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**PRODUCTIVE ENERGY OF SOME FEEDS AND
FOODS AS MEASURED BY GAINS OF
ENERGY BY GROWING
CHICKENS**

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The value of 62 feeds and foods for furnishing energy for growing chickens was measured by feeding the feeds in balanced rations to growing chickens and ascertaining the effect by weighing and analyzing the chickens. Individual chickens differ in their capacity to utilize feed and the results given are usually averages of several tests, each on 6 or more chickens. When the different feeds are compared, wide differences between their energy values are found. However, when the energy values of the digestible nutrients of the various feeds are compared, those of most of the feeds do not differ widely from those of corn meal. The differences in the energy of the feeds are therefore due chiefly to differences in digestibility, for with most feeds, the ability of chickens to utilize the digested feed is quite uniform. There are several exceptions, however; for example, the digested nutrients of lima beans have a low value and those of dried beef a high value compared with the value of the digested nutrients of corn meal. The productive energy values of 62 feeds expressed in different ways are shown in the tables. Other data secured in the work are also given.

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PRODUCTIVE ENERGY OF SOME FEEDS AND FOODS AS MEASURED BY GAINS OF ENERGY OF GROWING CHICKENS

G. S. Fraps and E. C. Carlyle*

The work here presented is a part of a comprehensive investigation of the value of the energy of feeds and foods as measured by the production of fat and flesh on growing chickens. Previous publications have discussed the digestibility of some chicken feeds (4), the utilization of energy of feeds by growing chickens (8), the utilization of the energy of wheat products by chickens (9), the energy values of corn bran, rice bran, and rye flour (10), the relation of gain in weight to gain in energy content of growing chickens (11), the metabolizable energy of chicken feeds (13), and the productive energy of alfalfa leaf meal and some other chicken feeds (12).

The object of the work was to measure the energy value of feeds in terms of the use made of it by chickens. Values of feeds have been compared in terms of digestible nutrients and of metabolizable energy on the assumption that these measure the utilization of the feed by the animal. Previous work (1,3,5,9,12) has shown that, measured in terms of gains of fat and flesh, neither digestible nutrients nor metabolizable energy are always correct measures for the energy value of feeds eaten by ruminants (9).

Extensive work on the utilization of the energy of feed by ruminants has been done by Kellner, Armsby, Forbes, and others. As the literature has already been summarized in previous publications (7,8), it will not again be summarized here. A deficiency of protein (5) or of calcium (14) or other elements or compounds necessary for growth may decrease the utilization of the energy of feed by animals. When productive energy is measured, the feed should be fed in a ration which is not deficient in any substance needed for the assimilation or utilization of the digested feed or which contains any substance which interferes with the utilization of the energy.

The work here presented compares the energy values of a number of chicken and human foods with that of corn meal. A complete ration was fed one group of chickens, and corresponding groups were fed similar rations in which the feed to be tested replaced part of the corn meal in the complete ration. Chemical analyses were made of one group of the chickens at the beginning, and others at the end of the experiments, so that the increase in the protein and fat content of the chickens was measured. The data so secured were used to compare the energy values of the feeds tested with that of corn meal. In previous work (8) the value of a mixed ration for the production of fat and flesh in growing

*Deceased Aug. 16, 1942.

chicks was found to be 2.78 Calories per gram of total digestible nutrients. By subsequent work (12), the productive energy of the total digestible nutrients of corn meal was found to be 3.00 Calories per gram. These values were used in calculating the work here reported.

Definition of Terms

Productive energy is the energy stored up as fat and protein by the chicken from that portion of the ration eaten which exceeds the quantity used for all maintenance purposes. The difference between metabolizable energy and productive energy is chiefly the cost of utilization of the energy.

Effective organic constituents of a feed is the sum of the percentages of the protein, the fat or ether extract multiplied by 2.25, and the nitrogen-free extract. Crude fiber is disregarded since it is digested only to a very small extent by chickens, while ash and water have no energy values.

Effective digestible nutrients of a feed is the sum of the percentages of digestible protein, the digestible ether extract multiplied by 2.25, and the digestible nitrogen-free extract. In other words, the effective digestible nutrients is that portion of the effective organic constituents which can be digested by the animal.

Metabolizable energy is the energy of the food less the energy in the excrement, both fecal and urinal and, in case of ruminants, in gases produced by fermentation. It includes all the energy of the food which can be used by the animal. The metabolizable energy of chicken feeds can be calculated by methods previously developed (13). For the purpose of this work, metabolizable energy values for maintenance were obtained in Calories per 100 grams by multiplying grams of effective digestible nutrients by 4.2. When part of the protein is retained, as in growing chickens, the metabolizable energy is higher than for maintenance.

Maintenance requirement is that portion of the energy of the feed used in the life processes of the animal, for keeping the body warm, and for movements of the body. The bodily activities consume energy, which in this work is included in the energy of maintenance.

The productive energy used for maintenance is the difference between the productive energy of the quantity of food eaten and the energy stored up in fat and flesh. For the work here presented it is calculated from the data secured with the corn meal ration.

Experimental Procedure

The procedure has already been described in detail (8, 12), and will here be given only in outline. The feeds to be tested were usually compared with corn meal as a standard. Sixty or more baby chicks, usually white Leghorns, were fed a corn meal ration for a preliminary period of approximately one week. From these, usually five equal groups of 6 chicks each were selected, although in some of the earlier work only two groups

were used. The remaining chickens were used for digestion experiments. One group was killed and analyzed. One of the four experimental groups received a balanced ration containing 50% of corn meal or corn meal and casein, while the other three groups received a ration in which the corn meal or casein, or both, were partly replaced by the feed to be tested. The chickens were fed individually in battery brooders and weighed at the end of each week. At the end of 2 weeks they were killed, the intestinal contents removed, and the chick ground for analysis. Beginning with Experiment 26 the chickens were heated in an autoclave at 15 pounds pressure for 3 hours, cooled and ground in a food chopper with 3% ground filter paper to take up the liquids. In the earlier experiments, the chickens were of both sexes, but in most of the later work, they were hatchery sexed cockerels. Up to the age of 4 weeks, little difference between the two sexes could be expected.

Protein ($N \times 6.25$) was determined on 3.5 gram samples by the Kjeldahl-Gunning method. Fat was determined on 4 gram portions by extraction with ether after drying under reduced pressure at 100°C and grinding in a mortar. The energy content was calculated by the use of the figures 5.66 Calories per gram of protein and 9.35 Calories per gram of fat. These figures were found in previous work (8) to give results agreeing with the heats of combustion of dried chicks as determined in a bomb calorimeter.

Two digestion tests were usually made on each ration. The digestible nutrients were calculated from the average of these two experiments and the analysis of the feeds used, each experiment being treated separately.

Details and Data of the Work

The work was done from Dec. 1, 1930 to July, 1942. The ingredients of the standard corn meal rations used in the various experiments are given in Table 1. The dried buttermilk used in earlier experiments was replaced by dried skim milk in later experiments. In nine of the experiments, casein was used in place of the dried skim milk, and in other experiments, it was added to increase the protein content of the basal ration. The cottonseed meal and tankage in the earlier experiments were discontinued in later experiments in order to make the ration less complex. Yeast was added to supply the vitamin B complex, and the amount was increased from 2% to 6%, beginning with Experiment 19. Manganese sulphate was included beginning with Experiment 47.

Analyses were made of all the rations; representative analyses of the standard corn meal ration are given in Table 2. The higher protein content in Experiments A.-65, 6, 13, 29 and 40 is due to the larger quantities of casein in the rations. The quantities of single feeds which replaced the corn meal in the experimental rations are given in Table 10. Table 3 gives the experiments in which two or more feeds replaced the corn meal or corn meal and casein. The percentage composition of the

Table 1. Constituents of the Standard Corn Meal Rations, in Per Cent.

Experiment Numbers	Corn meal	Wheat gray shorts	Dried butter-milk	Dried skim milk	Casein	Cotton seed meal	Tank-age	Alfalfa leaf meal	Yeast	Oyster shell or calcium carbonate	Bone meal	Tri-calcium phosphate	Salt	Cod liver oil concentrate
A31, A32, A33, A34	57.0	20.0	---	---	---	13.0	---	5.0	---	2.0	1.0	---	1.0	1.0
A38, A39, A41, A42	50.0	19.0	10.0	---	---	6.0	4.0	5.0	---	2.0	2.0	---	1.0	1.0
A62, A63, A64	51.0	19.0	10.0	---	---	6.0	4.0	5.0	---	2.0	2.0	---	1.0	.0
A65	58.9	25.0	---	---	12.0	---	---	---	1.0	---	---	1.0	1.0	.1
1, 2	50.0	19.0	10.0	---	---	6.0	4.0	5.0	---	2.0	2.0	---	1.0	1.0
3, 4	50.5	19.0	10.0	---	---	6.0	4.0	5.0	---	2.0	2.0	---	1.0	0.5
5	64.3	10.0	5.0	---	---	---	10.2	5.0	---	2.0	2.0	---	1.0	0.5
6, 7, 10	56.0	20.0	---	---	12.0	---	---	6.0	2.0	1.0	---	1.0	1.0	1.0
13, 15, 16, 17, 18	56.8	20.0	---	---	12.0	---	---	6.0	2.0	1.0	---	---	1.0	0.2
19, 25	50.0	16.3	---	10.0	---	10.0	---	4.0	6.0	1.5	---	1.0	1.0	0.2
29	30.0	16.3	---	10.0	20.0	---	---	4.0	6.0	1.5	---	1.0	1.0	0.2
37, 38, 42, 48, 51, 53, 54, 56, 57, 59, 60, 62, 65, 66	60.0	16.3*	---	10.0	---	---	---	4.0	6.0	1.5	---	1.0	1.0	0.2
40, 41, 43, 44, 46, 47, 52, 55, 61, 63	50.0	16.3*	---	10.0	10.0	---	---	4.0	6.0	1.5	---	1.0	1.0	0.2

*.20% manganese sulphate included from Exp. 47 on.

Table 2. Percentage Chemical Composition of Representative Corn Meal Rations

	Protein	Ether extract	Crude fiber	Nitrogen free extract	Water	Ash
Exp. A31-----	17.10	5.48	5.65	59.85	6.39	5.53
Exp. A38-----	19.73	5.64	3.59	55.46	8.05	7.53
Exp. A62-----	18.80	4.88	3.78	54.64	8.93	8.97
Exp. A65-----	22.13	4.20	2.58	56.20	9.93	4.96
Exp. 1-----	19.15	5.21	3.63	54.09	9.92	8.00
Exp. 3-----	19.50	5.11	3.49	54.38	8.56	8.96
Exp. 5-----	17.38	5.01	2.59	57.10	9.75	8.17
Exp. 6-----	21.80	3.67	3.59	56.33	9.19	5.42
Exp. 13-----	21.40	2.73	2.86	57.81	9.79	5.41
Exp. 25-----	19.89	3.10	2.97	57.83	9.42	6.79
Exp. 29-----	30.77	2.66	2.41	49.30	8.60	6.26
Exp. 37-----	16.76	3.19	2.70	61.69	9.69	5.97
Exp. 40-----	23.55	2.59	2.14	55.13	10.38	6.21

Table 3. Experiments in which two or more feeds replaced corn meal.

Experiment 1

Patent flour, 50.0; graham flour, 41.3, starch, 8.7; wheat bran, 41.3, starch, 3.9, cottonseed oil 3.9 per cent.

Experiment 2

Patent flour, 50.0; graham flour, 41.3, starch, 8.7; wheat bran, 41.3 starch, 3.9, cottonseed oil, 4.8 per cent.

Experiment 3

Oat meal, 35.2, starch, 15.3; dried sweet potatoes, 40.0, casein, 4.4, cottonseed oil 6.1; rice, 49.5, casein, 1.0 per cent.

Experiment 4

Rice, 49.5, casein, 1.0; dried sweet potatoes, 40.0, casein, 4.4, cottonseed oil 6.1; oat meal, 35.2, starch, 15.3 per cent.

Experiment 5

Raw lima beans, 60.0, cottonseed oil, 5.0; raw navy beans, 47.7, cottonseed oil 5.0; raw black eye peas, 46.6 per cent.

Experiment 18

Starch, 50.0; starch, 46.0, yeast, 4.0; starch, 44.0, yeast 4.0, corn oil 2.0 per cent.

Experiment 19

Starch, 44.0, casein, 4.0; wheat bran, 50.0; cottonseed oil 15.0 per cent.

Experiment 29

Soy bean oil meal, 37.0% replaced 20.0% casein and 17.0% corn meal; peanut meal, 40.0% replaced 20.0% casein and 20.0% corn meal; fish meal, 25% replaced 20.0% casein and 5.0% corn meal.

Experiment 56

Casein, 50.0%, yeast, 35.0%; alfalfa leaf meal, 30.0%, casein, 20.0%.

feeds tested and of the corn meal used as a standard are given in Table 4 and their effective organic constituents in Table 10.

Digestion experiments were made with all of the rations, usually two being made on each ration. The results will be presented in a subsequent publication. The digestion coefficients of the rations were averaged separately for each experiment and, together with the analysis of each ration, were used to calculate the effective digestible nutrients of

Table 4. Percentage Composition of Feeds

Laboratory number	Name of feed	Protein	Ether extract	Crude fiber	Nitrogen free extract	Water	Ash
58348	Barley seed, whole	9.40	1.59	5.87	71.34	9.64	2.66
63805	Barley seed, whole	13.97	1.58	5.92	65.69	10.27	2.57
46140	Lima beans	22.88	.91	4.70	56.65	9.85	5.01
65051	Lima beans, Baby	20.48	.95	4.32	56.16	14.01	4.08
46141	Navy beans	22.08	1.14	5.58	57.80	9.78	4.12
65048	Navy beans	21.70	1.13	4.08	56.94	11.86	4.29
65049	Pinto beans	21.64	1.04	3.74	56.53	12.27	4.78
63796	Chipped beef, dried	61.11	9.67	0	1.19	3.09	24.94
58591	Beet pulp	6.65	.36	13.98	62.99	9.86	6.16
62736	Beet pulp, dried	8.20	.18	19.87	57.49	11.85	2.91
62923	Broom corn seed	9.15	3.59	5.34	69.07	10.18	2.67
63807	Broom corn seed	9.19	3.70	4.99	69.27	10.38	2.47
62888	Casein	81.92	.09	.18	3.25	10.62	3.94
58434	Citrus pulp, dried	5.93	1.95	10.81	65.48	7.96	7.87
62765	Citrus pulp, dried	5.50	1.71	10.21	63.48	13.23	5.87
64059	Citrus pulp, dried	5.15	4.44	12.83	61.74	7.88	7.96
64098	Cocoonut oil meal	21.21	10.33	10.51	44.49	6.46	6.50
65030	Cocoonut oil meal	20.31	6.37	10.71	47.70	8.50	6.41
48800	Corn bran	10.40	10.22	10.88	57.41	7.96	3.13
50740	Corn bran	9.40	6.57	12.54	62.06	7.21	2.22
50742	Corn bran	10.49	8.16	10.20	61.70	6.92	2.53
50736	Corn bran	6.34	3.95	14.79	65.70	7.73	1.49
58432	Corn gluten feed	24.01	2.10	7.84	51.29	9.35	5.41
62767	Corn gluten feed	25.57	1.84	7.82	48.02	10.19	7.06
58433	Corn gluten meal	42.91	1.78	5.55	37.08	8.39	4.29
62768	Corn gluten meal	43.74	1.83	4.61	36.46	9.40	3.96
33300	Yellow corn meal, Exp. A31	9.97	4.37	2.72	71.88	9.96	1.60
33918	Corn feed meal, Exp. A41	10.20	4.40	2.64	72.07	9.43	1.26
40966	Yellow corn meal, Exp. A62	9.85	4.80	2.01	72.42	9.42	1.50
41442	Yellow corn meal, Exp. A64	9.45	3.99	1.68	73.70	10.08	1.10
41602	Yellow corn meal, Exp. A65	10.95	4.52	2.16	70.15	10.67	1.55
45005	Cream corn meal, Exp. 1	10.23	4.56	1.32	72.74	9.80	1.30
45803	Corn meal, Exp. 4	10.68	5.30	1.42	71.16	9.91	1.53
46079	Corn meal, Exp. 5	10.21	4.03	1.09	73.19	10.03	1.45
47955	Corn meal, Exp. 6	11.05	3.00	1.39	73.15	9.93	1.48
48260	Corn meal, Exp. 7	9.86	4.11	1.36	72.78	10.84	1.05
48986	Corn meal, Exp. 10	11.98	4.84	1.45	69.74	10.31	1.68
50868	Corn meal, Exp. 13	10.52	2.67	1.01	74.35	10.04	1.41
51556	Corn meal, Exp. 15	10.69	3.23	1.12	73.97	9.74	1.25
51824	Corn meal, Exp. 17	10.68	2.85	1.04	73.87	10.32	1.24
51960	Corn meal, Exp. 19	10.70	2.81	1.06	74.35	9.79	1.29
54823	Corn meal, Exp. 25	10.56	2.21	1.13	73.95	10.85	1.30
55321	Corn meal, Exp. 29	9.79	3.31	1.30	74.00	9.89	1.11
58600	Corn meal, Exp. 37	11.27	3.64	1.45	71.71	10.51	1.42
58715	Corn meal, Exp. 38	11.09	3.19	1.09	72.56	10.78	1.29
58934	Corn meal, Exp. 39	11.11	3.37	1.15	72.67	10.45	1.25
59229	Corn meal, Exp. 41	9.97	4.27	1.37	71.83	10.98	1.58
59496	Corn meal, Exp. 42	10.67	4.20	1.26	71.25	11.21	1.41
59713	Corn meal, Exp. 43	9.82	3.32	1.17	73.26	11.20	1.23
59969	Corn meal, Exp. 46	9.84	4.46	1.35	70.50	12.55	1.30
60219	Corn meal, Exp. 47	9.76	4.66	1.44	71.34	11.45	1.35
60321	Corn meal, Exp. 48	9.88	4.59	1.35	70.70	12.15	1.33
62891	Corn meal, Exp. 52	9.60	4.42	1.12	70.71	12.99	1.16
62977	Corn meal, Exp. 53	10.20	4.34	1.44	70.52	12.21	1.29
63077	Corn meal, Exp. 54	10.05	4.29	1.54	70.51	12.39	1.22
63683	Corn meal, Exp. 56	9.54	4.08	1.23	71.90	12.00	1.25
63913	Corn meal, Exp. 57	10.01	4.44	1.37	72.70	10.28	1.20
64267	Corn meal, Exp. 59	10.15	4.23	1.33	73.04	9.90	1.30
64291	Corn meal, Exp. 60	8.71	3.89	1.55	74.35	10.28	1.22
64523	Corn meal, Exp. 61	9.10	4.04	1.57	74.62	9.45	1.22
64878	Corn meal, Exp. 63	10.36	3.66	1.38	73.74	9.59	1.27
65056	Corn meal, Exp. 65	8.91	3.76	1.64	73.21	11.08	1.40
65172	Corn meal, Exp. 66	9.02	3.52	1.55	73.89	10.84	1.18
59165	Cottonseed flour	58.13	5.99	1.83	22.08	5.49	6.48
63621	Cottonseed flour	55.40	8.64	2.23	21.32	5.80	6.61
54898	Sudan grass	14.15	2.37	25.38	38.40	7.58	12.12
59524	Tabo (enzyme concentrate)	13.66	1.00	7.74	18.53	4.85	54.22
54666	Fish meal	64.28	4.39	.35	7.72	6.37	16.89
58346	Fish meal	65.34	3.73	.40	7.30	6.24	16.99

Table 4. Percentage Composition of Feeds—Continued

Laboratory number	Name of feed	Protein	Ether extract	Crude fiber	Nitrogen free extract	Water	Ash
62738	Fish meal	69.25	2.54	.40	5.03	9.40	13.38
48898	Clear flour	16.25	1.27	.22	64.90	16.62	.64
44486	Wheat flour, whole	12.59	1.90	2.28	69.50	12.01	1.72
45372	Graham flour	12.13	1.74	1.35	71.03	12.54	1.21
47762	Low grade flour	13.20	2.24	.43	71.67	11.52	.94
48244	Low grade flour	15.07	1.94	.50	70.18	11.46	.85
45217	Flour	14.16	1.09	.43	72.00	11.73	.59
45371	Flour	10.42	.91	.33	76.25	11.32	.77
47761	Flour	12.59	.91	.25	73.25	12.55	.47
48243	Patent flour	12.83	.84	.24	73.43	12.17	.49
48897	Patent flour	13.96	.96	.21	71.64	12.81	.42
64924	Gelatine	93.98	.05	.15	0	14.32	1.89
40968	Hegari	10.33	2.65	1.93	73.55	10.19	1.35
51581	Kafir, Black Hull	11.95	3.45	2.33	70.96	9.81	1.50
51582	Kafir, Waxy Endosperm	11.98	4.06	2.43	70.52	9.16	1.85
51568	Lactose	.24	00	.17	98.58	.97	.04
55287	Linseed oil meal	38.49	7.78	7.39	31.35	8.78	6.21
63622	Linseed oil meal	36.12	5.29	8.21	35.48	9.29	5.61
63907	Liver meal, dried	64.04	17.80	1.20	2.23	9.22	5.51
62887	Skim milk, dried	34.15	1.02	.23	48.84	8.62	7.14
63803	Millet seed	9.78	3.52	8.64	64.63	10.12	3.31
33301	Kafir chops	10.81	2.57	2.09	73.28	9.93	1.37
34077	Milo, yellow	10.87	2.90	2.02	71.92	10.86	1.43
58615	Oat hulls	3.35	.82	32.08	48.90	7.15	7.70
51609	Oat hulls	6.00	1.92	26.10	52.48	7.08	5.82
33829	Oat flakes	15.98	6.05	1.49	66.05	8.76	1.67
44487	Oat flakes	14.87	5.69	1.56	65.93	10.06	1.89
45805	Oat meal	16.51	5.94	1.42	64.64	9.72	1.77
54798	Peanut meal	44.23	6.74	8.89	25.54	7.12	7.48
58431	Peanut meal	40.60	7.44	7.39	29.78	5.80	8.99
59226	Peanut meal	44.12	6.96	14.53	23.01	5.97	5.41
63640	Peanut meal	45.27	7.93	9.45	24.79	7.02	5.54
46142	Blackeye peas	20.40	1.01	3.35	62.15	9.15	3.94
60500	Blackeye peas	22.38	1.09	2.82	57.59	12.51	3.61
44984	Sweet potatoes, dried	1.50	.20	.84	33.34	63.08	1.04
63909	Sweet potato meal	4.17	1.33	3.75	77.12	7.85	5.78
59177	Sweet potatoes, dehydrated	1.52	.39	2.37	75.86	15.83	4.03
59506	Sweet potato meal	5.76	.62	3.55	77.98	9.12	2.97
45544	Rice	7.78	.32	.33	77.16	13.18	1.23
45806	Rice	7.78	.32	.42	79.43	11.21	.84
51682	Rice bran	13.10	11.17	6.78	50.77	8.98	9.20
59166	Rice bran	12.18	12.44	11.65	41.28	9.03	13.42
62751	Rice bran	12.44	11.41	12.46	41.84	10.03	11.82
59620	Rice hulls	2.29	.84	40.40	26.90	9.30	20.27
51681	Rice polishings	13.17	15.31	2.10	52.11	9.53	7.78
59167	Rice polishings	11.58	11.44	1.91	55.89	10.27	8.91
62750	Rice polishings	14.33	13.42	3.41	49.70	10.71	8.43
51683	Rye flour	12.61	1.90	2.16	69.77	11.75	1.81
59649	Rye seed	14.85	1.54	2.37	68.80	10.58	1.86
62925	Rye seed	12.94	1.75	2.99	69.43	10.70	2.19
63804	Rye seed	12.75	1.47	2.67	71.15	10.18	1.78
62922	Cane seed, Red Top	7.80	4.25	2.52	72.23	11.60	1.60
63806	Cane seed	9.32	3.21	2.02	73.59	10.63	1.23
59650	Sunflower seed	19.88	25.79	30.97	14.58	5.87	2.91
63802	Sunflower seed	18.35	30.27	32.05	10.28	5.84	3.21
60014	Shrimp meal	43.83	3.43	9.06	1.90	12.22	29.56
64190	Shrimp meal	43.06	2.25	9.20	2.05	12.80	30.64
64058	Shrimp meal	53.45	2.72	14.78	0	4.08	24.97
54665	Soybean oil meal	47.34	.33	5.37	31.79	9.13	6.04
55286	Soybean oil meal	45.86	4.73	5.36	29.31	9.21	5.53
58839	Soybean oil meal	47.57	.51	5.19	32.33	8.44	5.96
63623	Soybean oil meal	22.69	.78	10.50	55.32	9.02	1.69
58838	Soybean oil meal	46.12	.50	6.56	32.51	8.63	5.68
51567	Starch	.64	.07	.16	87.90	11.15	.08
51955	Starch, corn	.63	0	.15	87.83	11.27	.12
52123	Starch	.58	.23	.17	88.46	10.45	.11
63908	60% Digester tankage	61.62	8.16	1.59	.51	7.21	20.91
33824	Wheat	14.25	1.56	2.70	69.47	10.28	1.74
33917	Wheat	13.91	1.73	2.55	70.54	9.36	1.91

Table 4. Percentage Composition of Feeds—Continued

Laboratory number	Name of feed	Protein	Ether extract	Crude fiber	Nitrogen free extract	Water	Ash
34076	Wheat -----	16.40	2.09	2.54	67.83	9.10	2.04
40967	Wheat bran -----	17.03	4.26	8.10	54.65	10.43	5.53
47763	Wheat bran -----	17.87	4.18	10.13	52.47	8.93	6.42
48264	Wheat bran -----	19.24	4.05	9.41	50.64	10.33	6.33
52122	Wheat bran -----	18.48	4.05	9.93	52.04	8.80	6.70
44488	Wheat bran, breakfast food-----	12.59	2.03	9.16	62.13	6.14	7.95
45373	Wheat bran, breakfast food-----	13.20	1.94	9.04	61.26	6.63	7.93
58601	Wheat gray shorts-----	17.61	4.23	6.26	57.24	10.40	4.26
59231	Wheat gray shorts-----	20.02	3.75	5.37	56.51	10.15	4.20
59770	Brewers yeast -----	52.98	.54	4.08	29.16	4.35	8.89
60221	Brewers yeast, dried-----	53.56	.64	4.53	25.04	7.05	9.18
63368	Brewers yeast, dried-----	51.12	.83	2.91	33.96	3.86	7.32

each ration. The effective digestible nutrients of each ration are given in Table 7. They were used to calculate the effective digestible nutrients of the feed for the experiment in question, and these are given in Table 10.

The average live weights, percentages of protein and fat, and Calories per 100 grams of chicken, as well as other data, are given in Table 5. The data from each individual chicken were calculated separately and then averaged. As already pointed out (8,12), in the same experiment on the same rations there are variations in the quantities of foods eaten by individual chickens, in gains in weights, and in fat and protein content. Since these variations have already been discussed from other data in Bulletin 571 (8) similar calculations were not made with the data here presented. Variations between the different experiments will be discussed later.

Calculation of Maintenance Requirements of the Chicks and Productive Energy of the Rations

The work is a comparison of the productive energy of the feed tested with that of corn meal, but it is necessary to make allowance for the differences in the quantities of energy used for maintenance by the groups compared.

The maintenance requirements are calculated from the data secured with the standard corn meal ration, and these in turn are used to calculate the productive energy of the other rations used at the same time in the same experiment. The productive energy of the corn meal ration was taken to be 2.78 Calories per gram of effective digestible nutrients, as found to be the average in Bulletin 571, although it may deviate slightly from this on account of changes in the constituents. For each experiment the productive energy was ascertained by multiplying by 2.78 the effective digestible nutrients of the corn meal ration, as found from the digestion experiments for that experiment and the analysis of the ration. The maintenance requirements with a few exceptions are cal-

Table 5. Average Composition, Weights and Calories Per 100 Grams for Chickens

Number of Experiment and Name of Ration	No. averaged	Live weight at beginning, gm.	Live weight at end, gm.	Empty weight at end, gm.	Per cent empty weight of live weight	Protein empty weight, %	Fat empty weight, %	Calories per 100 gm. empty weight
Experiment A31								
Preliminary chicks	3	---	42.9	39.4	92.00	17.81	7.99	175.8
Calories per 100 gm.	---	---	161.8	---	---	---	---	---
Yellow corn meal, 14 days	5	40.4	80.9	78.0	96.76	19.68	8.76	193.2
Milo ration, 14 days	6	40.9	64.2	62.3	96.92	20.55	8.44	195.2
Experiment A32								
Preliminary chicks	3	---	52.1	46.7	89.58	17.47	8.01	173.8
Calories per 100 gm.	---	---	155.7	---	---	---	---	---
Yellow corn meal	3	55.1	148.1	136.3	92.03	20.25	11.11	218.5
Milo	3	56.6	112.7	101.9	90.42	20.90	8.92	201.7
Wheat	3	55.4	160.4	152.2	94.89	20.95	10.16	213.6
Oat meal	3	54.2	159.2	148.6	93.34	21.33	8.03	196.1
Experiment A33								
Preliminary chicks	3	---	52.1	46.7	89.58	17.47	8.01	173.8
Calories per 100 gm.	---	---	155.7	---	---	---	---	---
Yellow corn meal	2	48.9	147.8	135.0	91.37	20.44	8.10	191.4
Milo	2	47.3	130.4	119.7	91.83	20.55	11.03	219.4
Wheat	2	47.8	164.9	151.4	91.81	21.28	7.00	185.9
Oat meal	2	47.3	158.0	145.1	91.86	23.12	9.11	216.0
Experiment A34								
Preliminary chicks	1	---	62.5	56.0	89.60	17.63	10.56	198.5
Calories per 100 gm.	---	---	177.9	---	---	---	---	---
Yellow corn meal	3	52.1	139.0	129.5	93.19	19.43	14.19	245.7
Milo	3	53.0	108.2	101.3	93.59	20.22	10.07	208.6
Wheat	3	52.1	119.1	107.4	90.23	21.39	6.65	183.3
Oat meal	3	55.0	135.7	125.9	92.78	21.52	5.92	177.2
Experiment A38								
Preliminary chicks	3	---	55.2	47.9	86.72	17.78	9.19	186.6
Calories per 100 gm.	---	---	161.8	---	---	---	---	---
Yellow corn meal	3	55.4	284.3	260.4	91.59	20.15	12.23	228.4
Kafir	3	54.8	318.8	293.4	92.04	18.94	12.34	222.6
Wheat	3	54.7	326.4	297.8	94.29	20.70	9.55	206.5
Milo	3	54.8	320.9	296.4	92.37	20.03	12.51	230.3
Experiment A39								
Preliminary chicks	2	---	63.0	57.6	91.41	19.17	8.70	189.9

Table 5. Average Composition, Weights and Calories Per 100 Grams for Chickens—Continued

Number of Experiment and Name of Ration	No. averaged	Live weight at beginning, gm.	Live weight at end, gm.	Empty weight at end, gm.	Per cent empty weight of live weight	Protein empty weight, %	Fat empty weight, %	Calories per 100 gm. empty weight
Calories per 100 gm.-----	--	---	173.5	---	---	---	---	---
Yellow corn meal-----	3	66.1	368.3	346.0	94.06	21.09	12.49	236.2
Kafir-----	3	65.6	231.6	217.3	95.78	23.25	8.88	214.7
Experiment A41								
Preliminary chicks-----	3	---	53.9	48.1	89.23	17.55	6.85	163.4
Calories per 100 gm.-----	--	---	145.8	---	---	---	---	---
Yellow corn meal-----	3	48.3	276.7	257.3	92.99	20.61	14.65	253.6
Kafir-----	3	50.7	276.8	259.3	93.67	20.01	11.02	216.3
Wheat-----	3	50.6	315.6	299.7	94.94	21.54	7.46	191.7
Milo-----	3	51.0	284.0	271.8	95.72	20.08	13.13	236.4
Experiment A42								
Preliminary chicks-----	1	---	90.6	79.4	87.64	17.79	9.00	184.8
Calories per 100 gm.-----	--	---	162.0	---	---	---	---	---
Yellow corn meal-----	3	93.4	407.7	381.4	93.54	20.76	13.12	240.2
Kafir-----	2	91.0	364.8	342.1	93.73	20.69	12.10	230.1
Experiment A62								
Preliminary chicks-----	4	---	36.4	31.8	87.36	16.81	4.46	136.8
Calories per 100 gm.-----	--	---	119.5	---	---	---	---	---
Corn meal-----	9	37.9	138.4	127.6	92.18	20.14	8.69	195.3
Wheat bran-----	10	37.4	178.0	165.0	92.69	20.73	7.41	186.7
Experiment A63								
Preliminary chicks-----	4	---	64.9	59.5	91.54	18.42	8.59	184.6
Calories per 100 gm.-----	--	---	169.0	---	---	---	---	---
Corn meal-----	10	69.9	205.4	192.6	93.76	20.62	9.12	202.0
Wheat bran-----	10	70.4	238.3	223.2	93.68	20.93	6.08	175.3
Experiment A64								
Preliminary chicks-----	4	---	45.2	43.2	89.53	16.96	7.19	163.2
Calories per 100 gm.-----	--	---	146.1	---	---	---	---	---
Corn meal-----	10	48.1	205.3	189.1	92.17	19.91	7.24	180.4
Hegari-----	10	48.5	183.9	168.2	91.52	19.85	7.41	181.6
Experiment A65								
Preliminary chicks-----	4	---	45.4	41.1	90.57	15.95	6.46	164.1
Calories per 100 gm.-----	--	---	148.6	---	---	---	---	---
Yellow corn meal-----	10	46.2	274.3	262.3	95.68	21.39	6.50	181.8

Yellow corn meal.....	10	46.5	279.6	268.0	95.79	21.66	7.58	193.4
Experiment 1								
Preliminary chicks.....	4	----	49.2	46.1	93.81	17.71	5.97	156.3
Calories per 100 gm.....	---	----	146.6	----	----	----	----	----
Corn meal.....	6	48.7	118.6	114.4	96.67	21.66	6.52	183.5
Patent flour.....	6	46.1	106.1	102.7	96.93	22.71	4.83	173.8
Graham flour.....	6	47.5	98.8	94.9	96.31	22.33	3.59	159.9
Bran.....	6	47.7	98.7	95.1	96.56	21.43	3.39	153.0
Experiment 2								
Preliminary chicks.....	3	----	37.6	33.4	88.83	18.33	5.65	156.5
Calories per 100 gm.....	---	----	139.0	----	----	----	----	----
Corn meal.....	6	41.2	147.9	138.6	93.67	19.28	7.80	182.1
Patent flour.....	6	54.0	144.2	136.9	94.75	20.13	6.12	171.2
Graham flour.....	6	45.5	167.3	155.3	92.86	19.97	6.33	172.3
Bran.....	6	57.4	201.3	180.5	89.98	19.23	5.95	164.5
Experiment 3								
Preliminary chicks.....	4	----	53.8	49.8	92.43	17.63	7.00	165.2
Calories per 100 gm.....	---	----	152.8	----	----	----	----	----
Corn meal.....	6	53.6	240.2	225.9	94.03	20.66	7.15	183.8
Rice.....	6	53.8	272.6	257.6	94.46	20.30	6.65	177.1
Sweet potato.....	6	53.7	247.0	230.7	93.43	19.45	8.37	188.4
Oat meal.....	6	53.9	252.3	239.3	94.78	19.90	6.45	172.9
Experiment 4								
Preliminary chicks.....	4	----	55.4	50.2	90.59	18.17	6.43	163.0
Calories per 100 gm.....	---	----	147.6	----	----	----	----	----
Corn meal.....	6	54.2	236.9	220.1	92.92	19.44	8.96	193.8
Rice.....	6	53.9	266.5	249.5	93.54	19.70	9.58	201.1
Sweet potato.....	6	53.7	178.5	165.9	92.81	18.73	10.43	205.5
Oat meal.....	6	54.5	243.0	227.0	93.39	20.05	7.76	186.0
Experiment 5								
Preliminary chicks.....	4	----	57.1	51.9	90.80	16.60	6.53	155.0
Calories per 100 gm.....	---	----	140.7	----	----	----	----	----
Corn meal.....	5	55.3	156.8	145.4	92.70	18.15	9.92	195.6
Lima bean.....	3	56.4	99.1	84.5	85.28	18.32	3.94	140.5
Navy bean.....	2	56.3	91.7	76.1	82.34	18.32	2.03	122.7
Blackeye pea.....	5	55.6	148.9	136.9	91.98	18.83	7.07	172.7
Experiment 6								
Preliminary chicks.....	4	----	65.5	56.3	86.05	16.74	7.42	164.1
Calories per 100 gm.....	---	----	141.2	----	----	----	----	----
Corn meal.....	6	65.9	191.7	181.4	94.64	20.69	8.51	196.1
Patent flour.....	6	65.6	187.6	169.7	90.61	20.14	7.75	186.4
Low grade flour.....	6	65.9	181.6	173.8	95.62	20.34	6.15	172.6
Wheat bran.....	6	65.8	177.2	167.9	94.57	20.84	2.96	145.6

Table 5. Average Composition, Weights and Calories Per 100 Grams for Chickens—Continued

Number of Experiment and Name of Ration	No. averaged	Live weight at beginning, gm.	Live weight at end, gm.	Empty weight at end, gm.	Per cent empty weight of live weight	Protein empty weight, %	Fat empty weight, %	Calories per 100 gm. empty weight
Experiment 7								
Preliminary chicks	4	---	51.5	49.5	96.20	16.93	5.23	144.7
Calories per 100 gm.	---	---	144.7	---	---	---	---	---
Corn meal	6	53.7	167.7	163.8	97.64	20.32	8.37	192.4
Patent flour	6	52.9	161.1	156.9	97.38	20.93	6.13	175.8
Low grade flour	6	52.9	173.4	169.6	97.81	21.25	6.23	178.5
Wheat bran	5	53.1	159.0	152.2	95.73	21.70	2.83	149.2
Experiment 10								
Preliminary chicks	4	---	52.4	48.1	91.63	17.46	4.82	143.9
Calories per 100 gm.	---	---	131.8	---	---	---	---	---
Corn meal	6	52.0	188.9	182.6	96.75	20.34	7.18	182.2
Patent flour	6	52.4	165.9	161.0	97.06	20.73	4.90	163.2
Clear flour	6	52.3	163.3	160.0	97.99	21.11	4.62	162.7
Corn bran	6	51.8	183.4	178.8	97.49	20.91	3.58	151.8
Experiment 13								
Preliminary chicks	4	---	53.3	51.1	95.82	18.40	6.75	167.3
Calories per 100 gm.	---	---	160.3	---	---	---	---	---
Corn meal	6	53.1	185.2	180.5	97.48	19.98	8.14	189.2
Corn bran	6	52.7	189.7	185.3	97.56	21.53	3.73	156.1
Corn bran	6	52.5	193.6	188.9	97.64	21.39	4.89	166.9
Corn bran	6	52.9	183.4	176.6	96.33	21.38	4.16	160.0
Experiment 15								
Preliminary chicks	4	---	48.6	47.4	97.62	17.06	5.11	144.4
Calories per 100 gm.	---	---	140.9	---	---	---	---	---
Corn meal	6	52.8	178.7	174.5	97.60	19.76	8.96	195.6
Starch	6	52.5	145.5	140.0	96.09	18.75	12.07	218.9
Lactose	6	52.1	109.9	102.5	93.38	20.35	2.05	134.3
Experiment 16								
Preliminary chicks	4	---	51.9	49.7	95.77	17.12	5.45	147.9
Calories per 100 gm.	---	---	141.6	---	---	---	---	---
Corn meal	6	52.8	188.4	184.5	97.89	19.78	8.65	192.8
Rice polish	6	53.0	173.9	170.1	97.82	20.69	6.10	174.1
Rice bran	6	53.4	179.9	173.5	96.53	20.97	4.62	161.9
Rye flour	6	53.8	140.2	136.1	96.87	21.03	2.94	146.5

Experiment 17								
Preliminary chicks	4	---	53.4	51.0	95.40	17.98	5.01	148.6
Calories per 100 gm.		---	141.7					
Corn meal	6	52.3	176.7	172.4	97.46	20.59	8.41	195.1
Oat hulls	6	52.9	164.6	159.5	96.84	21.49	2.36	143.7
Black kafir	6	53.0	183.2	177.7	97.06	20.54	8.26	193.4
Waxy endosperm kafir	6	54.1	175.2	172.1	98.20	20.72	7.46	187.0
Experiment 18								
Preliminary chicks	4	---	48.2	45.7	94.88	17.76	5.76	154.3
Calories per 100 gm.		---	146.4					
Corn meal	6	48.2	164.6	160.9	97.77	19.87	8.95	196.2
Starch	6	47.9	133.5	128.8	96.50	19.10	8.93	191.6
Starch and yeast	6	48.3	134.7	130.0	96.60	19.55	8.10	186.4
Starch, yeast and corn meal	6	48.6	140.6	135.8	96.62	18.93	9.60	197.2
Experiment 19								
Preliminary chicks	4	---	55.4	52.7	95.22	17.36	5.90	153.4
Calories per 100 gm.		---	146.0					
Corn meal	6	55.5	187.3	181.3	96.79	20.51	8.30	193.7
Starch and casein	6	55.7	181.7	177.3	97.61	20.79	7.00	183.1
Wheat bran	6	56.0	149.6	145.0	96.89	20.67	2.52	138.1
Wesson oil	6	56.4	172.8	166.9	96.56	18.79	13.37	231.4
Experiment 25								
Preliminary chicks	6	---	46.6	44.8	96.14	18.02	4.56	144.6
Calories per 100 gm.		---	139.0					
Corn meal	6	46.0	192.3	187.2	97.25	20.92	5.44	169.3
10% wesson oil	6	46.3	160.4	157.2	98.00	20.42	8.80	197.8
20% wesson oil	6	46.1	130.8	128.0	97.76	19.35	9.29	196.3
30% wesson oil	5	46.9	104.2	101.4	97.13	18.61	11.21	210.2
Experiment 29								
Preliminary chicks	6	---	51.4	49.5	96.29	18.31	4.92	149.6
Calories per 100 gm.		---	144.1					
Corn meal	6	51.8	196.2	189.6	96.70	20.88	4.39	159.2
Soybean oil meal	6	52.1	206.5	199.6	96.68	21.63	3.77	157.6
Peanut meal	6	52.3	214.8	208.6	97.13	21.68	4.77	167.3
Fish meal	6	52.1	196.4	186.3	94.75	21.94	4.14	162.9
Experiment 37								
Preliminary chicks	6	---	50.1	48.4	96.54	17.84	7.80	173.9
Calories per 100 gm.		---	167.9					
Corn meal	6	51.3	141.8	135.9	95.86	19.52	8.98	194.4
Linseed oil meal	4	51.4	139.3	135.2	97.12	20.77	2.05	136.8
Soybean oil meal	6	51.1	228.2	223.4	97.88	22.02	3.26	155.1
Fish meal	6	51.2	175.9	163.4	92.98	21.41	2.92	148.5

Table 5. Average Composition, Weights and Calories Per 100 Grams for Chickens—Continued

Number of Experiment and Name of Ration	No. averaged	Live weight at beginning, gm.	Live weight at end, gm.	Empty weight at end, gm.	Per cent empty weight of live weight	Protein empty weight, %	Fat empty weight, %	Calories per 100 gm. empty weight
Experiment 38								
Preliminary chicks.....	6	----	48.4	46.3	95.62	18.16	7.61	174.0
Calories per 100 gm.....	---	---	166.4	---	---	---	---	---
Corn meal.....	6	48.8	139.7	135.3	96.88	19.42	10.18	205.1
Corn gluten feed.....	6	48.9	177.6	171.5	96.59	21.57	2.97	149.8
Corn gluten meal.....	6	48.9	181.1	175.0	96.67	21.28	3.66	154.7
Peanut meal.....	6	48.2	184.9	180.4	97.58	21.06	3.48	151.7
Experiment 40								
Preliminary chicks.....	6	----	56.3	54.0	95.86	18.05	6.66	164.5
Calories per 100 gm.....	---	---	157.7	---	---	---	---	---
Corn meal.....	6	56.6	218.0	211.6	97.12	21.80	5.50	174.8
Citrus pulp.....	6	57.1	154.2	147.2	95.54	21.82	1.69	139.3
Beet pulp.....	3	58.2	60.5	56.1	92.53	19.49	1.37	123.1
Wheat gray shorts.....	6	56.8	215.8	206.6	95.76	21.94	2.63	148.8
Experiment 41								
Preliminary chicks.....	6	----	50.2	48.1	95.78	17.80	10.22	196.3
Calories per 100 gm.....	---	---	188.0	---	---	---	---	---
Corn meal.....	6	49.7	195.5	189.4	96.90	21.03	5.82	173.4
Barley.....	6	50.1	160.8	154.7	96.20	21.56	3.65	156.1
Dried citrus pulp.....	4	50.2	144.1	137.0	94.98	21.75	1.69	138.9
Wheat gray shorts.....	6	49.9	205.0	199.1	97.06	22.10	2.83	151.5
Experiment 42								
Preliminary chicks.....	5	----	42.7	40.7	95.42	16.56	4.18	132.8
Calories per 100 gm.....	---	---	126.7	---	---	---	---	---
Corn meal.....	5	44.5	209.5	199.9	95.44	18.86	10.49	204.9
Soybean oil meal.....	2	44.0	98.9	94.9	96.36	20.07	1.41	126.7
Soybean oil meal.....	6	43.6	178.6	171.0	95.74	20.77	3.27	148.1
Cottonseed flour.....	6	44.0	153.8	146.9	95.49	21.82	3.55	153.8
Experiment 43								
Preliminary chicks.....	6	----	54.0	51.4	95.36	18.32	6.14	161.1
Calories per 100 gm.....	---	---	153.6	---	---	---	---	---
Corn meal.....	6	53.9	219.9	212.8	96.79	20.43	6.22	173.8
Rice bran.....	6	54.2	225.9	217.9	96.47	20.97	3.67	153.0
Rice polish.....	6	54.9	233.4	226.8	97.19	21.03	5.05	166.2
Enzyme concentrate.....	6	54.5	232.6	226.4	97.34	20.84	6.00	174.1

Experiment 44								
Preliminary chicks	6	---	54.2	52.0	95.92	18.58	7.67	176.9
Calories per 100 gm.	---	---	169.7	---	---	---	---	---
Corn meal	6	54.2	226.6	219.5	96.85	21.68	5.95	178.4
Beet pulp	6	54.1	182.5	175.0	95.85	22.81	2.21	149.8
Dried sweet potato	6	54.4	159.1	153.3	96.31	21.22	6.52	181.1
Rice hulls	6	54.2	129.1	123.8	95.91	22.57	1.32	140.0
Experiment 46								
Preliminary chicks	6	---	53.5	50.4	94.20	18.68	6.29	164.5
Calories per 100 gm.	---	---	154.9	---	---	---	---	---
Corn meal	6	54.1	212.4	206.2	97.01	21.17	6.21	177.8
Sweet potato	6	54.0	127.2	120.1	93.84	20.18	6.00	170.3
Peanut meal	6	54.2	205.9	201.8	96.29	22.11	3.19	155.0
Yeast	5	53.6	106.2	102.5	90.52	22.38	1.50	140.7
Experiment 47								
Preliminary chicks	6	---	52.7	50.0	94.99	18.12	6.02	159.1
Calories per 100 gm.	---	---	151.1	---	---	---	---	---
Corn meal	6	52.3	207.3	199.5	96.18	21.94	4.75	168.6
Millet seed	6	52.8	226.2	227.8	96.42	21.87	4.64	167.2
Sunflower seed	6	53.2	225.7	217.3	96.23	21.90	4.27	163.9
Rye	4	51.5	193.1	185.3	95.88	21.92	3.21	154.1
Experiment 48								
Preliminary chicks	6	---	52.6	49.3	93.73	18.06	6.86	166.4
Calories per 100 gm.	---	---	155.9	---	---	---	---	---
Corn meal	6	52.7	215.0	207.2	96.35	20.43	9.59	205.3
Shrimp meal	6	52.5	157.0	145.8	93.63	21.37	1.49	134.9
Yeast	6	52.9	190.1	183.0	96.21	22.93	3.00	157.9
Dried sweet potato	6	53.1	95.9	90.8	94.67	20.36	7.18	182.3
Experiment 52								
Preliminary chicks	6	---	49.9	47.7	95.59	17.82	8.51	181.3
Calories per 100 gm.	---	---	173.3	---	---	---	---	---
Corn meal	6	50.2	202.8	195.7	96.48	20.95	6.56	179.9
Rice polish	6	51.0	216.0	207.8	96.20	21.85	4.79	168.5
Oat hulls	5	50.1	128.9	122.9	95.44	21.73	1.18	134.0
Skim milk	6	50.0	201.8	194.3	96.29	22.15	3.58	158.8
Experiment 53								
Preliminary chicks	6	---	50.7	47.0	92.79	17.02	9.20	182.4
Calories per 100 gm.	---	---	169.2	---	---	---	---	---
Corn meal	6	50.7	132.6	126.7	95.51	20.73	8.36	195.5
Corn gluten feed	6	50.9	178.8	171.2	95.11	22.08	2.83	151.5
Corn gluten meal	6	51.3	165.3	158.3	95.63	21.52	3.58	155.3
Rice bran	6	50.9	165.5	158.4	95.64	21.46	6.82	185.3

Table 5. Average Composition, Weights and Calories Per 100 Grams for Chickens—Continued

Number of Experiment and Name of Ration	No. averaged	Live weight at beginning, gm.	Live weight at end, gm.	Empty weight at end, gm.	Per cent empty weight of live weight	Protein empty weight, %	Fat empty weight, %	Calories per 100 gm. empty weight
Experiment 54								
Preliminary chicks	6	---	62.1	58.7	94.59	17.95	6.74	164.6
Calories per 100 gm.	---	---	155.7	---	---	---	---	---
Corn meal	6	61.8	210.7	203.2	96.42	20.16	11.83	224.7
Beet pulp	6	62.3	90.9	82.5	90.83	21.34	1.93	138.9
Citrus pulp	6	62.4	123.6	117.1	94.70	20.57	5.74	170.1
Fish meal	6	62.3	238.3	230.4	96.64	22.69	2.79	154.4
Experiment 55								
Preliminary chicks	6	---	56.8	53.5	94.10	18.07	7.33	170.8
Calories per 100 gm.	---	---	160.7	---	---	---	---	---
Corn meal	6	55.0	217.0	209.3	96.40	20.87	6.99	185.2
Cane seed	6	57.2	235.0	227.1	96.61	20.72	8.25	194.3
Broom corn seed	6	56.3	225.1	217.4	96.61	22.76	6.25	187.2
Rye	6	56.9	179.1	172.9	96.47	22.31	3.49	159.5
Experiment 56								
Preliminary chicks	6	---	46.9	43.2	92.31	17.44	7.50	168.8
Calories per 100 gm.	---	---	155.9	---	---	---	---	---
Corn meal	6	46.7	157.2	151.5	96.29	20.49	9.92	208.7
Casein	6	47.3	144.1	137.0	95.03	21.24	3.45	152.5
Yeast	6	47.4	117.1	109.6	93.20	22.96	1.84	147.1
Alfalfa leaf meal	6	47.4	177.6	170.1	95.87	22.33	2.61	150.8
Experiment 57								
Preliminary chicks	6	---	48.7	45.8	94.19	17.32	5.07	145.4
Calories per 100 gm.	---	---	136.6	---	---	---	---	---
Corn meal	6	48.0	161.5	155.5	95.82	19.14	10.33	209.5
Cottonseed flour	6	48.7	109.9	102.5	92.98	20.99	3.34	140.7
Linseed oil meal	5	48.7	80.7	74.0	91.55	19.72	1.62	128.8
Soybean oil meal	6	48.8	160.5	152.3	94.81	21.24	2.15	140.4
Experiment 59								
Preliminary chicks	6	---	46.0	42.9	93.30	17.44	6.17	156.4
Calories per 100 gm.	---	---	145.9	---	---	---	---	---
Corn meal	6	46.2	154.5	147.4	95.40	18.68	8.80	188.0
Sweet potato	6	46.5	99.2	93.8	94.60	18.65	8.03	180.6
Dried beef	6	46.8	186.4	176.4	94.70	19.74	3.01	139.9
Liver meal	6	46.3	255.9	247.1	96.50	21.10	4.27	159.4

Experiment 60								
Preliminary chicks	6	----	47.3	44.6	94.33	17.36	6.11	155.4
Calories per 100 gm.	---	----	146.6	---	---	---	---	---
Corn meal	6	47.4	154.1	147.8	95.94	19.72	10.08	205.8
Peanut meal	6	47.1	178.7	171.9	96.16	21.53	2.72	147.3
Tankage	6	47.5	202.8	194.4	95.84	21.78	2.84	149.9
Sunflower seed	5	47.0	182.9	175.7	80.03	20.65	7.74	189.2
Experiment 61								
Preliminary chicks	6	----	47.3	44.6	94.31	18.01	6.68	162.5
Calories per 100 gm.	---	----	153.2	---	---	---	---	---
Corn meal	6	48.3	184.4	177.4	96.15	20.78	4.36	158.3
Rye	5	47.7	145.8	139.6	95.90	21.73	3.63	147.6
Broom corn seed	6	48.5	205.4	198.0	96.43	21.61	5.87	177.2
Red Top sorghum	5	48.5	190.4	188.4	96.29	21.19	5.35	170.0
Experiment 62								
Preliminary chicks	6	----	49.1	46.5	94.80	17.73	8.39	182.9
Calories per 100 gm.	---	----	151.6	---	---	---	---	---
Corn meal	6	50.4	147.5	140.3	95.03	19.09	8.22	184.9
Coconut oil meal	6	49.8	155.4	147.6	94.99	21.16	3.17	149.4
Shrimp bran	6	50.0	170.7	162.2	95.04	22.10	1.48	138.0
Millet seed	6	50.4	141.6	135.8	95.79	20.37	7.94	183.3
Experiment 63								
Preliminary chicks	6	----	52.2	49.2	94.30	17.96	4.82	146.7
Calories per 100 gm.	---	----	138.4	---	---	---	---	---
Corn meal	5	51.9	229.4	219.7	95.76	20.94	5.09	166.1
Barley	6	52.6	234.0	226.0	96.28	21.57	2.83	148.6
Shrimp meal	5	53.2	123.4	114.2	91.94	20.22	1.48	128.3
Citrus pulp	3	53.4	104.1	95.9	92.09	20.06	1.17	124.5
Experiment 65								
Preliminary chicks	6	----	53.3	49.6	93.19	18.59	4.58	148.0
Calories per 100 gm.	---	----	137.9	---	---	---	---	---
Corn meal	6	63.4	169.4	161.6	95.35	20.27	9.54	204.0
Coconut oil meal	6	54.2	174.5	164.9	94.77	21.76	2.55	147.0
Navy bean	6	53.4	159.4	149.0	93.59	20.92	4.06	156.3
Pinto bean	6	53.4	121.4	111.8	92.14	20.79	3.25	148.1
Experiment 66								
Preliminary chicks	6	----	53.3	50.3	94.63	18.25	7.39	172.5
Calories per 100 gm.	---	----	163.2	---	---	---	---	---
Corn meal	6	53.3	176.9	168.8	95.38	19.69	12.28	226.2
Geatin	6	53.5	103.9	97.5	93.70	20.55	2.45	139.2
Blackeye pea	6	53.5	189.8	182.3	95.82	20.24	7.37	183.5
Lima bean	6	53.5	114.5	109.3	95.37	20.18	7.72	185.8

culated with use of the average weights by periods; this has been shown (8) to give more consistent results than the use of the average of the first and last weights and to give results more consistent and better in accord with the previous work of others than the use of the surface area. Average data and results of the calculations of the maintenance requirements are given in Table 6.

The initial energy content of each chicken is calculated from the initial live weight and the initial energy per gram, as found by analysis (Table 5), and the final energy content from the final empty weight and final energy content of the chicks (Table 5). The productive energy consumed is the grams of the corn meal ration eaten multiplied by the productive energy per gram of the ration used in the experiment. The total productive energy for maintenance is the productive energy of the feed eaten less the gain of energy of each chick, since, by definition, the productive energy is measured by the gain in energy. The total calories for maintenance are divided by the weight by periods and multiplied by 100 to find the calories of productive energy required to maintain 100 grams of chicken for the period of each experiment. The latter results, divided by the number of days, gives the maintenance requirement per day per 100 grams, expressed as calories or productive energy.

The average maintenance requirement per day per 100 grams for the 51 experiments shown in Table 5 is 14.12 Calories of productive energy. The maximum is 17.05, and the minimum is 9.72 Calories per day per 100 grams. It is pointed out in Bulletin 571 (6) that these variations from one experiment to another appear not materially to affect the productive energy which is compared by using the maintenance value. The causes of these variations will be studied later. Here the importance of placing the group on the standard corn meal ration at the same time as the other groups must be emphasized. The data from this group enables corrections to be made for variations in the maintenance requirements, which might otherwise seriously impair the accuracy of the work.

The average data and results of the calculation of the productive energy of the rations which were compared with corn meal are given in Table 7. The energy used for maintenance is calculated by multiplying the average weight by periods of each chicken by the average calories required to maintain 1 gram of chicken as found with use of the corn meal ration for the same experiment as calculated in Table 6. The sum of the calories for maintenance and for gain of energy gives the total productive energy of the quantity of the feed eaten. This sum divided by the quantity of feed eaten gives the calories of productive energy per gram of the ration. The productive energy is given in the next to last column of Table 7. It is to be noted that there is a range from .762 to 2.319 calories per gram productive energy values of the rations used.

In securing the values given in Table 6 and 7, the maintenance requirements or the productive energy was first calculated from the data for

Table 6. Average Data and Calculation of Maintenance Requirements for Chickens Fed on the Standard Corn Meal Ration

Experiment number	Number averaged	Average weight by periods gm.	Initial energy content Cal.	Final energy content Cal.	Gain of energy Cal.	Prod. energy of Ration per gm.	Ration eaten gm.	Prod. energy of feed eaten Cal.	For Maintenance		
									Total prod. energy Cal.	Prod. energy per period and 100 gm. Cal.	Prod. energy per day and 100 gm. Cal.
A31	5	60.7	65.4	150.7	85.3	1.980	131.2	259.8	174.5	286.7	20.48
A32	3	101.6*	85.8	297.8	212.0	1.984	297.4	530.5	318.5	318.1	14.91
A33	2	98.3*	258.5	182.4	182.4	1.984	302.2	500.6	417.2	493.9	15.14
A34	3	95.6*	92.7	314.2	221.5	1.984	925.0	595.8	304.3	318.0	15.14
A38	3	175.8	80.3	504.7	505.0	1.973	464.2	915.9	410.9	283.0	9.72
A39	3	212.2	114.8	818.0	703.2	1.973	673.1	1332.0	628.8	301.4	11.59
A41	3	168.8	70.4	632.6	582.2	1.973	489.0	964.8	382.6	226.0	9.42
A42	3	219.0	151.3	916.1	764.8	1.973	726.5	1433.3	668.6	307.2	10.97
A62	9	77.4	45.3	249.8	204.5	1.739	312.1	561.5	357.0	461.0	16.48
A63	10	139.7	118.1	390.2	272.1	1.747	392.6	633.5	391.4	280.0	13.32
A64	10	111.9	70.2	342.3	272.1	1.846	448.7	828.3	556.2	496.0	17.72
A65	10	139.1	68.7	478.1	409.5	1.991	479.9	955.5	546.0	393.0	14.05
1	6	77.5	71.4	210.8	139.4	1.909	290.9	498.1	358.7	466.0	16.37
2	6	82.3	57.2	252.6	195.4	1.909	344.9	467.5	272.1	328.0	15.35
3	6	133.7	82.0	416.9	345.0	1.919	472.4	903.5	511.6	426.0	15.00
4	6	133.8	80.1	435.7	345.0	1.877	444.7	834.7	489.1	364.0	12.75
5	5	94.9	77.8	287.5	209.7	1.948	252.8	492.5	292.8	301.1	14.34
6	6	118.0	93.1	357.5	264.4	1.961	275.2	539.7	275.3	284.5	11.10
7	6	107.3	74.7	315.5	240.8	1.892	249.0	471.1	230.3	215.2	10.21
10	6	116.7	68.5	333.0	258.2	1.925	285.9	550.4	285.9	247.0	11.79
13	6	118.7	85.1	343.3	264.5	1.909	297.4	525.7	267.5	226.4	10.78
15	6	114.0	74.4	341.9	267.6	1.972	267.4	557.3	259.7	229.0	10.90
16	6	118.3	74.8	355.2	280.4	1.952	289.7	565.5	285.1	240.6	11.46
17	6	114.4	74.2	338.4	264.3	1.962	275.7	543.1	278.8	244.5	11.64
28	6	103.6	70.5	315.7	245.2	1.962	246.0	482.7	257.5	229.4	10.93
19	6	126.4	81.0	331.2	270.2	1.828	327.0	507.8	327.6	259.0	12.34
25	6	118.9	64.0	318.3	254.3	1.767	360.8	637.6	383.3	322.4	15.35
29	6	125.9	74.6	392.5	227.8	1.889	302.6	571.6	343.8	273.3	13.01
37	6	90.7	86.2	263.1	179.0	1.925	270.2	520.2	341.2	332.6	16.79
38	6	95.6	89.2	279.6	198.4	1.964	267.3	524.9	326.5	246.7	16.37
40	6	143.5	89.2	370.3	231.1	1.838	353.0	648.9	367.8	353.0	12.19
41	6	122.2	93.4	330.2	231.1	1.914	331.4	634.3	397.6	327.5	15.59
42	6	123.8	56.4	410.2	333.7	1.917	335.3	637.5	404.1	337.0	15.59
43	6	137.4	82.7	368.1	285.3	1.924	359.8	692.2	406.8	293.9	13.90
44	6	143.3	91.9	393.1	301.2	1.904	375.0	714.1	412.9	290.7	13.84

Table 6. Average Data and Calculation of Maintenance Requirements for Chickens Fed on the Standard Corn Meal Ration—Continued

Experiment number	Number averaged	Average weight by periods gm.	Initial energy content Cal.	Final energy content Cal.	Gain of energy Cal.	Prod. energy of ration Cal. per gm.	Ration eaten gm.	Prod. energy of feed eaten Cal.	For Maintenance		
									Total prod. energy Cal.	Prod. energy per period and 100 gm. Cal.	Prod. energy per day and 100 gm. Cal.
46	6	132.1	84.8	367.4	282.6	1.865	344.7	642.8	360.3	273.9	13.04
47	6	136.7	79.0	335.5	256.5	1.950	365.4	712.6	456.1	333.0	15.86
48	6	136.6	82.1	427.6	345.5	1.909	421.6	804.7	459.3	337.9	16.09
52	6	128.7	87.0	352.5	265.5	1.900	331.2	629.4	363.9	283.3	13.49
53	6	95.8	85.7	248.1	162.4	1.937	253.7	491.5	307.1	323.4	15.40
54	6	141.1	96.2	458.7	362.5	1.937	419.6	812.8	450.3	320.8	15.28
55	6	139.4	88.4	389.9	301.5	1.863	362.9	681.0	379.6	273.0	12.99
56	6	102.0	72.8	321.6	248.8	1.869	326.9	611.0	362.1	358.0	17.05
57	6	110.6	65.5	328.7	263.1	1.894	343.4	650.3	387.2	353.8	16.85
59	6	101.3	67.4	278.7	211.3	1.979	302.8	599.2	361.9	358.9	17.09
60	6	105.5	69.5	305.9	236.4	1.952	308.9	602.9	366.6	319.6	16.65
61	6	117.4	74.0	281.0	190.3	1.888	312.4	589.8	383.0	324.9	15.47
62	6	103.5	76.4	259.4	183.0	1.923	277.2	533.1	350.1	338.1	16.09
63	5	139.3	71.9	364.4	292.6	1.875	391.5	734.1	412.1	316.6	15.52
65	6	116.4	73.6	334.1	260.6	1.866	323.0	602.8	342.2	294.2	14.01
66	6	122.0	86.9	382.3	295.4	1.890	324.4	613.2	317.8	260.7	12.42
Average (51)											14.12

*Average of first and last weights of chicks.

Table 7. Data and Calculation for Average Productive Energy of Rations and Effective Digestive Nutrients

Experiment Number and Name of Ration	Number averaged	Average weight by periods gm.	Initial energy content Cal.	Final energy content Cal.	Gain of energy Cal.	Ration eaten gm.	Used for maintenance Cal.	For gain and maintenance Cal.	Prod. energy of ration Cal. per gm.	Effective digest. nut. of ration per 100 gm.
Experiment A31										
Milo-----	6	52.6*	66.1	122.5	56.4	105.8	150.8	207.2	1.995	71.0
Experiment A32										
Milo-----	3	84.7*	88.1	205.6	117.5	198.5	265.0	382.5	1.927	71.0
Ground wheat-----	3	107.9*	86.3	325.1	238.8	317.9	337.8	576.6	1.814	70.7
Oat meal-----	3	106.7*	84.3	291.3	207.0	278.7	333.9	540.9	1.941	69.4
Experiment A33										
Milo-----	2	88.8*	73.6	262.7	189.1	291.5	376.5	565.6	1.910	71.0
Ground wheat-----	2	106.3*	74.4	281.4	207.0	342.0	450.7	657.7	1.923	70.7
Oat meal-----	2	102.6*	73.6	313.5	239.9	327.7	435.0	674.9	2.060	69.4
Experiment A34										
Milo-----	3	80.6*	94.2	211.3	117.1	206.8	256.3	373.4	1.805	71.0
Ground wheat-----	3	85.6*	92.7	196.9	104.2	253.1	272.2	376.4	1.487	70.7
Oat meal-----	3	95.3*	97.8	223.0	125.2	248.5	303.2	428.4	1.724	69.4
Experiment A38										
Milo-----	3	188.4	88.7	653.0	564.4	520.0	439.0	1008.4	1.930	69.5
Wheat-----	3	191.8	88.5	635.4	546.9	558.9	446.8	993.7	1.778	66.6
Milo-----	3	193.0	88.6	682.7	594.1	583.2	449.7	1043.8	1.790	60.3
Experiment A39										
Milo-----	3	180.5	113.8	485.2	371.4	478.2	543.2	914.6	1.867	69.5
Experiment A41										
Milo-----	3	171.1	73.9	560.8	486.9	522.5	386.8	873.6	1.672	69.5
Wheat-----	3	183.5	73.8	574.4	500.6	564.1	421.5	922.1	1.635	66.6
Milo-----	3	175.3	74.4	642.7	568.3	569.7	396.1	964.4	1.693	69.3
Experiment A42										
Milo-----	2	206.1	147.5	792.7	645.2	784.1	632.6	1277.8	1.623	69.5
Experiment A62										
Wheat bran-----	10	94.1	44.7	308.6	263.8	449.9	433.7	697.5	1.553	56.0

*Average of first and last weights of chicks.

PRODUCTIVE ENERGY OF FEEDS AND FOODS FOR GROWING CHICKENS

Table 7. Data and Calculation for Average Productive Energy of Rations and Effective Digestible Nutrients—Continued

Experiment Number and Name of Ration	Number averaged	Average weight by periods gm.	Initial energy content Cal.	Final energy content Cal.	Gain of energy Cal.	Ration eaten gm.	Used for maintenance Cal.	For gain and maintenance Cal.	Prod. energy of ration Cal. per gm.	Effective digest. nut. of ration per 100 gm.
Experiment A63 Wheat bran.....	10	144.0	119.0	392.4	273.4	461.2	403.1	676.5	1.465	51.5
Experiment A64 Hegari.....	10	101.7	70.8	306.7	235.9	400.7	504.2	740.1	1.849	65.3
Experiment A65 Corn meal, yellow.....	10	146.2	69.1	520.4	451.3	511.7	574.4	1025.7	2.003	71.6
Experiment 1 White flour.....	6	70.7	67.6	179.7	112.1	260.9	329.5	441.7	1.693	63.9
Graham flour.....	3	67.6	69.6	152.4	82.9	260.9	313.2	396.1	1.520	61.1
Wheat bran.....	6	68.0	69.9	146.4	76.6	241.8	316.7	393.2	1.528	58.5
Experiment 2 White flour.....	6	89.6	75.1	235.7	160.7	229.1	293.9	454.5	1.979	63.9
Graham flour.....	6	94.7	63.3	268.4	205.2	321.4	310.4	515.6	1.653	61.1
Wheat bran.....	6	110.6	79.9	297.1	217.2	355.3	362.8	580.0	1.644	58.5
Experiment 3 Rice.....	6	149.8	82.2	456.9	374.7	512.1	637.9	1012.6	1.978	68.1
Sweet potatoes.....	6	139.5	82.1	435.2	353.1	493.3	594.3	947.4	1.923	72.0
Oat meal.....	6	136.7	82.4	416.6	334.2	483.1	582.4	916.7	1.894	68.5
Experiment 4 Rice.....	6	149.5	79.6	503.0	423.4	518.2	544.1	967.5	1.863	66.5
Sweet potatoes.....	6	112.5	79.3	346.2	267.0	355.2	409.5	676.4	1.906	74.1
Oat meal.....	6	140.9	80.4	425.3	344.9	458.2	513.0	857.9	1.867	66.4
Experiment 5 Lima beans.....	3	72.4	79.4	118.6	89.2	251.1	217.8	257.0	1.025	47.8
Navy beans.....	2	72.1	79.2	93.3	14.1	172.1	216.9	231.0	1.372	52.7
Blackeye peas.....	5	90.8	78.3	237.2	159.0	251.6	273.4	432.4	1.725	62.1
Experiment 6 Patent flour.....	6	111.6	92.6	316.2	223.6	271.9	262.2	455.8	1.792	68.5
Low grade flour.....	6	115.4	93.1	302.1	209.1	277.2	271.1	480.2	1.737	66.5
Wheat bran.....	6	114.6	93.0	244.8	151.8	356.5	268.8	420.6	1.178	47.9

Experiment 7										
Patent flour	6	103.8	73.6	276.6	203.0	249.0	223.3	426.2	1.718	69.4
Low grade flour	e	111.6	73.6	303.4	229.8	260.6	239.9	409.6	1.800	68.3
Wheat bran	5	106.5	74.0	228.4	154.4	355.2	228.9	382.3	1.072	45.9
Experiment 16										
Patent flour	6	104.9	69.0	264.0	195.0	264.6	259.0	454.0	1.715	64.5
Clear flour	6	107.2	68.9	260.6	191.7	252.4	234.7	456.4	1.811	69.0
Corn bran	6	117.8	68.2	272.2	204.0	368.9	291.0	495.0	1.342	48.0
Experiment 13										
Corn bran	6	120.8	84.4	291.4	207.0	363.8	273.0	480.0	1.316	46.1
Corn bran	6	121.1	84.2	314.9	230.8	346.1	273.6	504.4	1.461	50.4
Corn bran	6	116.8	84.4	282.0	197.6	415.1	264.0	461.6	1.117	39.3
Experiment 15										
Starch	6	101.7	73.9	306.1	232.2	256.4	232.9	465.1	1.809	70.2
Lactose	6	84.9	73.4	137.6	64.1	312.3	240.9	328.0	.836	48.3
Experiment 16										
Rice polish	6	111.0	75.1	296.2	221.2	262.7	267.6	488.8	1.880	70.6
Rice bran	6	114.4	75.6	281.3	205.8	281.9	275.6	481.4	1.706	61.4
Rye flour	e	97.0	76.2	201.5	125.3	244.1	233.7	359.0	1.470	59.0
Experiment 17										
Oat hulls	6	110.3	75.0	229.7	154.7	392.9	271.1	425.8	1.091	37.6
Kafir	6	121.3	75.0	344.1	269.0	290.0	296.0	565.1	1.950	68.6
Kafir (waxy)	6	113.9	76.6	321.6	245.0	275.3	278.0	523.0	1.902	68.7
Experiment 18										
Starch	6	88.8	70.2	247.6	177.5	213.7	203.4	380.8	1.777	71.3
Starch and yeast	6	89.2	70.7	243.1	172.4	203.5	204.4	376.8	1.852	71.2
Starch+(yeast+corn oil)	6	92.9	71.1	268.2	197.1	218.6	212.7	409.8	1.887	74.6
Experiment 19										
Starch	6	123.2	81.4	325.5	244.2	308.1	319.0	563.2	1.823	65.6
Wheat bran	3	106.1	81.8	200.5	118.7	424.6	274.9	393.6	.932	37.9
Wesson oil	6	118.9	82.3	387.2	305.0	280.3	308.0	613.0	2.188	84.6
Experiment 25										
Wesson oil (10%)	6	105.1	64.4	310.5	246.1	287.2	334.2	580.3	2.034	75.9
Wesson oil (20%)	e	91.3	64.0	253.2	189.2	215.4	290.4	479.6	2.216	86.5
Wesson oil (30%)	5	78.2	65.2	216.3	151.1	173.8	248.7	399.9	2.319	95.7
Experiment 29										
Soybean oil meal	6	135.7	75.1	315.4	240.3	383.1	370.4	610.7	1.593	54.8
Peanut meal	e	138.9	75.4	349.2	273.8	388.2	379.2	652.9	1.633	58.7
Fish meal	6	132.4	75.0	303.8	228.8	320.6	361.5	590.3	1.840	62.4

Table 7. Data and Calculation for Average Productive Energy of Rations and Effective Digestible Nutrients—Continued

Experiment Number and Name of Ration	Number averaged	Average weight by periods gm.	Initial energy content Cal.	Final energy content Cal.	Gain of energy Cal.	Ration eaten gm.	Used for maintenance Cal.	For gain and maintenance Cal.	Prod. energy of ration Cal. per gm.	Effective digest. nut. of ration per 100 gm.
Experiment 37										
Linseed oil meal.....	4	95.7	86.2	209.2	98.0	333.5	337.7	435.7	1.302	47.7
Soybean oil meal.....	6	138.5	85.7	345.3	259.6	439.9	439.0	748.6	1.697	53.0
Fish meal.....	6	117.6	86.0	243.0	157.0	361.9	415.1	572.1	1.583	52.2
Experiment 38										
Corn gluten feed.....	6	116.4	81.4	257.1	175.8	409.7	400.5	576.3	1.409	47.1
Corn gluten meal.....	6	116.2	81.4	270.7	189.3	350.9	399.7	500.0	1.683	53.3
Peanut meal.....	6	116.7	80.1	273.9	193.8	354.1	401.6	595.4	1.681	55.5
Experiment 40										
Citrus pulp.....	6	117.0	90.0	205.2	115.2	409.6	286.7	401.9	.980	39.2
Beet pulp.....	3	65.8	91.7	68.6	23.0	147.6	168.4	145.3	.989	35.3
Wheat gray shorts.....	6	141.9	89.5	309.0	219.5	430.9	363.2	582.7	1.342	59.2
Experiment 41										
Barley.....	6	106.6	94.3	241.4	147.2	292.6	348.7	495.8	1.707	59.7
Citrus pulp.....	4	104.1	94.4	192.0	97.6	392.7	340.4	438.0	1.122	42.0
Wheat gray shorts.....	6	132.0	93.9	302.2	208.3	393.4	431.7	640.0	1.623	53.2
Experiment 42										
Soybean oil meal.....	2	69.3	55.7	121.8	66.1	305.2	226.6	292.7	.933	41.6
Soybean oil meal.....	6	108.6	55.3	253.3	198.0	374.2	355.0	553.0	1.487	48.0
Cottonseed flour.....	6	98.8	55.8	228.3	172.6	321.5	322.9	495.5	1.538	56.3
Experiment 43										
Rice bran.....	6	142.6	83.3	334.2	250.9	407.2	419.3	670.2	1.649	54.9
Rice polish.....	6	142.5	84.3	379.0	294.7	369.0	418.9	713.6	1.929	68.5
Enzyme concentrate.....	6	142.5	83.7	394.5	310.9	378.5	418.9	729.8	1.928	69.8
Experiment 44										
Beet pulp.....	6	126.1	91.7	261.3	169.6	413.2	366.8	536.4	1.297	43.8
Sweet potato.....	6	107.8	92.2	278.4	186.2	323.8	313.6	499.8	1.534	63.2
Rice hulls.....	6	118.9	92.1	173.1	81.1	500.1	346.1	427.1	0.861	27.7
Experiment 46										
Sweet potato.....	6	95.7	83.6	204.3	120.7	272.5	262.3	383.0	1.399	61.1
Peanut meal.....	6	133.5	83.9	310.0	226.1	430.1	365.7	561.8	1.373	56.8

Yeast-----	5	84.9	83.0	144.5	61.5	275.2	232.7	294.2	1.070	47.8
Experiment 47										
Millet seed-----	6	151.6	79.7	381.0	301.3	417.1	504.8	806.1	1.926	63.6
Sunflower seed-----	6	145.0	80.3	357.1	276.8	396.1	482.7	759.4	1.904	60.3
Rye seed-----	4	129.7	77.7	290.3	212.5	402.6	431.8	644.4	1.590	58.1
Experiment 48										
Shrimp meal-----	6	118.7	81.9	196.6	114.7	363.6	401.2	515.9	1.414	46.8
Yeast-----	6	124.5	82.5	238.9	206.4	369.7	420.9	627.3	1.669	57.6
Dried sweet potato-----	6	80.9	82.8	166.0	83.2	222.0	273.3	356.5	1.626	61.5
Experiment 52										
Rice polish-----	6	137.2	88.3	350.8	262.4	339.1	388.2	650.7	1.917	65.9
Oat hulls-----	5	97.4	86.1	164.3	78.3	464.0	275.6	353.9	1.762	29.8
Skim milk-----	6	132.7	86.7	308.4	221.7	306.7	375.4	597.1	1.633	61.1
Experiment 53										
Corn gluten feed-----	6	123.2	86.1	259.7	173.6	402.5	392.4	557.4	1.342	46.6
Corn gluten meal-----	6	110.3	86.8	245.6	158.8	277.7	356.4	515.1	1.783	55.9
Rice bran-----	6	123.5	86.1	294.0	207.9	372.5	399.0	607.7	1.630	54.4
Experiment 54										
Beet pulp-----	6	79.9	97.0	116.2	19.2	254.9	256.6	275.8	1.075	41.0
Citrus pulp-----	6	98.5	97.2	201.2	104.0	372.8	316.3	420.3	1.123	41.5
Fish meal-----	6	163.0	97.0	356.6	259.7	424.1	523.2	782.8	1.848	55.4
Experiment 55										
Cane seed-----	6	149.2	91.8	443.4	351.6	436.0	407.4	759.0	1.738	63.9
Broom corn seed-----	6	144.4	90.5	408.2	317.7	433.0	394.3	712.0	1.644	60.1
Rye-----	6	127.0	91.4	279.1	187.7	366.0	346.6	534.2	1.443	56.4
Experiment 56										
Casein-----	6	95.7	73.8	208.9	135.1	236.8	342.7	477.8	2.088	65.2
Yeast-----	6	82.3	73.8	163.1	89.3	286.3	294.6	383.9	1.348	57.1
Alfalfa leaf meal-----	6	112.5	73.9	257.6	183.7	377.9	402.8	586.5	1.552	51.8
Experiment 57										
Cottonseed flour-----	6	80.3	66.5	140.7	74.2	235.7	284.1	358.3	1.557	59.0
Linseed oil meal-----	5	66.5	66.5	128.8	62.3	232.3	235.5	297.8	1.304	40.2
Soybean oil meal-----	6	107.0	66.7	140.4	73.7	384.1	378.7	452.3	1.179	41.5
Experiment 59										
Sweet potato-----	6	73.7	67.8	170.7	276.5	235.7	264.5	367.4	1.572	59.7
Dried beef-----	6	123.5	68.3	249.4	181.1	278.2	443.4	624.5	2.260	67.1
Liver meal-----	6	151.2	67.6	392.5	324.9	389.4	542.9	867.9	2.242	66.0
Experiment 60										
Peanut meal-----	6	115.8	69.1	253.4	184.4	338.1	404.8	589.1	1.749	57.8

Table 7. Data and Calculation for Average Productive Energy of Rations and Effective Digestible Nutrients—Continued

Experiment Number and Name of Ration	Number averaged	Average weight by periods gm.	Initial energy content Cal.	Final energy content Cal.	Gain of energy Cal.	Ration eaten gm.	Used for maintenance Cal.	For gain and maintenance Cal.	Prod. energy of ration Cal. per gm.	Effective digest. nut. of ration per 100 gm.
Tankage.....	6	130.9	69.6	291.9	222.3	404.3	458.0	679.8	1.682	54.0
Sunflower seed.....	5	120.7	69.0	332.6	263.6	340.6	421.9	685.6	2.015	66.3
Experiment 61										
Rye.....	5	101.0	73.0	206.2	133.2	298.0	328.0	461.2	1.549	58.3
Broom corn seed.....	6	130.3	74.3	352.0	277.7	381.1	423.3	701.0	1.859	60.2
Sorghum seed.....	5	123.9	74.3	313.6	239.3	346.5	402.4	641.7	1.871	65.4
Experiment 62										
Coconut oil meal.....	6	105.9	75.6	220.5	144.9	327.2	359.9	502.7	1.543	50.6
Shrimp bran.....	6	119.7	75.8	224.4	148.6	387.1	404.7	553.3	1.436	46.0
Millet seed.....	6	101.0	76.5	256.0	179.6	293.9	341.6	521.1	1.763	62.0
Experiment 63										
Barley.....	6	146.0	72.8	335.4	262.6	428.5	462.1	770.2	1.692	57.4
Shrimp bran.....	5	94.5	73.3	151.0	77.5	238.9	299.3	376.8	1.198	43.3
Citrus pulp.....	3	87.3	74.0	121.6	50.4	276.5	276.5	326.8	1.211	39.2
Experiment 65										
Coconut oil meal.....	6	124.6	74.7	242.5	167.8	424.0	366.2	534.0	1.263	45.1
Navy bean.....	6	113.9	73.6	233.4	159.8	362.2	335.0	494.8	1.375	49.6
Pinto beans.....	6	94.5	73.6	167.6	102.4	304.2	277.8	371.8	1.230	50.5
Experiment 66										
Gelatin.....	5	83.4	86.7	150.1	63.4	184.0	217.4	280.8	1.55	64.1
Blackeye peas.....	5	137.2	88.3	385.7	297.4	395.1	357.6	655.0	1.66	60.4
Lima beans.....	6	86.0	87.3	208.2	115.9	247.3	224.1	340.0	1.40	57.5

each individual chicken and the averaged. The results would be slightly different had the maintenance requirements or the productive energy been calculated from the average data.

The average difference from the mean and standard deviations are given in Table 8. The variations were much greater with some of the rations than with others. The difference may in part be due to differences between the quantities of energy used for maintenance by the group in the corn meal ration, and that used by the groups which are compared with it. It is evident that in order to secure accurate averages, the work must be repeated several times.

Calculation of the Productive Energy of the Feeds

The productive energy of the individual feeds compared with corn meal was calculated by the method illustrated in Table 9. The effective digestible nutrients of the corn meal ration, multiplied by 2.78, gives its calories of productive energy. The effective digestible constituents of the corn meal multiplied by 3.00 gives its calories of productive energy. The difference between the productive energy value of 1 gram of the corn meal ration, 1.869 Cal., and of the cocoanut oil meal rations, 1.263, gives the effect, —.603, of substitution of 0.5 gram of cocoanut oil meal for 0.5 gram of corn meal. This difference added to the productive energy of 0.5 gram of the corn meal for which it was substituted, 1.200, gives the productive energy of 0.5 gram of the cocoanut oil meal to be .597 Cal., which is 119 Cal. for 100 grams. The productive energies of the effective organic constituents and of the effective digestible constituents were then calculated from the values for the productive energy. Values of the other feeds used to replace corn meal were calculated in a similar way.

In a few of the experiments, however, the calculation was slightly different since both corn meal and some other feeds were used in the standard ration, and the feed tested was substituted partly for corn meal and partly for casein (12).

These calculations are based upon corn meal having an average productive energy of 3.00 Cal. per gram of effective digestible nutrients, as found in previous work (12). The effective digestible nutrients of the feeds compared with corn meal were calculated from the digestion experiments on the rations by methods similar to those used for calculating the productive energy, as described above (Table 9). That is to say, the total digestible nutrients of the test ration were subtracted from those of the standard corn meal ration and the calculations completed in a way similar to that for productive energy.

Productive Energy of the Feeds Used

The productive energy of certain feeds, their effective digestible nutrients, the productive energy per gram of effective digestible nutrients as compared with that of corn meal as 100, as found in each test, are

Table 8. Variations of average productive energy of rations as calculated from data from individual chickens

Experience Number and Name of Ration	Number aver- aged	Productive energy of ration calories per gram			Average differ- ence	Standard devia- tions
		Average	Maxi- mum	Mini- mum		
Experiment A31						
Milo.....	6	1.995	2.217	1.767	.140	.175
Experiment A39						
Milo.....	2	1.867	2.122	1.686	.160	.211
Experiment A42						
Milo.....	2	1.623	1.707	1.538	.085	.119
Experiment A62						
Wheat bran.....	10	1.553	1.673	1.473	.047	.061
Experiment A63						
Wheat bran.....	10	1.465	1.556	1.345	.072	.083
Experiment A64						
Hegari.....	10	1.849	2.073	1.661	.093	.126
Experiment A65						
Corn meal, yellow.....	10	2.003	2.166	1.837	.108	.125
Experiment 1						
Patent flour.....	6	1.693	1.839	1.537	.085	.107
Graham flour.....	6	1.520	1.610	1.420	.060	.078
Wheat bran.....	6	1.528	1.678	1.438	.062	.085
Experiment 2						
Patent flour.....	6	1.979	2.175	1.837	.089	.118
Graham flour.....	6	1.653	1.952	1.028	.208	.323
Wheat bran.....	6	1.644	1.731	1.359	.095	.142
Experiment 3						
Oatmeal.....	6	1.978	2.034	1.700	.073	.107
Sweet potato.....	6	1.923	1.989	1.850	.055	.064
Rice.....	6	1.894	1.984	1.565	.135	.193
Experiment 4						
Rice.....	6	1.868	1.968	1.564	.125	.166
Sweet potato.....	6	1.906	2.086	1.745	.088	.119
Oatmeal.....	6	1.867	2.028	1.695	.086	.116
Experiment 5						
Lima bean.....	3	1.025	1.059	1.000	.022	.030
Navy bean.....	2	1.372	1.498	1.246	.126	.178
Blackeye pea.....	5	1.725	1.809	1.638	.059	.073
Experiment 6						
Patent flour.....	6	1.792	1.928	1.656	.080	.098
Low grade flour.....	6	1.737	2.011	1.246	.164	.257
Wheat bran.....	6	1.178	1.287	.982	.071	.107
Experiment 7						
Patent flour.....	6	1.718	1.785	1.658	.031	.044
Low grade flour.....	6	1.800	1.965	1.625	.117	.143
Wheat bran.....	5	1.072	1.131	.931	.060	.083
Experiment 10						
Patent flour.....	6	1.715	2.044	1.395	.161	.222
Clear flour.....	6	1.811	1.900	1.730	.040	.057
Corn bran.....	6	1.342	1.433	1.256	.055	.069
Experiment 13						
Corn bran.....	6	1.316	1.372	1.263	.034	.042
Corn bran.....	6	1.461	1.536	1.375	.056	.064
Corn bran.....	6	1.117	1.341	.955	.080	.126
Experiment 15						
Starch.....	6	1.809	2.071	1.636	.149	.178
Lactose.....	6	.828	.892	.743	.039	.053
Experiment 16						
Rice polish.....	6	1.880	2.066	1.562	.191	.224
Rice bran.....	6	1.706	1.803	1.593	.058	.075
Rye flour.....	6	1.470	1.610	1.274	.111	.134
Experiment 17						
Oat hull.....	6	1.091	1.316	.884	.122	.154
Kafir.....	6	1.950	2.130	1.733	.083	.129
Kafir.....	6	1.902	2.067	1.778	.101	.120
Experiment 18						
Starch.....	6	1.777	1.839	1.667	.046	.061
Starch+yeast.....	6	1.852	1.922	1.769	.045	.057
Starch+yeast+corn oil.....	6	1.887	2.024	1.708	.114	.137

Table 8. Variations of average productive energy of rations as calculated from data from individual chickens—Continued

Experience Number and Name of Ration	Number averaged	Productive energy of ration calories per gram			Average difference	Standard deviations
		Average	Maximum	Minimum		
Experiment 19						
Starch.....	6	1.823	2.013	1.686	.100	.126
Wheat bran.....	6	.932	1.066	.869	.058	.065
Wesson oil.....	6	2.188	2.615	1.816	.189	.266
Experiment 25						
Wesson oil.....	6	2.034	2.171	1.870	.100	.122
Wesson oil.....	6	2.216	2.406	2.047	.107	.140
Wesson oil.....	5	2.319	2.849	1.947	.297	.365
Experiment 29						
Soybean oil meal.....	6	1.593	1.665	1.547	.033	.044
Peanut meal.....	6	1.683	1.781	1.617	.055	.067
Fish meal.....	6	1.840	1.924	1.707	.053	.077
Experiment 37						
Linseed oil meal.....	4	1.302	1.329	1.239	.031	.043
Soybean oil meal.....	6	1.697	1.775	1.574	.069	.085
Fish meal.....	6	1.583	1.783	1.344	.106	.150
Experiment 38						
Corn gluten feed.....	6	1.409	1.515	1.349	.047	.062
Corn gluten meal.....	6	1.683	1.845	1.567	.092	.111
Peanut meal.....	6	1.681	1.726	1.650	.022	.028
Experiment 40						
Citrus pulp.....	6	.980	1.068	.911	.043	.056
Beet pulp.....	3	.989	1.034	.908	.054	.070
Wheat gray shorts.....	6	1.342	1.501	1.231	.065	.093
Experiment 41						
Barley.....	6	1.707	1.861	1.503	.125	.146
Dried citrus pulp.....	4	1.122	1.179	1.054	.038	.052
Wheat gray shorts.....	6	1.623	1.699	1.549	.049	.062
Experiment 42						
Soybean oil meal.....	2	.933	1.098	.767	.166	.234
Soybean oil meal.....	6	1.487	1.674	1.214	.112	.157
Cottonseed flour.....	6	1.538	.748	1.302	.169	.190
Experiment 43						
Rice bran.....	6	1.649	1.752	1.519	.068	.085
Rice polish.....	6	1.929	2.010	1.829	.064	.078
Enzyme concentrate.....	6	1.928	2.084	1.855	.067	.087
Experiment 44						
Beet pulp.....	6	1.297	1.355	1.240	.029	.039
Dried sweet potato.....	6	1.534	1.668	1.365	.101	.124
Rice hulls.....	6	.861	1.337	.740	.159	.234
Experiment 46						
Sweet potato.....	6	1.399	1.569	1.285	.102	.119
Peanut meal.....	6	1.373	1.499	1.279	.072	.089
Yeast.....	5	1.070	1.198	.930	.065	.103
Experiment 47						
Millet seed.....	6	1.926	2.034	1.720	.091	.117
Sunflower seed.....	6	1.904	2.014	1.670	.096	.127
Rye.....	4	1.590	1.779	1.212	.189	.261
Experiment 48						
Shrimp meal.....	6	1.414	1.602	1.349	.067	.096
Yeast.....	6	1.699	1.813	1.553	.068	.091
Dried sweet potato.....	6	1.626	1.870	1.412	.113	.155
Experiment 52						
Rice polish.....	6	1.917	2.026	1.813	.072	.094
Oat hulls.....	5	.762	.820	.731	.026	.036
Skim milk.....	6	1.633	1.746	1.527	.061	.080
Experiment 53						
Corn gluten feed.....	5	1.342	1.432	1.277	.045	.059
Corn gluten meal.....	6	1.783	1.892	1.715	.055	.068
Rice bran.....	6	1.630	1.744	1.540	.074	.088
Experiment 54						
Beet pulp.....	6	1.075	1.221	.920	.094	.117
Citrus pulp.....	6	1.123	1.162	1.085	.033	.037
Fish meal.....	6	1.848	1.904	1.750	.054	.065

Table 8. Variations of average productive energy of rations as calculated from data from individual chickens—Continued

Experience Number and Name of Ration	Number aver- aged	Productive energy of ration calories per gram			Average differ- ence	Standard devia- tions
		Average	Maxi- mum	Mini- mum		
Experiment 55						
Cane seed-----	6	1.738	1.804	1.648	.039	.053
Broom corn seed-----	6	1.644	1.839	1.349	.069	.100
Rye-----	6	1.443	1.562	1.242	.084	.118
Experiment 56						
Casein-----	6	2.088	2.300	1.683	.203	.240
Yeast-----	6	1.348	1.537	1.160	.135	.159
Alfalfa leaf meal-----	6	1.552	1.743	1.353	.151	.176
Experiment 57						
Cottonseed flour-----	6	1.557	1.812	1.421	.155	.193
Linseed oil meal-----	5	1.304	1.494	1.107	.137	.167
Soybean oil meal-----	6	1.179	1.267	1.069	.069	.075
Experiment 59						
Sweet potato-----	6	1.572	1.738	1.357	.124	.151
Dried beef-----	6	2.260	2.406	2.089	.113	.132
Liver meal-----	6	2.242	2.405	2.036	.120	.145
Experiment 60						
Corn meal-----	6	1.749	1.863	1.565	.092	.116
Peanut meal-----	6	1.682	1.820	1.562	.063	.088
Tankage-----	6	2.015	2.107	1.910	.065	.081
Sunflower seed-----	5	2.015	2.107	1.910	.065	.081
Experiment 61						
Corn meal-----	5	1.549	1.671	1.340	.119	.143
Rye-----	6	1.859	1.958	1.748	.079	.094
Broom corn seed-----	6	1.871	2.080	1.698	.115	.147
Red Top cane seed-----	5	1.871	2.080	1.698	.115	.147
Experiment 62						
Corn meal-----	6	1.543	1.691	1.459	.050	.081
Coconut oil meal-----	6	1.436	1.636	1.218	.127	.159
Shrimp meal-----	6	1.763	1.906	1.519	.106	.139
Millet seed-----	6	1.763	1.906	1.519	.106	.139
Experiment 63						
Corn meal-----	6	1.612	1.679	1.569	.027	.040
Barley-----	5	1.125	1.217	1.046	.060	.073
Shrimp meal-----	5	1.125	1.217	1.046	.060	.073
Citrus pulp-----	3	1.133	1.232	1.037	.066	.097
Experiment 65						
Corn meal-----	6	1.263	1.319	1.172	.049	.069
Coconut oil meal-----	6	1.375	1.448	1.231	.068	.085
Dried navy beans-----	6	1.230	1.433	1.073	.080	.118
Dried pinto beans-----	6	1.230	1.433	1.073	.080	.118
Experiment 66						
Corn meal-----	5	1.550	1.690	1.210	.014	.020
Gelatin-----	5	1.660	1.750	1.500	.009	.011
Blackeye peas-----	6	1.400	1.600	1.230	.012	.015
Baby lima beans-----	6	1.400	1.600	1.230	.012	.015

given in Table 10. Other data for some feeds are included from Bulletin 600 (12). The average productive energy is given in Table 12. The standard deviation and standard error for some of the feeds are given in Table 11. A similar table has been given for other feeds (12).

The work here presented reports 51 experiments on 138 samples of feed. Table 10, also contains the work previously reported in Bulletin 600 and includes 62 kinds of feeds and 192 tests.

The differences in the values of the same feed compared with corn meal are greater in some cases than are desirable. The errors of the work on the digestion experiments as well as those in determining the

Table 9. Calculation of productive energy of feeds substituted for corn meal

	Corn meal	Coco- nut oil meal	Navy beans	Pinto beans
A Percentage substituted-----	-----	50	30	30
B Productive energy, calories per gram-----	2.399	-----	-----	-----
C Productive energy of mixture-----	1.869	1.263	1.375	1.230
E Effect of substitution, line C less 1.869-----	-----	-.603	-.491	-.636
F Productive energy of quantity of corn meal substituted-----	-----	1.200	.720	.720
G Productive energy of quantity of feed substituted line F plus line E-----	-----	.597	.229	.084
H Productive energy of 100 grams feed substituted--	240	119	76	28
I Effective digestible nutrients of 100 grams feed---	80.0	35.9	21.6	24.7
J Productive energy of 100 grams effective digestible nutrients (line H divided by line I x 100)-----	300	331	352	113
K Relative productive energy of effective digestible nutrients with corn meal as 100-----	100	110	117	38
L Metabolizable energy, calories per 100 grams (line I x 4.2)-----	336.0	150.8	90.7	103.7
M Metabolizable energy used for productive energy, per cent, line H divided by line L x 100-----	71.4	78.9	83.8	27.0
N Effective organic constituents-----	90.58	82.34	81.18	80.54
O Productive energy of effective organic constituents, calories per 100 grams line H divided by line N x 100-----	265.0	144.5	93.6	34.8

productive energy have some effect on the results for the productive energy. It is considered, however, that the average values are approximately correct.

The average productive energies of the different feeds differ widely, ranging from one Calorie per 100 grams for cottonseed hulls and 13 for oat hulls to 467 for cottonseed oil, compared with corn meal which usually had a value of about 240 Calories per 100 grams. As was to be expected, feeds high in crude fiber, such as alfalfa leaf meal, have a low productive energy. Some of the raw legume seeds, such as raw lima beans, raw navy beans and raw pinto beans also have low values.

Similar variations are seen with the productive energy of the effective organic constituents, which is the sum of the percentages of protein, fat x 2.25, and nitrogen-free extract, and excludes the water, ash, and crude fiber, which have no value for energy purposes.

Variations are to be seen with different experiments on the same kind of feed. If the individual tests are studied, differences are found in the ability of individual chickens to utilize the ration in the same experiment, as has been previously pointed out (8) and as shown in Table 8. Since these differences occur for both the standard ration and the test

Table 10. Productive energy in terms of feed, effective organic constituents, effective digestible nutrients, and metabolizable energy

Name and Laboratory Number of Feed	Experiment number	Per cent of ration	Effective organic constituents per cent	Effective digestible nutrients per cent	Metabolizable energy Cal. per 100 gm.	Productive energy				
						Total feed Cal. per 100 gm.	Effective organic constituents Cal. per 100 gm.	Effective digestible nutrients Cal. per 100 gm.	Rank with effective digestible nutrients of corn meal as 100	In percentage of metabolizable energy
Alfalfa leaf meal										
54172*-----	24	25	64.9	17.4	73	18	28	106	35	25
54985*-----	26	30	67.0	23.9	99	75	112	320	105	76
54985*-----	28	30	67.0	15.0	63	45	67	302	99	71
54985*-----	32	30	67.0	14.8	62	50	75	338	111	81
50438*-----	36	30	72.9	21.4	90	29	40	137	45	32
Average (5)-----	--	--	67.8	18.5	77	43	64	241	79	57
Barley, whole										
58348-----	41	50	84.3	62.3	262	200	237	321	107	76
63805-----	63	50	83.1	61.2	257	207	249	338	113	81
Average (2)-----	--	--	83.8	61.8	260	204	243	330	110	79
Beans, lima, raw										
46140-----	5	60	81.6	31.7	133	58	71	183	61	44
65061-----	66	30	78.8	44.7	188	77	98	172	57	41
Average (2)-----	--	--	80.2	38.2	161	68	85	178	59	43
Beans, navy, raw										
46141-----	5	47.7	82.0	29.2	123	83	101	284	95	67
65048-----	65	30	81.2	21.6	91	76	94	352	117	84
Average (2)-----	--	--	81.6	25.4	107	80	98	318	106	76
Beans, Pinto										
65049-----	65	30	80.5	24.7	104	28	35	113	38	27
Beef, dried										
63706-----	59	30	84.0	68.1	286	339	403	498	166	119
Beet pulp, dried										
58591-----	40	50	70.5	18.5	78	71	101	384	128	91
58591-----	44	35	70.5	18.6	39	66	94	710	118	85
Average (2)-----	--	--	70.5	18.6	59	69	98	547	123	88

62736-----	54	35	66.1	0	0	0	0	0	0	0
Broom corn seed										
62923-----	55	50	86.3	65.7	276	195	226	297	99	71
63807-----	61	50	86.8	66.5	279	239	276	357	119	85
Average (2)-----	--	--	86.6	66.1	278	217	251	327	109	78
Buttermilk, dried										
49648*-----	22	50	90.6	52.9	222	135	149	256	84	61
49648*-----	23	25	90.6	58.5	246	171	189	293	96	70
49648*-----	24	25	90.6	64.0	269	114	126	178	58	42
49648*-----	34	25	90.6	54.7	230	135	149	246	81	59
Average (4)-----	--	--	90.6	57.5	242	139	163	243	80	58
Casein										
48261*-----	11	38	87.2	77.9	327	195	224	250	82	60
49469*-----	12	38	87.7	83.4	350	216	246	259	85	62
54170*-----	21	50	88.2	69.7	293	239	271	344	113	83
54170*-----	22	50	88.2	64.0	269	222	252	347	114	82
55732*-----	36	30	87.4	68.1	286	196	224	288	94	69
62888-----	56	50	85.4	65.7	276	274	321	416	139	99
Average (6)-----	--	--	87.4	71.5	300	224	256	317	105	76
Citrus pulp, dried										
58434-----	40	50	75.8	26.2	110	67	88	256	85	61
58434-----	41	50	75.8	26.7	112	83	109	311	104	74
62765-----	54	50	72.8	23.1	97	76	104	329	110	78
64059-----	63	50	76.9	24.8	104	111	144	448	149	106
Average (4)-----	--	--	75.3	25.2	106	84	111	336	112	80
Coconut oil meal										
64008-----	62	50	89.4	52.8	222	170	201	322	108	81
65030-----	65	50	82.3	35.9	151	119	145	331	110	79
Average (2)-----	--	--	85.9	44.4	187	145	173	327	109	80
Corn bran										
48706*-----	9	50	84.8	35.7	150	121	143	340	111	81
48800-----	10	50	90.8	38.7	163	127	140	328	109	78
50740-----	13	50	86.2	34.8	146	121	140	348	116	83
50742-----	13	50	90.6	43.4	182	150	166	346	115	82
50786-----	13	50	80.9	21.2	89	81	100	382	127	91
Average (5)-----	--	--	86.6	34.8	146	120	138	349	116	83
Corn gluten feed										
55120*-----	31	39	76.5	32.4	136	94	123	291	96	69
58432-----	38	50	80.0	32.6	137	123	160	393	131	93
62767-----	53	50	76.6	33.5	141	120	157	358	119	85
Average (3)-----	--	--	77.7	32.8	138	114	147	347	115	82

*For details see Bulletin No. 600.

Table 10. Productive energy in terms of feed, effective organic constituents, effective digestible nutrients, and metabolizable energy—Continued

Name and Laboratory Number of Feed	Experiment number	Per cent of ration	Effective organic constitu- ents per cent	Effective digestible nutrients per cent	Metabo- lizable energy Cal. per 100 gm.	Productive energy				
						Total feed Cal. per 100 gm.	Effective organic constitu- ents Cal. per 100 gm.	Effective digestible nutrients Cal. per 100 gm.	Rank with effective nutrients of corn meal as 100	In per- centage of metabo- lizable energy
Corn gluten meal										
55121*-----	30	88	84.8	53.9	226	170	200	315	103	75
58433-----	38	50	84.0	44.9	189	183	218	408	136	97
62768-----	53	50	83.3	52.1	219	208	250	399	133	95
Average (3)-----	--	--	84.0	50.3	211	187	223	341	124	89
Corn meal, yellow										
41603-----	A65	58.8	91.3	50.2	337	241	264	300	100	72
41603 (with enzyme)-----	A65	58.5	91.3	79.7	335	241	264	302	101	72
Cottonseed flour										
54679*-----	27	30	94.6	53.7	226	247	261	459	151	109
54679*-----	34	30	94.6	52.1	219	172	182	330	108	79
59165-----	42	50	93.7	55.1	231	165	176	299	100	71
63621-----	57	50	96.2	63.4	266	178	185	280	93	67
Average (4)-----	--	--	94.8	56.1	236	191	201	342	113	82
Average (3)-----	--	--	94.8	56.9	239	172	181	303	100	72
Cottonseed meal										
54177*-----	21	50	87.4	51.1	215	153	175	299	98	71
54177*-----	23	43	87.4	48.1	202	134	153	273	91	66
54715*-----	24	43	86.5	51.1	215	139	161	273	89	65
54993*-----	28	43	83.2	40.5	170	105	126	200	85	62
55733*-----	32	43	84.6	41.7	175	121	143	290	95	69
Average (5)-----	--	--	85.8	46.5	195	130	152	280	92	67
Cottonseed hulls delinted										
54860*-----	33	50	47.6	0	0	1	2	0	100	0
Cottonseed oil, (Wesson)										
49095*-----	11	15	225.0	186.5	783	367	163	197	65	47
49095*-----	12	15	225.0	210.3	883	438	195	208	68	50
-----	19	15	225.0	205.7	864	481	214	234	78	56
54898-----	25	10	225.0	202.0	848	503	224	249	83	59

54898.....	25	20	225.0	199.6	813	592	263	309	102	73
54898.....	25	30	225.0	185.8	780	420	187	226	75	54
Average (6).....	--	--	225.0	197.3	829	467	208	237	79	57
Enzyme concentrate										
59524.....	43	0.5	90.6	80.8	339	240	265	297	99	71
Fish meal										
54666.....	29	25	81.9	49.2	207	197	241	400	133	95
58246.....	37	50	81.0	46.0	193	172	212	374	125	89
62738.....	54	50	80.0	50.8	213	221	276	435	145	104
Average (3).....	--	--	81.0	48.7	204	197	243	403	134	96
Gelatine										
64924.....	66	50	94.1	66.7	280	127	135	190	63	45
Hegari, grain										
40968.....	A64	51	89.8	79.0	332	244	272	309	103	73
Kafir, grain										
51581.....	17	50	90.7	75.5	317	236	260	313	104	74
51582 (waxy).....	17	50	91.6	75.6	318	226	247	299	100	71
Average (2).....	--	--	91.2	75.6	318	231	254	306	102	73
Lactose (milk sugar)										
51568.....	15	50	98.8	35.6	150	14	14	39	13	9
Linseed oil meal										
55287.....	37	50	97.3	37.0	155	116	119	314	105	75
63622.....	57	50	88.5	28.9	121	127	152	439	146	105
Average (2).....	--	--	90.4	33.0	138	121	136	377	126	90
Liver meal										
63907.....	59	50	106.2	72.4	304	298	280	412	137	98
Meat and bone scraps										
54872*.....	27	35	71.5	39.8	167	136	190	343	112	81
55082*.....	30	35	73.0	45.6	192	146	200	320	105	76
54872*.....	35	35	71.5	33.7	142	81	113	239	78	57
Average (3).....	--	--	72.0	39.7	167	121	168	301	98	71
Meat meal										
54664*.....	26	37	73.0	45.8	192	171	234	374	123	89
54664*.....	28	37	73.0	42.6	179	114	156	267	88	64
54664*.....	32	37	73.0	35.8	150	84	115	235	77	56
Average (3).....	--	--	73.0	41.4	174	123	168	292	96	70

*For details see Bulletin No. 600.

Table 10. Productive energy in terms of feed, effective organic constituents, effective digestible nutrients, and metabolizable energy—Continued

Name and Laboratory Number of Feed	Experiment number	Per cent of ration	Effective organic constituents per cent	Effective digestible nutrients per cent	Metabolizable energy Cal. per 100 gm.	Productive energy				
						Total feed Cal. per 100 gm.	Effective organic constituents Cal. per 100 gm.	Effective digestible nutrients Cal. per 100 gm.	Rank with effective digestible nutrients of corn meal as 100	In percentage of metabolizable energy
Milk, dried skim										
56047*-----	34	25	87.1	50.4	212	95	109	188	62	45
62887-----	52	25	85.3	70.5	296	132	155	187	62	45
Average (2)-----	--	--	86.2	60.5	254	114	132	188	62	45
Millet seed										
60219-----	47	50	80.6	67.7	284	237	294	350	117	83
62803-----	62	50	82.3	75.5	317	214	284	282	94	68
Average (2)-----	--	--	81.5	71.6	300	226	289	316	106	76
Milo										
43899*-----	A66	51	89.4	83.8	352	219	241	258	84	62
33301-----	A31	57	88.8	79.9	336	244	275	305	102	73
33301-----	A32	57	88.8	79.6	334	251	260	290	97	69
33301-----	A33	57	88.8	79.6	334	233	262	293	98	70
33301-----	A34	57	88.8	80.5	338	212	239	263	88	63
33301-----	A38	50	89.8	78.1	328	235	262	301	100	72
34077-----	A38	50	89.3	77.9	327	207	232	266	89	63
33301-----	A39	50	89.8	78.1	328	222	247	284	95	68
33301-----	A41	50	89.8	78.1	328	183	204	234	78	56
33301-----	A42	50	89.8	78.1	328	174	194	223	74	53
34077-----	A41	50	89.3	77.9	327	188	211	241	80	57
Average (11)-----	--	--	89.3	79.2	333	213	239	269	90	64
Oat hulls										
55505*-----	33	50	56.0	0	0	15	27	0	100	0
58615-----	52	50	54.1	0	0	11	20	0	100	0
Average (2)-----	--	--	55.1	0	0	13	24	0	100	0
Oat mill feed										
51609-----	17	50	63.4	13.5	57	64	101	474	158	112
Oat meal										
43895*-----	A66	51	93.6	89.0	374	213	228	240	79	57

33829	A32	57	95.6	76.9	323	233	244	303	101	72
33829	A33	57	95.6	76.9	323	254	266	330	110	79
33829	A34	57	95.6	77.7	326	198	207	255	85	61
44487	3	35.2	93.6	80.5	338	253	270	322	107	77
45806	4	85.2	94.5	78.6	330	259	274	330	110	78
Average (6)	--	--	94.8	79.9	336	235	248	297	99	71
Peanut meal										
54798*	35	40	84.9	52.9	222	127	150	240	79	57
54798	29	40	84.9	52.0	218	175	206	337	112	80
58431	38	50	87.1	49.5	208	183	210	370	124	88
57226	46	50	82.8	59.0	248	140	169	237	79	56
63640	60	50	87.9	56.2	236	203	230	360	120	86
Average (5)	--	--	85.5	53.9	226	166	193	309	103	73
Peas, blackeye, raw										
46142	5	46.6	84.8	62.5	263	180	212	288	96	68
65050	66	30	81.3	54.4	229	163	200	299	100	71
Average (2)	--	--	83.1	58.5	246	172	206	294	98	70
Potato, sweet (dried, or dehydrated)										
44984	3	40	92.4	70.3	295	216	234	307	102	73
44984	4	40	92.4	79.7	335	224	242	281	93	67
63909	59	50	84.3	58.7	247	164	195	280	93	67
59177	44	50	78.3	69.2	291	165	211	238	80	57
59506	46	50	85.1	67.5	284	146	172	216	72	51
59506	48	50	85.1	65.8	276	184	211	280	93	67
Average (6)	--	--	86.3	68.5	288	183	212	267	89	64
Rice, polished										
45544	3	49.5	85.7	79.8	335	259	302	317	100	76
45806	4	49.5	87.9	80.7	339	246	280	305	101	73
Average (2)	--	--	86.8	80.3	337	263	291	311	104	75
Rice bran										
51682	16	50	89.0	63.2	265	193	217	305	101	73
59166	43	50	81.5	51.1	215	184	226	360	120	86
62751	53	50	80.0	49.1	206	178	223	363	121	86
Average (3)	--	--	83.5	54.5	229	185	222	343	114	82
Rice polish										
51681	16	50	99.7	81.6	343	228	229	279	93	66
59167	43	50	93.2	78.4	329	240	258	306	102	73
62750	52	50	94.2	84.6	355	242	257	286	95	68
Average (3)	--	--	95.7	81.5	342	237	248	280	97	69
Rice hulls										
59320	44	50	31.1	0	0	51	100	0	100	0

*For details see Bulletin No. 600.

Table 10. Productive energy in terms of feed, effective organic constituents, effective digestible nutrients, and metabolizable energy—Continued

Name and Laboratory Number of Feed	Experiment number	Per cent of ration	Effective organic constituents per cent	Effective digestible nutrients per cent	Metabolizable energy Cal. per 100 gm.	Productive energy				
						Total feed Cal. per 100 gm	Effective organic constituents Cal. per 100 gm.	Effective digestible nutrients Cal. per 100 gm.	Rank with effective digestible nutrients of corn meal as 100	In percentage of metabolizable energy
Rye flour										
51683-----	16	50	86.7	58.4	245	146	168	250	83	60
Rye seed										
59649-----	47	50	87.1	56.5	237	170	195	301	100	72
62925-----	55	50	86.3	58.3	245	154	179	264	88	63
63804-----	61	50	87.2	62.5	263	177	203	284	95	68
Average (3)-----	--	--	86.9	59.1	248	167	192	283	94	68
Shrimp meal										
60014-----	48	50	53.5	36.4	153	142	265	390	130	93
64190-----	63	50	50.2	33.0	139	108	215	327	109	78
64058-----	62	50	59.6	43.6	183	148	248	340	113	81
Average (3)-----	--	--	54.4	37.7	158	133	243	352	117	84
Sorghum (sweet) seed (red top cane)-----										
62922-----	55	50	89.6	73.2	307	213	238	291	97	69
63806-----	61	50	90.1	76.6	313	242	268	315	105	75
Average (2)-----	--	--	89.9	74.9	310	228	253	303	101	72
Sunflower seed										
59650-----	47	50	92.5	61.1	257	233	252	381	127	91
63802-----	60	50	96.7	73.2	308	256	264	349	116	83
Average (2)-----	--	--	94.6	67.2	283	245	258	365	122	87
Soybean oil meal										
54665*-----	31	37	80.0	39.5	166	119	149	302	99	72
54665-----	29	37	79.9	38.9	163	145	181	373	124	89
55256-----	37	50	85.8	47.5	200	195	227	411	137	98
58839-----	42	50	81.1	38.4	161	155	191	404	135	96
Average (4)-----	--	--	81.7	41.1	173	154	187	373	124	89

Soybean oil meal—special										
63623	57	35	79.8	28.5	120	102	128	358	119	85
58338	42	50	79.8	26.6	108	44	55	172	57	41
Average (2)	--	--	79.8	27.1	114	73	92	265	88	63
Starch										
49094*	11	50.8	87.7	86.7	364	217	247	251	82	60
49094*	12	50.8	87.7	81.9	344	194	222	237	78	56
51567	15	50	88.7	79.3	333	210	237	265	88	63
51955	18	50	88.5	81.5	342	203	229	249	83	59
51955	18	46	88.5	83.4	350	225	254	270	90	64
51955	18	44	88.5	86.3	358	223	262	261	87	62
52123	19	44	89.6	81.1	341	244	272	301	100	72
Average (7)	--	--	88.5	82.7	347	217	245	262	87	62
Tankage										
54178*	21	50	86.3	39.0	164	137	159	352	115	84
54178*	23	28	86.3	40.1	168	61	71	153	50	36
54178*	26	32	86.3	41.8	176	101	117	241	79	57
54873*	27	29	76.5	45.6	192	146	191	321	105	76
55081*	30	29	81.1	39.4	165	97	120	245	80	59
54873*	31	28	76.5	48.1	202	108	141	224	73	53
54873*	35	28	76.5	48.4	203	69	90	142	46	34
63908	60	50	80.5	48.6	204	189	235	389	129	93
Average (8)	--	--	81.3	43.9	184	114	141	258	85	62
Wheat (grain)										
33824	A32	57	87.2	79.1	332	211	242	267	89	64
33824	A33	57	87.2	79.1	332	230	264	291	97	69
34076	A38	50	88.9	72.4	304	205	231	283	94	67
34076	A41	50	88.9	72.4	304	176	198	243	81	58
Average (4)	--	--	88.1	75.8	318	206	234	271	90	65
Wheat bran										
48741*	9	50	79.3	36.8	155	94	119	254	83	61
40667	A62	25	81.3	46.7	196	148	182	317	106	76
40667	A63	25	81.3	36.6	154	133	164	363	121	87
47763	6	50	79.8	34.6	145	83	104	240	80	57
48264	7	50	79.0	36.7	154	79	100	215	72	51
52122	19	50	79.6	24.7	104	62	78	251	84	60
Average (6)	--	--	80.1	36.0	151	100	125	273	91	65
Wheat bran (breakfast food)										
44488	1	41.3	79.3	53.7	226	131	165	244	81	58
54373	2	41.3	78.8	53.7	226	159	202	296	99	70
Average (2)	--	--	79.1	53.7	226	145	184	270	90	64

*For details see Bulletin No. 600.

Table 10. Productive energy in terms of feed, effective organic constituents, effective digestible nutrients, and metabolizable energy—Continued

Name and Laboratory Number of Feed	Experi- ment number	Per cent of ration	Effective organic constit- uents per cent	Effective digestible nutrients per cent	Metabo- lizable energy Cal. per 100 gm.	Productive energy				
						Total feed Cal. per 100 gm.	Effective organic constit- uents Cal. per 100 gm.	Effective digestible nutrients Cal. per 100 gm.	Rank with effective digestible nutrients of corn meal as 100	In per- centage of metabo- lizable energy
Wheat flour, clear 48898-----	10	50	84.0	80.7	339	221	263	274	91	65
Wheat flour, low grade										
48436*-----	8	50	88.4	69.2	291	197	223	284	93	68
47762-----	6	50	89.9	71.9	302	195	217	271	90	65
48244-----	7	50	89.6	81.4	342	225	251	276	92	66
Average (3)-----	--	--	89.3	74.2	312	206	230	277	92	66
Wheat flour, patent										
48435*-----	8	50	87.1	78.7	331	205	235	260	85	62
45217-----	1	50	88.6	72.5	305	203	229	280	93	67
45371-----	2	50	88.7	72.5	305	200	233	259	120	85
47761-----	6	50	87.9	75.9	319	206	234	271	90	65
48243-----	7	50	88.2	83.6	351	208	236	249	83	59
48897-----	10	50	87.8	71.8	302	202	230	281	94	67
Average (6)-----	--	--	88.1	75.8	319	214	243	283	94	68
Wheat flour, graham										
44486-----	1	4 3	86.4	63.7	268	160	185	251	84	60
45372-----	2	41.3	87.1	63.7	268	192	220	301	100	72
Average (2)-----	--	--	86.8	63.7	268	176	203	276	92	66
Wheat gray shorts										
48898*-----	A66	40	83.5	65.4	275	131	157	200	66	48
47764*-----	8	50	83.4	45.9	193	102	122	222	73	53
47764*-----	9	50	83.4	48.3	203	169	203	350	115	83
55462*-----	33	50	84.4	48.8	205	154	182	316	104	75
56077*-----	36	50	85.7	49.9	210	131	153	262	86	62
58601-----	40	50	84.4	54.2	228	141	167	260	87	62
59231-----	41	50	85.0	49.2	207	183	215	372	124	88
Average (7)-----	--	--	84.3	51.7	217	144	171	283	94	67

Yeast	46	50	83.4	41.1	173	80	96	195	65	46
59770.....	46	50	83.4	41.1	173	80	96	195	65	46
60224.....	48	45	80.0	48.3	203	180	225	373	124	89
63368.....	56	35	87.0	50.6	213	91	105	180	60	43
Average (3).....	--	--	83.5	46.7	196	117	142	249	83	59
Average (2).....	--	--	85.2	45.9	193	86	100	188	63	45

*For details see Bulletin No. 600.

Table 11. Standard deviation and standard error of the productive energy of the feed, the effective organic constituents, the effective digestible nutrients and the metabolizable energy

	Dried citrus pulp	Corn bran	Cotton seed oil	Milo	Oat meal	Peanut meal	Soybean oil meal	Starch	Wheat (grain)	Wheat bran	Wheat flour (patent)
Number of tests.....	4	5	6	11	6	5	4	7	4	6	6
Total feed.....											
Productive energy per 100 gm., Cal.....	84	120	467	213	235	166	154	217	206	100	214
Standard deviation, Cal.....	19	25	78	23	25	31	32	16	22	34	23
Standard error, Cal.....	9.5	11.2	31.8	6.9	10.2	13.8	16.0	6.0	11.0	13.9	9.4
Standard error, per cent.....	11.3	9.3	6.8	3.2	4.3	8.3	10.4	2.8	5.3	13.9	4.4
Effective organic constituents.....											
Productive energy per 100 gm., Cal.....	111	138	298	239	248	193	187	245	234	125	243
Standard deviation, Cal.....	24	24	35	26	27	33	32	17	28	40	25
Standard error, Cal.....	12.0	10.7	14.3	7.8	11.4	14.7	16.0	6.4	14.0	16.3	10.2
Standard error, per cent.....	10.8	7.8	6.9	3.3	4.6	7.6	8.6	2.6	6.0	13.0	4.2
Effective digestible nutrients.....											
Productive energy per 100 gm., Cal.....	336	349	237	269	297	309	373	262	271	273	283
Standard deviation, Cal.....	81	20	39	28	40	65	50	20	21	55	39
Standard error, Cal.....	40.5	8.9	15.9	8.4	16.3	29.0	25.0	7.5	10.5	22.4	15.9
Standard error, per cent.....	12.1	2.6	6.7	3.1	5.5	9.4	6.7	2.9	3.9	8.2	5.6
In percentage of metabolizable energy.....											
Productive energy per 100 gm., Cal.....	80	83	57	64	71	73	89	62	65	65	68
Standard deviation, Cal.....	19	5	9	7	9	16	12	5	5	13	9
Standard error, Cal.....	9.5	2.2	3.7	2.1	3.7	7.1	6.0	1.9	2.5	5.3	3.7
Standard error, per cent.....	11.9	2.7	6.5	3.3	5.2	9.7	6.7	3.1	3.8	8.2	5.4

Table 12. Average productive energy of certain feeds for chickens

Name of feed	Number averaged	Total feed Cal. per 100 gm.	Effective organic constituents Cal. per 100 gm.	Effective digestible nutrients Cal. per 100 gm.	Rank with effective digestible nutrients of corn meal as 100	In per centage of metabolizable energy
Alfalfa leaf meal.....	5	43	64	241	79	57
Barley, whole.....	2	204	243	330	110	79
Beans, lima, raw.....	2	68	85	178	59	43
Beans, navy, raw.....	2	80	98	318	106	76
Beans, pinto.....	1	28	35	113	38	27
Beef, dried.....	1	339	403	498	166	119
Beet pulp, dried.....	2	69	98	547	123	88
Broom corn seed.....	2	217	251	327	109	78
Buttermilk, dried.....	4	139	153	243	80	58
Casein.....	6	224	256	317	105	76
Citrus pulp, dried.....	4	84	111	336	112	80
Coconut oil meal.....	2	145	173	327	109	80
Corn bran.....	5	120	138	349	116	83
Corn gluten feed.....	3	114	147	347	115	82
Corn gluten meal.....	3	187	223	341	124	89
Corn meal, (standard).....	---	241	264	300	100	72
Cottonseed flour.....	3	172	181	303	100	72
Cottonseed meal.....	5	130	152	280	92	67
Cottonseed hulls, delinted.....	1	1	2	0	100	0
Cottonseed oil (wesson).....	6	467	208	237	79	57
Enzyme concentrate.....	1	240	265	297	99	71
Fish meal.....	3	197	243	403	134	96
Gelatine.....	1	127	135	190	63	45
Hegari, grain.....	1	244	272	309	103	73
Kafir, grain.....	2	231	254	306	102	73
Lactose (milk sugar).....	1	14	14	39	13	9
Linseed oil meal.....	2	121	136	377	126	90
Liver meal.....	1	298	280	412	137	98
Meat and bone scraps.....	3	121	168	301	98	71
Meat meal.....	3	123	168	292	96	70
Milk, dried skim.....	2	114	132	188	62	45
Millet seed.....	2	226	239	316	106	76
Milo.....	11	213	239	269	90	64
Oat hulls.....	2	13	24	0	100	0
Oat mill feed.....	1	64	101	474	158	112
Oat meal.....	6	235	248	297	99	71
Peanut meal.....	5	166	193	309	103	73
Peas, blackeye, raw.....	2	172	206	294	98	70
Potato, sweet, dried or dehydrated.....	6	133	212	267	89	64
Rice, polished.....	2	253	291	311	104	75
Rice bran.....	3	185	222	343	114	82
Rice polish.....	3	237	248	290	97	69
Rice hulls.....	1	31	100	0	100	0
Rye flour.....	1	146	168	250	83	60
Rye seed.....	3	167	192	233	94	68
Shrimp meal.....	3	133	243	352	117	84
Sorghum (sweet) seed (Red Top cane).....	2	228	253	303	101	72
Sunflower seed.....	2	245	258	365	122	87
Soybean oil meal.....	4	154	187	373	124	89
Soybean oil meal—special.....	2	73	92	265	88	63
Starch.....	7	217	245	262	87	62
Tankage.....	8	114	141	258	85	62
Wheat (grain).....	4	206	234	271	90	65
Wheat bran.....	6	100	125	273	91	65
Wheat bran (breakfast food).....	2	145	184	270	90	64
Wheat flour, clear.....	1	221	263	274	91	65
Wheat flour, low grade.....	3	206	230	277	92	66
Wheat flour, patent.....	6	214	243	283	94	68
Wheat flour, Graham.....	2	176	203	276	92	66
Wheat gray shorts.....	7	144	171	283	94	67
Yeast.....	3	117	142	249	83	59
Yeast.....	2	86	100	188	63	45

rations, the average results from different tests of the same feed may be expected to differ, thus the average productive energy of different feeds can be calculated only from the results of several experiments, each of which is the average of several individual tests.

In Experiment 17, waxy kafir furnished by Mr. R. E. Karper was compared with ordinary kafir. The difference in the productive energy is within the limits of error.

One experiment was made with a commercial enzyme preparation "TABO" (No. 59524) which was claimed to produce better digestion and assimilation of the feed by chickens, resulting in faster growth, and said to be used in the western states for several years. This preparation did not increase digestibility of the feed or affect the productive energy of the ration to which it was added.

Soy bean oil meal No. 58838 was cooked at a low temperature, and especially prepared by the Archer-Daniels-Midland Company, Minneapolis, Minnesota. As expected, it had a low digestibility, and the digestible constituents had a low productive energy.

Productive Energy of the Effective Digestible Constituents and of the Metabolizable Energy

It is naturally to be expected that the chicken cannot utilize the energy of feed which is not digested. The productive energy calculated for 100 grams of effective digestible nutrients in the feeds studied and the productive energy of the effective digestible nutrients compared with that of corn meal as 100 are given in Tables 10 and 12. The differences between different kinds of feed are not as great as when values in terms of the total feed or the affective organic constituents are considered. The average productive energy of the digestible constituents of most of the feeds comes within 10% of those of corn meal. There are definite differences between feeds, but the differences are small with most of the feeds. This means that the chicken can use effectively what it digests from most feeds. The differences between the energy value of different feeds is due to a much greater extent to differences in digestibility than to differences in the utilization of the energy of the materials which have been digested. Some feeds have a low digestibility, but the digested material is utilized as well as that from feeds which have a high digestibility. The digested material consists, for the most part, of sugars, starches, and protein; although the pentosans and residual nitrogen-free extracts are digested to some extent, the amounts digested are relatively low. (6). The average productive energy values of wheat and wheat by-products, while not far from that of corn meal, are low. Why this is so remains to be decided.

Of the feeds whose effective digestible nutrients have low energy values compared with those of corn meal, one group include buttermilk, which has a value of 80 compared with 100 for corn meal, 62 for dried skim milk, and 13 for milk sugar (lactose). These feeds tend to produce

looseness of the bowels; this was especially pronounced with the milk sugar, with which only 2 of the 6 chickens survived. Since the digested part of casein, the chief protein of milk, had practically the same productive energy as the digested part of corn meal, the low value of dried skim milk and buttermilk is probably due to the lactose present. It is possible that the lactose is lost by fermentation within the chicken and not really digested. Lactose no doubt has a high energy value for young mammals, if not for chickens.

A second group whose effective digestible nutrients had a low value compared with 100 for those of corn meal contains raw lima beans with a value of 79, raw pinto beans, 38, and the sample of soy bean meal cooked at a low temperature, 57, referred to above. It is well known that the proteins of these beans are defective in amino acids. This defect is probably the cause of the low energy values of the digestible nutrients found in these experiments. It should be added that the digestibility was also low. Gelatine, which is also known to be a protein deficient in some amino acids, also has a low value.

The comparative value of the effective digestible nutrients of cottonseed oil averaged 79 compared with those of corn meal as 100. It is evident that this oil, in the quantities in which it was fed, furnished energy to the extent of only 1.8 times that of corn meal, instead of 2.25 times as it is generally considered to have. Since the metabolizable energy not used for fat is probably evolved as heat, the oil would be more of a heating food than starches, producing heat which might be useful in cold weather but might be a burden in warm weather. It is possible that oil has the energy value usually given it when fed to chickens in smaller amounts than in these experiments.

The feeds whose effective digestible nutrients had high productive energy values compared with those of corn meal include the corn products, corn bran 116, corn gluten feed 115, and corn gluten meal 124. These moderately high values would seem to indicate that corn contains compounds which increase the energy value of the nutrients in the rations used, and this is in accord with the data that the digestible nutrients of corn starch and wheat products have a value of only about 90 compared with corn as 100.

The other group of feeds whose productive energy for their effective digestible nutrients is greater than that for corn meal includes feeds high in protein such as shrimp meal, soy bean oil meal, linseed oil meal, fish meal, liver meal and dried beef. These high values are not due to their high protein content, since casein, cottonseed meal, peanut meal, and meat meal are also high in protein but do not have such high values for productive energy. Some of these high values may be due to variations or errors in the work so that they will average out when the work is repeated, but others are consistently high. It may be that these feeds contain proteins of exceptionally high value for productive energy which improve the ration in which they are fed.

The metabolizable energy for maintenance of the feeds studied was calculated from the effective digestible nutrients by multiplying by 4.2, (13) so that the utilization of the metabolizable energy for productive energy is similar to the utilization of the effective digestible nutrients. With most of the feeds, the percentage of metabolizable energy utilized is not far from the 72% utilized from corn meal. The same exceptions noted above for digestible nutrients apply to metabolizable energy. Only 9% of the metabolizable energy of lactose was utilized, but the calculated metabolizable energy is a little high (13). Of the metabolizable energy, 43% was used from raw lima beans, 27% from pinto beans and 57% from cottonseed oil. The group with high utilization of the metabolizable energy for productive energy was 96% for fish meal, 119% for dried beef and 90% for linseed oil meal, so that possibly these additions increased the value of the entire ration.

According to Kellner (15), 56.4% of the metabolizable energy of starch, 64.4% of that of fat, 45.2% of that of cane sugar and 48% of that of protein can be converted into fat by ruminants. According to Forbes and Kriss (2), the percentage utilization by cattle of the metabolizable energy of mixed hay is 49.37. The utilization of the metabolizable energy of corn meal by chickens, 72%, is much higher than by cattle. Since feeds eaten by cattle are subject to the action of micro-organism, the difference between the utilization of digested nutrients of corn meal by chickens and by ruminants may be due in part to losses in this fermentation, rather than to differences in the ability of the animal body to utilize the nutrients which have been digested. The micro-organisms in the digestive organs of cattle no doubt convert compounds in the nitrogen-free extracts and crude fiber which cannot be digested and utilized by chickens into compounds which can be digested and utilized by cattle, but the micro-organisms may also use a portion of the more easily digested compounds and reduce their value.

The standard deviation, standard error, and the per cent the standard error is of the productive energy for 11 of the feeds is given in Table 11. These calculations were made from the productive energy values secured for the particular feed in different experiments. Similar values for 7 other feeds, alfalfa leaf meal, dried buttermilk, casein, cottonseed meal, tankage and wheat gray shorts are given in Tables 16 and 18 of Bulletin 600 (12). The standard error of the mean productive energy of the digestible nutrients is 21 per cent for alfalfa leaf meal, 10 to 13 per cent for dried buttermilk, tankage, wheat gray shorts, wheat bran and dried citrus pulp, 6 to 9 per cent for corn bran, cottonseed oil, peanut meal, soybean oil meal, wheat (grain), wheat flour, and casein, and 2.6 to 5 per cent for milo, oat meal, starch, and cottonseed meal.

The determination of the productive energy of feed is concerned only with measuring the utilization of the energy of the feed eaten by the chicken for the storage of energy in the form of fat and protein and does not deal with the effect of differences in the rations upon the quan-

tity of feed eaten, the amount of growth made and the degree of fatness obtained by the chickens. As can be seen by examining the results of the experiments, there were wide variations in these respects, but they did not affect the final results of the determination of the productive energy of the feeds studied. In spite of these variations the average productive energy of the effective digestible nutrients for most of the feeds did not deviate widely from that of the standard corn meal. The utilization of the digested nutrients was remarkably uniform.

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SUMMARY

The energy values of various feeds were measured by the production of flesh and fat in growing chickens in 51 experiments on 138 samples of feed. Results on 62 kinds of feeds and 192 tests are summarized.

Chickens differ individually in their efficiency in the utilization of feed so that for accurate averages several tests must be made with a number of chickens.

When the different feeds are compared, there are wide differences in productive energy ranging from one Calorie per 100 grams for cottonseed hulls to 467 Calories for cottonseed oil.

When the productive energies of the effective digestible nutrients of the different feeds are compared, most of the feeds do not differ widely but have value within 10% of that of corn meal.

Differences in the energy values of different feeds for chickens are due chiefly to differences in digestibility. The ability of the chickens to utilize the digested material is on the average usually quite uniform.

Low productive energy values found for the digestible nutrients of milk sugar (lactose) and milk products may be due to the destruction by micro-organisms in the chickens. Low values of the digested nutrients of raw lima beans, raw pinto beans, partly cooked soy beans and gelatin may be due to deficiency of needed amino acids in the proteins.

Oil had a lower energy value than would be expected, about 1.8 instead of the 2.25 times the nitrogen-free extract which is generally believed to be correct. Wheat products had a slightly lower productive energy for their digested nutrients than corn products.

The digestible nutrients of corn bran, corn gluten feed and corn gluten meal had slightly higher energy values than those of corn meal.

The digestible nutrients of some feeds high in protein, including fish meal, soy bean oil meal and dried beef, had higher productive energy values than those of most of the feeds.

Usually about 72% of the metabolizable energy of the feed can be used for storage of energy in fat and protein.

Waxy kafir seed had the same productive energy as ordinary kafir.

A commercial enzyme preparation claimed to produce better digestion and assimilation of feed did not affect either the digestibility or the productive energy of the ration.

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