	.....	2.487	.....	.....	.....	.....	.....	.....
Productive energy of gain K × G = L	.791	.....	.453	.560	.729	.841	.587	.644
Productive energy of ration M + L = O	1.458	.....	1.064	1.170	1.391	1.518	1.218	1.276
Productive energy of supplement fed O—T = E	.349	.....	—045	.061	.113	.181	.127	.185
Productive energy of 100 lbs. supplement = E ÷ wt. feed ×100	28.6	.....	0	4.4	52.3	83.8	11.4	15.9

high results. These high results were secured with small additions of cottonseed meal, when a small difference in gain would make a large difference in productive energy, but the fact that the results are consistently high, indicates that they are not due to errors. The average productive energy in the 36 tests on sheep was 100.7, compared with 72.8 calculated from the production coefficient, or about 49 per cent excess.

Table 18. Productive energy calculated from feeding experiments, Bulletin 245, Ohio Experiment Station.

	Corn stover	Soy bean straw	Clover hay	Standard
Lot No.	1	2	3	4
Average weight, pounds (W)	81.96	83.04	85.82	85.38
Average daily gain, pounds (G)	.259	.277	.359	.329
Daily feed, pounds, corn	1.15	1.15	1.38	1.34
Linseed oil meal	.23	.23	....	....
Alfalfa hay	....	....	....	1.35
Clover hay	....	....	1.28	....
Corn stover	1.21	....	....	....
Soy bean straw	....	1.16	....	....
Productive value, therms, corn (.860)	.989	.989	1.187	1.152
Linseed meal (.737)	.170	.170	....	....
Alfalfa hay (.314)	....	....	....	.424
Total therms T	1.159	1.159	1.187	1.576
Maintenance therms, W ×.0085 = M	.697	.706	.729	.726
Productive value of gain T—M = B	....	....	....	.850
Therms for 1 lb. gain in standard B ÷ G = K	....	....	....	2.584
Productive energy of gain K × G = L	.669	.716	.928	....
Productive energy of ration M + L = O	1.366	1.422	1.657	....
Productive energy of supplement fed O—T = E	.207	.263	.470	....
Productive energy of 100 lbs. supplement = E ÷ wt. feed × 100	17.1	22.7	36.7	....

It appears probable that the supplementary action of the protein in cottonseed meal either increases the digestibility of the mixture or the capacity of the animal to utilize the productive energy of the other feeds, or else it decreases the maintenance requirements of the animals, perhaps by making them more quiet and less restless, so as to leave more of the productive energy of the feed to be used for productive purposes. In either case, the net result is that cottonseed meal added in small amounts to supplement a ration, has an effect upon fattening higher than its own productive value. This effect may appear not only when the cottonseed meal is fed with roughage low in protein (Table 15) but also when it is added to a ration containing alfalfa and corn silage (Table 26) or clover hay and corn silage (Tables 19, 22). It occurs only when fed in moderate amounts; when fed in large quantity, the productive value is lower and apparently the same as that calculated from previous production coefficients (Table 19, Lot 8).

Table 19. Productive energy calculated from feeding experiments, Bulletin 179, Indiana Experiment Station.

	Cottonseed meal	Oats	Clover hay	Standard	Oat straw	Corn silage (open shed)	Cottonseed meal	Cottonseed meal	Corn silage (barn)
Lot No.	1	2	3	4	5	6	7	8	9
Average weight, pounds (W)	70.9	75.2	75.2	74.2	70.5	74.8	76.6	76.6	74.1
Average daily gain, pounds (G)	.240	.334	.344	.313	.241	.333	.374	.365	.315
Daily feed, pounds, shelled corn	.88	.79	1.15	1.08	.89	1.11	1.03	.95	1.13
Oats	.07	.45	.07	.07	.07	.07	.07	.07	.07
Cottonseed meal	.12				.13		.14	.23	
Corn silage	1.80	1.21			1.60	1.21	1.22	1.22	1.22
Clover hay	.04	1.06	1.76			1.04	1.15	1.15	1.05
Alfalfa hay				1.72					
Oat straw					.45				
Productive value, therms, shelled corn (.822)	.723	.649	.945	.888	.732	.912	.847	.781	.929
Oats (.546)	.038		.038	.038	.038	.038	.038	.038	.038
Cottonseed meal (.717)					.093				
Corn silage (.220)	.396	.266			.352		.268	.268	
Clover hay (.354)	.014	.375				.368	.407	.404	.372
Alfalfa hay (.345)				.593					
Total therms T	1.171	1.290	.983	1.519	1.215	1.318	1.560	1.491	1.339
Maintenance therms, W ×.0085 = M	.603	.639	.639	.631	.599	.636	.651	.651	.630
Productive value of gain T—M = B				.888					
Therms per 1 lb. gain in standard B ÷ G = K				2.837					
Productive energy of gain K × G = L	.681	.948	.976		.684	.945	1.061	1.036	.894
Productive energy of ration M + L = O	1.284	1.587	1.615		1.283	1.581	1.712	1.687	1.524
Productive energy of supplement fed O—T = E	.113	.297	.632		.068	.263	.152	.196	.185
Productive energy of 100 lbs. supplement = E ÷ wt. feed ×100	94.2	66.0	35.9		15.1	21.7	108.6	85.2	15.2

Table 20. Productive energy calculated from feeding experiments, Bulletin 173, Nebraska Experiment Station.

	Standard	Corn silage	Oil meal	Cotton-seed meal	Cold-pressed cotton-seed cake	Prairie hay	Hominy feed	Sugar beets	Alfalfa hay
Lot No.	1	4	5	6	7	8	9	10	11
Average weight, pounds (W)	72.97	75.39	76.59	76.13	75.19	71.81	73.36	73.72	75.76
Average daily gain, pounds (G)	.337	.388	.407	.437	.43	.50	.36	.366	.377
Daily feed, pounds, corn	1.329	1.241	1.219	1.293	1.221	1.326	....	1.261	1.487
Oil meal	....	....	.218	....	....	1.047	....	....	....
Cottonseed meal	....	....	....	.226	....	....	....	....	....
Cold-pressed cottonseed cake	....	....	....	....	.322	....	....	....	....
Hominy feed	....	....	....	....	....	....	1.286	....	....
Sugar beets	....	....	....	....	....	....	....	1.091	....
Prairie hay	....	....	....	....	....	.363	....	....	....
Alfalfa hay	1.007	.681	1.078	1.071	1.035	....	1.083	.956	1.074
Corn silage	....	1.525	....	....	....	....	....	....	....
Productive value, therms, corn (.822)	1.092	1.020	1.002	1.063	1.004	1.090	....	1.037	1.222
Oil meal (.780)	....	....	....	....	....	.817	....	....	....
Alfalfa hay (.345)	.347	.235	.372	.369	.357	....	.374	.330	....
Total therms T	1.439	1.255	1.374	1.432	1.361	1.907	.374	1.367	1.222
Maintenance therms, W ×.0085 = M	.620	.641	.651	.647	.639	.610	.624	.627	.644
Productive value of gain T—M = B	.819	....	....	....	....	....	....	....	....
Therms for 1 lb. gain in standard B ÷ G = K	2.430	....	....	....	....	....	....	....	....
Productive energy of gain K × G = L	....	.943	.989	1.062	1.045	1.215	.875	.889	.916
Productive energy of ration M + L = O	....	1.584	1.640	1.709	1.684	1.825	1.499	1.516	1.560
Productive energy of supplement fed O—T = E	....	.329	.266	.277	.323	—.082	1.125	.149	.338
Productive energy of 100 lbs. supplement = E ÷ wt. feed × 100	....	21.6	122.0	122.6	100.3	0	87.5	13.7	31.5

Table 21. Productive energy calculated from feeding experiments, Bulletin 192, Indiana Experiment Station.

	Cotton-seed meal	Molasses (cane)	Clover hay	Standard	Oat straw	Corn silage	Cotton-seed meal	Ground soy beans	Corn silage
Lot No.	1	2	3	4	5	6	7	8	9
Average weight, pounds (W)	64.9	69.0	68.4	69.1	64.7	68.7	68.6	68.4	68.2
Average daily gain, pounds (G)	.175	.256	.240	.260	.172	.247	.252	.243	.239
Daily feed, pounds, shelled corn	.773	.683	.930	.930	.809	.930	.819	.819	.930
Oats	.075	.075	.075	.075	.075	.075	.075	.075	.075
Cottonseed meal	.107	.114	...	...	.113	...	.114	...	...
Ground soy beans	...	...	...	...	...	...	...	.114	...
Molasses (cane)	...	.152	...	...	...	...	...	...	...
Corn silage	1.879	1.120	...	...	1.270	1.120	1.120	1.120	1.090
Clover hay	.102	1.190	1.820	...	.048	1.170	1.170	1.160	1.170
Alfalfa hay	...	...	...	1.700	...	...	...	...	...
Oat straw	...	...	...	...	.577	...	...	...	...
Productive value, therms, shelled corn (.822)	.635	.561	.764	.764	.665	.764	.673	.673	.764
Oats (.546)	.041	.041	.041	.041	.041	.041	.041	.041	.041
Cottonseed meal (.990)	...	.113	...	...	.112	...	...	...	...
Corn silage (.170)	.319	.190	...	...	.216	...	.190	.190	...
Clover hay (.290	.030	.345	...	...	.014	.339	.339	.336	.339
Alfalfa hay (.345)	...	...	...	.587	...	...	...	...	...
Total therms T	1.025	1.250	.805	1.392	1.048	1.144	1.243	1.240	1.144
Maintenance therms, W ×.00933 = M	.606	.644	.638	.645	.604	.641	.640	.638	.636
Productive value of gain T—M = B	...	...	...	.747	...	...	...	...	...
Therms for 1 lb. gain in standard B ÷ G = K	...	...	...	2.873	...	...	...	...	...
Productive energy of gain K × G = L	.503	.735	.690	...	.494	.710	.724	.698	.687
Productive energy of ration M + L = O	1.109	1.379	1.328	...	1.098	1.351	1.364	1.336	1.323
Productive energy of supplement fed O—T = E	.084	.129	.523	...	.050	.207	.121	.096	.179
Productive energy of 100 lbs. supplement = E ÷ wt. feed ×100	78.5	84.9	28.7	...	8.7	18.5	106.1	84.2	16.4

A similar high supplemental value is observed in some experiments with linseed oil meal (Table 9) and with soy beans, but it does not occur in so many of the feeding experiments here reported as with cottonseed meal.

The supplemental value of cottonseed meal varies so it does not seem to be advisable to give corrected production coefficients for cottonseed meal when it is used to balance a ration.

Hay, native or prairie. The productive energy varies from 19.4 to 39.1 therms. These results are approximately what could be expected. Native hay varies so much in composition and constituent grasses that it is difficult to decide on the digestion coefficients or production coefficients to be used for the particular hay. On an average of the eleven tests the productive value of the native hay was about ten therms lower than the value calculated from the assumed production coefficients, which is about 30 per cent. If digestible nutrients were used, the discrepancy would be still greater.

Hominy feed. The productive energy calculated from the results of the feeding experiments with the sheep, check with the productive energy calculated from the production coefficients. The average of the four tests agrees quite well with the calculated result from the analyses. Detailed calculations are given in Tables 20 and 26.

Kafir, grain. There seems to be little difference in the productive energy of the ground and the whole kafir. The average productive energy agrees closely with the value calculated from the production coefficients.

Linseed meal. Linseed meal, like cottonseed meal, gives a higher productive value in many of the feeding experiments than would be expected from the calculated value, no doubt due, as with cottonseed meal, to the supplemental value of the protein. The difference is not so great as with cottonseed meal. The average productive energy calculated from the 24 feeding experiments with sheep was 88.3, while calculated from the production coefficients it was 73.6, a difference of 14.7 therms or nearly 20 per cent. The average difference with cottonseed meal was about 40 per cent.

Millet hay. There is a wide difference between the results calculated from the two tests in the same experiment (see Table 29). The difference is due to supplementing the ration with clover hay. The productive value without clover hay was 22.0 therms; with clover hay it was 40.9 therms.

Molasses. The productive energy calculated from the feeding experiments in four tests is approximately the same as that calculated from the production coefficients, in two tests it is materially lower, while in five tests it is materially higher. The average is about 17 per cent higher for the feeding experiments than for the calculated. It seems that a

Table 22. Productive energy calculated from feeding experiments, Bulletin 184, Indiana Experiment Station.

	Cottonseed meal	Oats	Clover hay	Standard	Oat Straw	Corn silage	Cottonseed meal	Cottonseed meal	Corn silage
Lot No.	1	2	3	4	5	6	7	8	9
Average weight, pounds (W)	66.6	70.5	70.3	69.5	70.1	71.3	71.7	72.2	71.1
Average daily gain, pounds (G)	.256	.307	.304	.286	.301	.327	.335	.350	.324
Daily feed, pounds, shelled corn	.846	.640	1.028	1.028	.903	1.028	.903	.840	1.028
Oats	.053	.360	.053	.053	.053	.053	.053	.053	.053
Cottonseed meal	.120	....	....	....	.128	....	.128	.207	....
Corn silage	2.170	1.380	....	....	1.880	1.380	1.380	1.380	1.380
Clover hay	.040	1.030	1.81	....	.020	1.120	1.120	1.120	1.120
Alfalfa hay	....	....	....	1.810	....	....	....	....	....
Oat straw	....	....	....	....	.530	....	....	....	....
Productive value, therms—shelled corn (.822)	.695	.526	.845	.845	.742	.845	.742	.690	.845
Oats (.546)	.029	....	.029	.029	.029	.029	.029	.029	.029
Cottonseed meal (1.10)	....	....	....	....	.141	....	....	....	....
Corn silage (.26)	.564	.359	....	....	.489	....	.359	.359	....
Clover hay (.352)	.014	.363	....	....	.007	.394	.394	.394	.394
Alfalfa hay (.345)	....	....	....	.624	....	....	....	....	....
Total therms T	1.302	1.248	.874	1.498	1.408	1.268	1.524	1.472	1.268
Maintenance therms, W ×.00933 = M	.621	.658	.656	.648	.654	.665	.669	.674	.663
Productive value of gain T—M = B	....	....	....	.850	....	....	....	....	....
Therms for 1 lb. gain in standard B ÷ G = K	....	....	....	2.972	....	....	....	....	....
Productive energy of gain K × G = L	.761	.912	.903	....	.895	.972	.996	1.040	.963
Productive energy of ration M + L = O	1.382	1.570	1.559	....	1.549	1.637	1.665	1.714	1.626
Productive energy of supplement fed O—T = E	.080	.322	.685	....	.141	.369	.141	.242	.358
Productive energy of 100 lbs. supplement = E ÷ wt. feed ×100	66.7	89.4	37.8	....	26.6	26.7	110.2	116.9	25.9

Table 23. Productive energy calculated from feeding experiments, Bulletin 202, Indiana Experiment Station.

	Corn silage	(Shorn lambs)	Clover hay	Standard	Corn silage	Cotton-seed meal (clover every 5th day)	Cotton-seed meal	Ground soy beans	Shorn and fed in barn
Lot No	1	2	3	4	5	6	7	8	9
Average weight, pounds (W)	68.8	77.0	76.4	77.1	76.9	74.0	77.8	77.3	75.5
Average daily gain, pounds (G)	.145	.281	.287	.305	.288	.238	.304	.293	.276
Daily feed, pounds, shelled corn	.805	.916	1.044	1.064	1.075	.949	.977	.916	.916
Oats	.050	.048	.048	.048	.048	.048	.048	.048	.048
Cottonseed meal	.113	.129				.134	.138		.129
Ground soy beans								.129	
Corn silage	1.922	1.496			1.401	1.792	1.426	1.356	1.50
Clover hay	.038	1.157	1.65			.231	.987	.961	1.045
Alfalfa hay				1.594	.952				
Productive value, therms, shelled corn (.822)	.662	.753	.858	.875	.884	.780	.803	.753	.753
Oats (.546)	.027	.026	.026	.026	.026	.026	.026	.026	.026
Cottonseed meal (.717)	.081	.092							.092
Corn silage (.120)		.180				.215	.171	.163	.180
Clover hay (.310)	.012	.359				.072	.306	.298	.324
Alfalfa hay (.345)				.550	.328				
Total therms T	.782	1.410	.884	1.451	1.238	1.093	1.306	1.240	1.375
Maintenance therms, W ×.0085 = M	.585	.655	.649	.655	.654	.629	.661	.657	.642
Productive value of gain T—M = B		.755		.796					.733
Therms for 1 lb. gain in standard B ÷ G = K		2.684		2.610					2.656
Productive energy of gain K × G = L	.378		.749		.752	.621	.793	.765	
Productive energy of ration M + L = O	.963		1.398		1.406	1.250	1.454	1.422	
Productive energy of supplement fed O—T = E	.181		.514		.168	.157	.148	.182	
Productive energy of 100 lbs. supplement = E ÷ wt. feed ×100	9.4		31.2		12.0	117.2	107.2	141.1	

higher productive value is justified, and a change in the production coefficient is made, as given in Table 39.

Oats. The productive energy calculated from the feeding experiment on an average agrees well with that calculated from the production coefficients. In the 20 tests, the productive energy calculated from the feeding experiments averaged 73.3 therms, while the value calculated from the production coefficients was 73.6 therms, or practically the same.

Silage, oat and pea. The productive energy calculated from the feeding experiment agrees well with the productive energy calculated from the production coefficients. The average productive energy calculated from the five tests with sheep was 16, compared with 15.5 calculated from the production coefficients.

Table 24. Productive energy calculated from feeding experiments, Circular 109, Kansas Experiment Station.

	Standard	Whole kafir	Ground kafir	Kafir heads	Sweet clover hay	Sweet clover hay	Sweet clover hay
Lot No.	1	2	3	4	5	6	7
Average weight, pounds (W)	75.16	74.67	73.20	76.66	78.26	75.16	74.39
Average daily gain, pounds (G)	.36	.34	.34	.34	.36	.34	.36
Daily feed, pounds—shelled corn	1.30	....	....	....	1.29	1.29	1.29
Whole kafir	....	1.30	....	....	....	....	....
Ground kafir	....	....	1.30	....	....	....	....
Kafir heads	....	....	....	2.05	....	....	....
Cottonseed meal	.16	.16	.16	.16	.16	....	....
Sweet clover hay	....	....	....	....	1.44	1.50	2.77
Alfalfa hay	1.02	1.02	1.02	.96	....	....	....
Cane silage	.90	.91	.89	.79	1.34	1.20	....
Productive value, therms—shelled corn (.822)	1.069	....	....	....	1.060	1.060	1.060
Cottonseed meal (.717)	.115	.115	.115	.115	.115	....	....
Alfalfa hay (.345)	.352	.352	.352	.331	....	....	....
Corn silage (.103)	.093	.094	.092	.081	.138	.124	....
Total therms T	1.629	.561	.559	.527	1.313	1.184	1.060
Maintenance therms W×.0085=M	.639	.635	.622	.652	.665	.639	.632
Productive value of gain T—M=B	.990	....	....	....	....	....	....
Therms for 1 lb. gain in standard B÷G=K	2.750	....	....	....	....	....	....
Productive energy of gain K×G=L	....	.935	.935	.935	.990	.935	.990
Productive energy of ration M+L=O	....	1.570	1.557	1.587	1.655	1.574	1.622
Productive energy of supplement fed O—T=E	....	1.009	.998	1.060	.342	.390	.562
Productive energy of 100 lbs. supplement =E÷wt. feed × 100	....	77.6	76.8	51.7	23.8	26.0	20.3

Oat straw. The productive energy calculated from the feeding experiments varies widely, from 0 to 26.6 therms per hundred pounds, but is on an average lower than that calculated from the production coefficients. The average of the ten tests with sheep was 15.6 therms per 100 pounds, while that calculated from the production coefficient was 25.6 therms, a difference of 9.1 therms, or about 35 per cent. How much of this is due to failure to eat the straw cannot be stated. Higher production values were obtained when linseed meal (Tables 16, 17) or

Table 25. Productive energy calculated from feeding experiments, Bulletin 245, Ohio Experiment Station.

	Standard	Linseed oil meal	Alfalfa hay	Alfalfa hay
Lot No.	1	2	3	4
Average weight, pounds, (W)	79.40	80.90	82.22	79.50
Average daily gain, pounds (G)	.295	.344	.379	.310
Daily feed, pounds, corn	1.33	1.165	1.247	.895
Linseed meal	....	.233	.154	.157
Timothy hay	1.16	1.190	.668	.775
Alfalfa hay	....	....	.707	.830
Productive value, therms, corn (.860)	1.144	1.002	1.072	.770
Linseed meal (1.232)	....	....	.190	.193
Timothy hay (.340)	.394	.405	.227	.264
Total therms T	1.538	1.407	1.489	1.227
Maintenance therms, W ×.0085 =M	.675	.688	.699	.676
Productive value of gain T—M =B	.863	....	....	....
Therms for 1 lb. gain in standard B ÷G =K	2.925	....	....	....
Productive energy of gain K ×G =L	....	1.006	1.109	.907
Productive energy of ration M +L =O	....	1.694	1.808	1.583
Productive energy of supplement feed O—T =E	....	.287	.319	.356
Productive energy of 100 lbs. supplement =E ÷wt. feed ×100	....	123.2	45.1	42.9

Table 26. Productive energy calculated from feeding experiments, Circular 79, Kansas Experiment Station.

	Linseed meal	Corn gluten feed	Cotton-seed meal	Corn silage	Hominy feed	Linseed meal	Standard
Lot No.	1	2	3	4	5	6	7
Average weight, pounds (W)	74.42	73.27	74.51	72.18	72.81	72.91	74.67
Average daily gain, pounds (G)	.40	.32	.34	.28	.29	.31	.38
Daily feed, pounds, shelled corn	1.24	1.24	.124	.124	....	....	1.24
Hominy feed	....	....	....	....	1.24	....	....
Linseed meal	.16	....	....	....	....	1.14	....
Cottonseed meal	....	....	.16	....	....	....	....
Corn gluten feed	....	.16	....	....	....	....	....
Alfalfa hay	1.04	1.04	1.04	1.04	1.08	1.16	2.14
Corn silage (a)	1.52	1.52	1.52	1.52	1.58	1.78	....
Productive value, therms, shelled corn (.822)	1.019	1.019	1.019	1.019	....	....	1.019
Alfalfa hay (.345)	.359	.359	.359	.359	.373	.400	.738
Corn silage (.041)	.062	.062	.062	....	.065	.073	....
Total therms T	1.440	1.440	1.440	1.378	.438	.473	1.757
Maintenance therms, W×.0085=M	.633	.623	.633	.614	.619	.620	.635
Productive value of gain T—M=B	....	....	....	....	....	....	1.122
Therms for 1 lb. gain in standard B÷G=K	....	....	....	....	....	....	2.953
Productive energy of gain K×G=L	1.181	.945	1.004	.827	.856	.915	....
Productive energy of ration M+L=O	1.814	1.568	1.637	1.441	1.475	1.535	....
Productive energy of supplement fed C—T=E.	.374	.128	.197	.063	1.037	1.062	....
Productive energy of 100 lbs. supplement= E÷wt. feed×100	233.8	80.0	123.1	4.1	83.6	93.2	....

Table 27. Productive energy calculated from feeding experiments, Bulletin 211, Nebraska Experiment Station.

	Standard	Linseed meal	Corn silage	Linseed meal	Tankage	Barley	Barley
Lot No.	1	2	3	4	5	6	7
Average weight, pounds (W)	70.66	74.80	72.16	75.28	72.18	71.74	73.20
Average daily gain, pounds (G)	.240	.308	.260	.322	.261	.263	.278
Daily feed, pounds, shelled corn	1.16	1.25	1.22	1.25	1.21	....	.75
Linseed meal	....	.17	....	.18	....	....	....
Corn silage	....	....	.70	.70	....	....	....
Alfalfa hay	.95	.98	.78	.75	.96	.94	.99
Barley	....	....	....	....	....	1.43	.56
Tankage	....	....	....	....	.06	....	....
Productive value, therms, shelled corn (.822)	.954	1.028	1.003	1.028	.995	....	.617
Corn silage (.155)	....	....	....	.109	....	....	....
Alfalfa hay (.345)	.328	.338	.269	.259	.331	.324	.342
Total therms T	1.282	1.366	1.272	1.396	1.326	.324	.959
Maintenance therms, $W \times .0085 = M$	.601	.636	.613	.640	.614	.610	.622
Productive value of gain $T - M = B$	.681	....	....	....	....	....	....
Therms for 1 lb. gain in standard $B \div G = K$	2.838	....	....	....	....	....	....
Productive energy of gain $K \times G = L$	....	.874	.738	.914	.741	.746	.789
Productive energy of ration $M + L = O$	....	1.510	1.351	1.554	1.355	1.356	1.411
Productive energy of supplement fed $O - T = E$	....	.144	.079	.158	.029	1.032	.452
Productive energy of 100 lbs. supplement = $E \div$ wt. feed $\times 100$	....	84.7	11.3	87.8	48.3	72.2	80.7

Table 28. Productive energy calculated from feeding experiments, Bulletin 215, Iowa Experiment Station.

	Standard	Cane molasses	Cane molasses	Cane molasses	Beet molasses	Beet molasses	Beet molasses
Lot No.	1	2	3	4	5	6	7
Average weight, pounds (W)	71.6	72.7	75.3	74.5	73.1	75.6	74.9
Average daily gain, pounds (G)	.290	.313	.366	.355	.323	.391	.384
Daily feed, pounds, shelled corn	1.182	1.120	1.050	1.033	1.116	1.048	1.042
Linseed oil meal	.150	.150	.150	.150	.150	.150	.150
Cane molases	....	.250	.504	.713	....	....	....
Beet molasses	....	....	....	....	.250	.504	.716
Corn silage	1.504	1.537	1.539	1.533	1.537	1.531	1.537
Hay	.180	.179	.179	.178	.179	.180	.178
Block salt	.005	.005	.006	.003	.003	.002	.001
Productive value, therms, shelled corn (.822)	.972	.921	.863	.849	.917	.861	.857
Linseed oil meal (.606)	.091	.091	.091	.091	.091	.091	.091
Corn silage (.161)	.242	.247	.248	.247	.247	.246	.247
Hay (.330)	.059	.059	.059	.059	.059	.059	.059
Total therms T	1.364	1.318	1.261	1.246	1.314	1.257	1.254
Maintenance therms, $W \times .0085 = M$	.609	.618	.640	.633	.621	.643	.637
Productive value of gain $T - M = B$	.755	....	....	....	....	....	....
Therms for 1 lb. gain in standard $B \div G = K$	2.603	....	....	....	....	....	....
Productive energy of gain $K \times G = L$	....	.815	.953	.924	.841	1.018	1.000
Productive energy of ration $M + L = O$	....	1.433	1.593	1.557	1.462	1.661	1.637
Productive energy of supplement fed $O - T = E$	....	.115	.332	.311	.148	.404	.383
Productive energy of 100 lbs. supplement = $E \div$ wt. feed $\times 100$	....	46.0	65.9	43.6	59.2	80.2	53.5

Table 29. Productive energy calculated from feeding experiments, Bulletin 136, Michigan Experiment Station.

	Standard	Alfalfa	Millet hay	Millet hay	Oat straw	Oat straw	Corn stalks	Corn stalks	Bean straw	Bean straw
Lot No	1	2	3	4	5	6	7	8	9	10
Average weight, pounds (W)	91.4	91.2	91.4	85.8	89.3	88.2	89.3	90.4	90.5	89.3
Average daily gain, pounds (G)	.330	.350	.338	.263	.323	.290	.340	.307	.328	.301
Daily feed, pounds, corn	1.397	1.385	1.397	1.378	1.391	1.391	1.391	1.390	1.386	1.398
Rutabagas	1.205	1.191	1.205	1.191	1.191	1.193	1.191	1.191	1.191	1.191
Clover hay	1.196	....	.615	....	.616	....	.614	....	.617	....
Alfalfa	....	1.308	....	....	....	....	....	....	....	....
Millet hay	....	....	.553	.978	....	....	....	....	....	....
Oat straw	....	....	....	....	.667	1.421	....	....	....	....
Corn stalks	....	....	....	....	....	....	.668	1.423	....	....
Bean straw	....	....	....	....	....	....	....	....	.683	
Productive value, therms, corn (.822)	1.148	1.138	1.148	1.133	1.143	1.143	1.143	1.143	1.139	1.149
Rutabagas (.06)	.072	.071	.072	.071	.071	.072	.071	.071	.071	.071
Clover hay (.354)	.423	....	.218	....	.218	....	.217	....	.218	....
Total therms T	1.643	1.209	1.438	1.204	1.432	1.215	1.431	1.214	1.428	1.220
Maintenance therms, W ×.0085 =M	.777	.775	.777	.729	.759	.750	.759	.768	.769	.759
Productive value of gain T—M =B	.866	....	....	....	....	....	....	....	....	....
Therms for 1 lb. gain in standard B ÷G =K	2.624	....	....	....	....	....	....	....	....	....
Productive energy of gain K ×G =L	....	.918	.887	.690	.848	.761	.892	.806	.861	.790
Productive energy of ration M +L =O	....	1.693	1.664	1.419	1.607	1.511	1.651	1.574	1.630	1.549
Productive energy of supplement fed O—T =E	....	.484	.226	.215	.175	.296	.220	.360	.202	.329
Productive energy of 100 lbs. supplement =E ÷wt. feed ×100	....	37.0	40.9	22.0	26.2	20.8	32.9	25.3	29.6	22.4

clover hay (Table 29) was present. In Table 17 the value increased from 0 to 11.4. Detailed calculations are given in Tables 16, 17, 19, 22, 29, and 30. Revised production coefficients for oat straw are given in Table 39. Since unbalanced rations were used in some of the tests, the factor used is .75 instead of .65.

Peas and pea hay. The value for peas is low; it is low for one of the experiments with pea hay, but the other two are about what could be expected.

Pea and barley silage. The results are about what could be expected.

Table 30. Productive energy calculated from feeding experiments, Bulletin 260, Illinois Experiment Station.

	Standard	Soy bean hay	Whole soy bean	Oat straw	Soy bean straw	Linseed oil meal
Lot No.	1	2	3	4	5	6
Average weight, pounds (W)	75.6	74.5	72.3	71.8	72.4	72.3
Average daily gain, pounds (G)	.32	.31	.24	.24	.26	.25
Daily feed, pounds—corn, shelled	1.16	1.10	.87	.91	.92	.91
Soy bean oil meal				.23	.23	
Alfalfa hay	1.34					
Soy bean hay		1.51				
Whole soy bean			.22			
Soy bean straw			2.03		2.04	2.03
Oat straw				1.41		
Linseed oil meal						.23
Productive value, therms—corn shelled (.822)	.954	.904	.715	.748	.756	.748
Soy bean oil meal (.79)				.182	.182	
Alfalfa hay (.345)	.462					
Soy bean straw (.14)			.284			.284
Total therms T	1.416	.904	.999	.930	.938	1.032
Maintenance therms W×.0085=M	.643	.633	.615	.610	.615	.615
Productive value of gain T—M=B	.773					
Therms for 1 lb. gain in standard B÷G=K	2.416					
Productive energy of gain K×G=L		.749	.580	.580	.628	.604
Productive energy of ration M+L=O		1.382	1.195	1.190	1.243	1.219
Productive energy of supplement fed O—T=E		.478	.196	.260	.305	.187
Productive energy of 100 lbs. supplement=E÷wt. feed × 100		31.7	89.1	18.4	15.0	81.3

Peanut meal. The results are a little high.

Roots and rutabagas have values about what would be expected.

Rye. The results average about 11 per cent lower than the calculated. Corrected coefficients are given in Table 39.

Soy bean meal and soy beans, whole or ground. The average of the results checks as closely as could be expected with the calculations. There are some wide variations.

Soy bean hay. The results calculated from the three feeding tests average somewhat lower than those calculated from the production coefficients, but the results do not seem to justify a change.

Soy bean straw. Soy bean straw averages better than was calculated, and corrected production coefficients are given in Table 39. Detailed calculations are given in Tables 18, 30, and 31. The results justify a change in the production coefficients.

Emmer or spelt. The average productive energy calculated from the seven feeding experiments is about 25 per cent lower than that calculated from the production coefficients. A correction of the production coefficients seems to be justified, and is made in Table 39.

Table 31. Productive energy calculated from feeding experiments, Bulletin 260, Illinois Experiment Station.

	Standard	Soy bean hay	Soy bean straw	Ground soy bean	Soy bean oil meal	Linseed oil meal
Lot No.	1	2	3	4	5	6
Average weight, pounds (W)	74.65	74.45	71.20	71.00	70.85	70.90
Average daily gain, pounds (G)	.34	.33	.26	.25	.27	.27
Daily feed, pounds—corn	1.09	1.12	.88	.87	.90	.90
Alfalfa hay	1.45					
Soy bean hay		1.74				
Whole soy beans			.22			
Soy bean straw			2.16	2.16	2.16	2.16
Ground soy beans				.22		
Soy bean oil meal					23	
Linseed oil meal						.23
Productive value, therms—corn (.822)	.896	.921	.723	.715	.740	.740
Alfalfa hay (.345)	.500					
Whole soy beans (.83)			.183			
Soy bean straw (.13) from 3				.281	.281	.281
Total therms T	1.396	.921	.906	.996	1.021	1.021
Maintenance therms W×.0085=M	.635	.633	.605	.604	.602	.603
Productive value of gain T—M=B	.761					
Therms for 1 lb. gain in standard B÷G=K	2.238					
Productive energy of gain K×G=L		.739	.582	.560	.604	.604
Productive energy of ration M+L=O		1.372	1.187	1.164	1.206	1.207
Productive energy of supplement fed O—T =E		.451	.281	.168	.185	.186
Productive energy of 100 lbs. supplement= E÷wt. feed × 100		25.9	13.0	76.4	80.5	80.9

Sugar beets. The average of the productive energy calculated from the feeding tests (12.3) agrees well with the productive energy (12.6) calculated from the average composition given by Henry and Morrison, and the production coefficients.

Sunflower silage. The productive energy calculated from the six tests averages 14.8 therms per 100 pounds compared with an average of 8.5 therms calculated from the analyses and production coefficients. This is a difference of 6.3 therms, or 74 per cent. The sunflower silage evidently has higher production coefficients than were assumed. Corrected values are given in Table 39.

Table 32. Productive energy calculated from feeding experiments, Bulletin 86, South Dakota Experiment Station.

	Wheat bread	Wheat macaroni	Oats	Barley	Spelt	Millet	Standard	Spelt	Barley	Wheat macaroni
Lot No.	1	2	3	4	5	6	7	8	9	10
Average weight, pounds (W)	86.3	86.3	84.3	84.8	82.7	86.4	86.4	84.2	86.6	82.2
Average daily gain, pounds (G)	.28	.28	.25	.20	.22	.28	.27	.25	.26	.21
Daily feed, pounds, prairie hay	1.333	1.333	1.333	1.333	1.333	1.333	1.333	1.333	1.333	1 333
Wheat (bread)	1.512									
Wheat (macaroni)		1.522								.795
Oats			1.618							
Barley				1.587					.852	
Spelt					1.653			.764	.852	.795
Millet						1.633				
Corn							1.542	.764		
Productive value, therms, prairie hay (.220)	.293	.293	.293	.293	.293	.293	.293	.293	.293	.293
Spelt (.656)									.559	.522
Corn (.822)							1.268	.628		
Total therms T	.293	.293	.293	.293	.293	.293	1.561	.921	.852	.815
Maintenance therms, W ×.0085 =M	.734	.734	.717	.721	.703	.734	.734	.716	.736	.699
Productive value of gain T—M =B							.827			
Therms for 1 lb. gain in standard B ÷G =K							3.063			
Productive energy of gain K ×G =L	.858	.858	.766	.613	.674	.858		.766	.796	.643
Productive energy of ration M +L =O	1.592	1.592	1.483	1.334	1.377	1.592		1.482	1.532	1.342
Productive energy of supplement fed O—T =E	1.299	1.299	1.190	1.041	1.084	1.299		.561	.680	.527
Productive energy of 100 lbs supplement = E ÷wt. feed ×100	85.9	85.3	73.5	65.6	65.6	79.5		73.4	79.8	66.3

Table 33. Productive energy calculated from feeding experiments, Bulletin 110, Iowa Experiment Station.

	Standard	Corn silage	Sugar beets	Mangels
Lot No.	1	2	3	4
Average weight, pounds (W)	100.7	102.1	106.3	102.2
Average daily gain, pounds (G)	.30	.29	.39	.37
Daily feed, pounds, corn	1.37	1.33	1.32	1.34
Cottonseed meal	.17	.15	.16	.16
Mixed hay	1.89	1.43	1.51	1.55
Corn silage	....	1.69	....	....
Sugar beats	....	....	4.40	....
Mangels	....	....	....	4.37
Productive value, therms, corn (.822)	1.126	1.093	1.085	1.101
Cottonseed meal (.855)	.145	.128	.137	.137
Mixed hay (.330)	.624	.472	.498	.512
Total therms T	1.895	1.693	1.720	1.750
Maintenance therms, W ×.0079 = M	.796	.807	.840	.807
Productive value of gain T—M = B	1.099	....	....	....
Therms for 1 lb. gain in standard B ÷ G = K	3.663	....	....	....
Productive energy of gain K × G = L	....	1.062	1.429	1.355
Productive energy of ration M + L = O	....	1.869	2.269	2.162
Productive energy of supplement fed O—T = E	....	.176	.549	.412
Productive energy of 100 lbs. supplement = E ÷ wt. feed × 100	....	10.4	12.5	9.4

Table 34. Productive energy calculated from feeding experiments, Bulletin 198, Oregon Experiment Station.

	Standard	Wheat	Oats	Barley
Lot No.	1	2	3	4
Average weight, pounds (W)	70.5	68.8	68.6	65.5
Average daily gain, pounds (G)	.366	.348	.332	.334
Daily feed, pounds, alfalfa hay	2.42	2.38	2.13	2.17
Corn	.95	....	....	....
Wheat	....	.95	....	....
Oats	....	....	.95	....
Barley	....	....	....	.95
Productive value, therms, alfalfa hay (.345)	.835	.821	.735	.749
Corn (.822)	.781	....	....	....
Total therms T	1.616	.821	.735	.749
Maintenance therms, W ×.00933 = M	.658	.642	.640	.611
Productive value of gain T—M = B	.958	....	....	....
Therms for 1 lb. gain in standard B ÷ G = K	2.617	....	....	....
Productive energy of gain K × G = L	....	.911	.869	.874
Productive energy of ration M + L = O	....	1.553	1.509	1.485
Productive energy of supplement fed O—T = E	....	.732	.774	.736
Productive energy of 100 lbs. supplement = E ÷ wt. feed × 100	....	77.1	81.5	77.5

Table 35. Productive energy calculated from feeding experiments, Bulletin 106, Nebraska Experiment Station.

	Standard	Oats	Wheat bran	Prairie hay	Linseed meal	Oats	Wheat bran	Wheat bran
Lot No.	1	2	3	4	5	6	7	8
Average weight, pounds (W)	69.28	69.75	67.15	62.25	64.50	61.38	60.19	68.25
Average daily gain, pounds (G)	.337	.327	.306	.204	2.45	.194	.194	.347
Daily feed, pounds, shelled corn	1.00	.75	.72	.86	.80	.66	.66	.78
Alfalfa	1.36	1.27	1.30	......	......	......	......	1.42
Oats	......	.25	......	......	......	.22	......	......
Wheat bran	......	......	.24	......	......	......	.22	.26
Prairie hay	......	......	......	.85	.96	.86	.87	......
Linseed meal	......	......	......	......	.16	......	......	......
Productive value, therms, shelled corn (.822)	.822	.617	.592	.707	.658	.543	.543	.641
Alfalfa (.345)	.469	.438	.449	......	......	......	......	.490
Prairie hay (.310)	......	......	......	......	.298	.267	.270	......
Total therms T	1.291	1.055	1.041	.707	.956	.810	.813	1.131
Maintenance therms W ×.00933 = M	.646	.651	.627	.581	.602	.573	.562	.637
Productive value of gain T—M = B	.645	......	......	......	......	......	......	......
Therms for 1 lb. gain in standard B ÷ G = K	1.914	......	......	......	......	......	......	......
Productive energy of gain K × G = L	......	.626	.586	.390	.469	.371	.371	.664
Productive energy of ration M + L = O	......	1.277	1.213	.971	1.071	.944	.933	1.301
Productive energy of supplement fed O—T = E	......	.222	.172	.264	.115	.134	.120	.170
Productive energy of 100 lbs. supplement = E ÷ wt. feed × 100	......	88.8	71.7	31.1	71.9	60.9	54.5	65.4

Timothy hay. The results are about what would be expected.

Wheat screenings. These screenings, consisting chiefly of broken grains and some weed seeds, have a high productive value.

Wheat. The productive energy of wheat is less than would be expected. The average productive energy in the 20 tests, including both whole and ground wheat, is 76.3 as compared with 89.8, calculated from Henry and Morrison's averages and the production coefficients. As only one analysis of the wheat used in the feeding tests was made, it is not possible to say whether it averaged poorer or better than the average. If we assume that the wheat was a little poorer than the average (86 therms), there would be an average deficiency of 10 therms, or about 11 per cent. A change in the production coefficients of wheat seems to be justified. It is made in Table 39. Detailed calculations of the tests with wheat are given in Tables 3, 34, 36, 37, and 38.

Whole versus ground wheat. Comparisons of ground wheat with whole wheat are given in Tables 36, 37, and 38. Grinding slightly increased the productive energy of wheat, on an average of three tests, 3.9 therms, or 5 per cent of that of the whole wheat.

Wheat bran. The average productive energy of wheat bran from the nine tests was 57.4. No analyses were reported in connection with any of the experiments, but the average productive energy of wheat bran calculated from Henry and Morrison's averages and the production coefficients is 49.1. Wheat bran seems to have about 16 per cent higher value than has been assigned to it. Corrections are made in the production coefficients in Table 39.

Table 36. Productive energy of feeds calculated from feeding experiments, Bulletin 257, Nebraska Experiment Station.

	Standard	Whole wheat	Ground Wheat
Lot No.	1	2	3
Average weight, pounds (W)	80.55	78.80	77.65
Average daily gain, pounds (G)	.330	.278	.249
Daily feed, pounds, shelled corn	1.19		
Whole wheat		1.18	
Ground wheat			1.01
Alfalfa hay	1.31	1.32	1.31
Productive value, therms, shelled corn (.82)	.976		
Alfalfa hay (.354)	.464	.467	.464
Total therms T	1.440	.467	.464
Maintenance *therms* W × *.0085* = M	.685	.670	.660
Productive value of gain T—M = B	.755		
Therms for 1 lb. gain in standard B ÷ G = K	2.288		
Productive energy of gain K × G = L		.636	.570
Productive energy of ration M + L = O		1.306	1.230
Productive energy of supplement fed O—T = E		.839	.766
Productive energy of 100 lbs. supplement = E ÷ wt. feed × 100		71.1	75.8

Table 37. Productive energy of feeds calculated from feeding experiments, Bulletin 256, Nebraska Experiment Station.

	Standard	Whole wheat	Whole rye	Whole wheat	Whole rye
Lot No.	1	2	3	4	5
Average weight, pounds (W)	76.60	75.10	75.35	75.75	75.50
Average daily gain, pounds (G)	.252	.231	.237	.246	.238
Daily feed, pounds—shelled corn	1.06	....	....	.53	.525
Whole wheat	....	1.06	....	.53	....
Whole rye	....	....	1.05	....	.525
Alfalfa hay	1.39	1.39	1.40	1.39	1.39
Productive value, therms, shelled corn (.82)	.869	....	....	.435	.431
Alfalfa hay (.354)	.492	.492	.496	.492	.492
Total therms T	1.361	.492	.496	.927	.923
Maintenance therms W×.0085=M	.651	.638	.640	.644	.642
Productive value of gain T—M=B	.710	....	....	....	....
Therms for 1 lb. gain in standard B÷G=K	2.817	....	....	....	....
Productive energy of gain K×G=L	....	.651	.668	.693	.670
Productive energy of ration M+L=O	....	1.289	1.308	1.337	1.312
Productive energy of supplement fed O—T=E	....	.797	.812	.410	.389
Productive energy of 100 lbs. supplement=E÷wt. feed ×100	....	75.2	77.3	77.4	74.1

Table 38. Productive energy of feeds calculated from feeding experiments, Bulletin 257, Nebraska Experiment Station.

	Standard	Ground corn	Whole wheat	Ground wheat
Lot No.	1	2	3	4
Average weight, pounds (W)	74.80	74.30	73.15	73.75
Average daily gain, pounds (G)	.304	.294	.267	.284
Daily feed, pounds, shelled corn	1.05	....	....	....
Ground corn	....	1.05	....	....
Whole wheat	....	....	1.05	....
Ground wheat	....	....	....	1.044
Alfalfa hay	1.44	1.44	1.44	1.44
Productive value, therms, shelled corn (.82)	.861	....	....	....
Alfalfa hay (.354)	.510	.510	.510	.510
Total therms T	1.371	.510	.510	.510
Maintenance therms, W×.0085=M	.636	.632	.622	.627
Productive value of gain T—M=B	.735	....	....	....
Therms for 1 lb. gain in standard B÷G=K	2.418	....	....	....
Productive energy of gain K×G=L	....	.711	.646	.687
Productive energy of ration M+L=O	....	1.343	1.268	1.314
Productive energy of supplement fed O—T=E	....	.833	.758	.804
Productive energy of 100 lbs. supplement =E÷wt. feed ×100	....	79.3	72.2	77.0

CORRECTED PRODUCTION COEFFICIENTS

The results of the feeding tests discussed in the preceding pages justify changes in the production coefficients for some feeds, as stated in connection with the discussion of the individual feeds. These changes may be partly due to differences in digestibility, partly due to waste of feed, especially of corn fodder or oat straw, and partly to the digestible nutrients of the feeds having a higher or lower energy value than that previously assumed. Further study and investigations will no doubt make other changes necessary. It is to be expected that as the matter is studied more thoroughly, the quantitative data will become more exact, more nearly accurate.

The revised production coefficients are given in Table 39. The changes made from those previously published (6, 8) are as follows:

For alfalfa meal, the correction for grinding, made on the crude fiber, is .488 instead of .318.

With molasses, the factor was changed from .88 to 1; with wheat bran, from .77 to .88. With the other feeds listed, the production coefficients previously given were multiplied by the factor shown in Table 39.

Table 39. Energy production coefficients revised from results of feeding tests with sheep.

Feed and factor	Protein	Ether extract	Crude fiber	Nitrogen free extract	Factor
Alfalfa meal (30 to 33% fiber)	.720	.618	.017	.755	CT
Alfalfa meal (26 to 30% fiber)	.761	.833	0	.778	CT
Alfalfa meal (24% fiber)	.648	.531	.053	.757	CT
Bean straw (same as soy bean straw)	.184	.373	—.276	.720	CM 1.25
Barley	.756	1.692	.010	.915	BM .93
Beet pulp, dried	.602	0	.340	1.070	BM 1.20
Clover hay (red)	.545	.929	—.062	.643	CM .90
Corn fodder cured, dough to mature	.394	1.113	.077	.566	CM .75
Corn stover, blades or shucks	.364	.890	.123	.534	CM .75
Corn stover, pulled, chiefly blades	.297	1.021	.101	.499	CM .75
Corn stover, entire plant except ears	.308	.956	.058	.472	CM .75
Emmer or spelt	.620	1.521	.132	.725	BN .75
Molasses	.141	0	0	.961	1.00
Oat straw	.122	.590	.019	.425	CM .75
Rye	.763	1.298	0	.876	B .89
Soy bean straw	.184	.373	—.276	.720	CM 1.25
Sunflower silage	.866	2.830	—.075	1.211	CM 1.75
Wheat, whole	.732	1.541	.038	.949	BM .89
Wheat, ground	.774	1.628	.040	1.002	BM .94
Wheat bran	.683	1.346	.302	.678	B .88

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SUMMARY

The productive energy of a number of feeding stuffs is calculated from 81 feeding experiments for 336 lots of sheep, made by various Experiment Stations.

The productive energy is measured by the gain in flesh and fat of the animal when the feed is added to a ration a little more than sufficient for maintenance. The productive energy was calculated by comparing the gain in weight from a ration containing a standard feed, with the gain for corresponding rations in which the standard feed was

replaced by the feed for which the calculation was made. The method of calculation is described fully.

Many feeding experiments could not be used to calculate the productive energy of individual feeds on account of the presence of two or more interfering variables.

One pound of gain in weight of fattening sheep on an average required 2.60 therms of productive energy.

Productive values used were calculated from the production coefficients for sheep, already published, and the composition of the feed, as given in the experiments, or from average analyses, if it was not given.

Pounds feed for 100 pounds of gain is a measure of the ration as a unit, and is especially closely related to the palatability of the feed, since the gain depends upon the quantity of productive energy in the ration the animal is induced to eat daily.

The digestible nutrients required for a pound of gain when sheep were fed mixtures composed of various proportions of corn and alfalfa, increased as the gain in weight decreased, which is evidence of the lower value of the digestible nutrients of alfalfa compared with corn, since the energy in the gain increases as the gain increases. The productive energy required decreased as the gain decreased.

The productive energy of corn fodder and of oat straw was greater in a balanced ration than in an unbalanced ration.

The productive energy of cottonseed meal and of linseed meal when used to balance a ration was apparently greater than when used to replace another proteid feed in a ration already balanced.

The effect of a protein concentrate used to balance a ration may be much greater than the productive energy of the protein concentrate itself.

Grinding alfalfa to a meal added about 14 per cent to its productive energy, which was less than provided for in the production coefficients previously published. Corrected production coefficients are given.

The productive energy calculated from the feeding experiments agrees reasonably well with the productive energy calculated from the analyses and production coefficients previously published, with alfalfa hay, corn, corn silage, corn gluten feed, native hay, hominy feed, kafir, oats, oat and pea silage, peas and pea silage, peanut meal, roots, rutabagas, soy bean oil meal, soy bean hay, sugar beets and timothy hay.

The productive energy calculated from the feeding tests was somewhat different from the values calculated from the analysis and previous production coefficients, and revised production coefficients are given for alfalfa meal, bean straw, dried beet pulp, clover hay, corn fodder and stover, emmer or spelt, molasses, oat straw, rye, soy bean straw, sunflower silage, whole wheat, ground wheat, and wheat bran.

The productive energy of cottonseed meal or linseed meal is greater than the calculated value when they are used to balance a ration, but as the effect is variable, no attempt is made to give corrected production coefficients for them under this condition.

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