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A TECHNICAL STUDY OF THE MAINTENANCE AND FATTENING OF LAMBS

AND THEIR UTILIZATION OF A RATION OF ALFALFA HAY AND CORN

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A TECHNICAL STUDY OF THE MAINTENANCE AND FATTENING OF LAMBS AND THEIR UTILIZATION OF A RATION OF ALFALFA HAY AND CORN

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The lack of information concerning the nutrient requirements of sheep and their efficiency in utilizing food nutrients, is mainly responsible for the general application to sheep of results obtained with cattle, and for the complacency felt in thus transferring bodily to one species information and measurements secured with another. It is high time that experimental investigations on the nutrition of sheep be carried out that will either establish this assumed similarity between sheep and cattle or will permit a separate evaluation of sheep.

In Bulletin 283 of this Station is a description of an experiment on 12 sheep designed to determine the maintenance requirement in terms of metabolizable energy, the composition of gains put on during fattening, and the relation between the metabolizable energy consumed above maintenance and the gross energy of the gains made. The rations used in all cases consisted of alfalfa hay only. The rate of fattening secured on alfalfa hay alone was slow, and the refusal of feed in some of the metabolism trials as well as during the fattening period complicated the interpretation of some of the results secured. It was therefore decided to repeat the experiment using a ration more acceptable to sheep and more conducive to fattening. In other respects also the plan of the second experiment differed from that of the first tho the objects sought were essentially the same.

PLAN OF THE EXPERIMENT

The general plan of the experiment provided for the slaughter and analysis of a group of check lambs at the beginning of the experiment and of a group of fattened lambs at the end of the experiment. From these results the composition of the gains put on during fattening could be computed. A third group of lambs was to be fed such amounts of the fattening ration as may be required for the maintenance of weight. The slaughter and analysis of these lambs at the end of their maintenance feeding either would demonstrate that the ration consumed was in fact a maintenance ration (with respect to energy) or would afford

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a more or less satisfactory basis for correcting the ration fed by making due allowance for energy stored in or lost from the body during the feeding period.

It was decided to use young lambs in this work and to carry the fattened lambs to a desirable market weight of approximately 90 pounds. In the spring of 1925 the required number of grade lambs, about three months of age was available, and accordingly on April 16 six of these lambs were killed and subsequently analyzed. These were to constitute the check group. The ration chosen consisted of equal parts of alfalfa hay and corn. Two other groups of lambs were started on maintenance and fattening rations, but they did not eat well. They did not adapt themselves to the system of individual feeding, probably because they were too young, and the experiment was therefore discontinued.

In the fall of the same year some lambs were obtained from an Oregon ranch. They were a mixed group of ewes and wethers, dropped by western ewes bred to purebred Hampshire rams. At the time the experiment was resumed in September, they were from five to five and a half months old. On September 21, eight of these lambs were slaughtered and analyzed as a check group; another group of eight was fed a ration of alfalfa hay and corn in equal parts for maintenance of weight, while a third group of nine was fed for fattening on the same ration. The lambs were fed individually in all cases.

The individual feeding of these lambs was successful. The maintenance group was on feed until the early part of February or March, the final date varying for different individuals. During this period metabolism and digestion trials were made upon each of the eight lambs. At the termination of the period of experimental feeding, the lambs were slaughtered and analyzed.

The lambs in the fattening group were fed until weights approximating 90 pounds were reached, when they were slaughtered and analyzed. Two of the lambs were slaughtered on December 21, 1925, five on January 5, 1926, one on February 9, and one on February 18. Digestion and metabolism trials were made upon only five of the nine lambs in this group.

The pen in which the lambs were allowed to exercise was approximately one by five rods. The lambs were fed in individual feeding crates located in a shed open toward the south. Water and salt were provided *ad libitum*. Except at feeding time, the lambs were allowed the run of the open pen. Body weights were taken weekly, and all feed used was sampled continuously and submitted to a routine chemical analysis, including the determination of calcium and of the heat of combustion. The carcass samples also were analyzed for calcium and gross energy.

CHEMICAL COMPOSITION OF CHECK LAMBS

Altho the results of the analysis of the first group of check lambs were not used in the later computations of the experiment, they are nevertheless reported because of their interest and importance as representative of the composition of lambs three to four months of age.

Two samples were prepared from each lamb for chemical analysis: (1) a carcass sample prepared from one-half of the dressed carcass, including one kidney; and (2) an offal sample, including the blood, head, skin, and feet, visceral fats, and all viscera except the kidneys. A composite wool sample for the group of six lambs was also analyzed, the lambs being shorn before slaughter. In preparing the two samples the different tissues were ground separately according to convenience and ultimately mixed together thoroly.

The slaughter data, the total weights of lean, fat, bone, offal, and wool, and the percentage composition of the chemical samples from the first group of grade lambs will be found in Tables 1, 2, and 3. The estimated percentage composition and gross energy content of the lambs, on the basis of the live weight as well as of the empty weight, are given in Table 4.

About a year before the first group of check lambs was slaughtered, advantage was taken of an opportunity to analyze a number of new-born lambs that had died from unknown causes a day or two after birth. Four of these new-born lambs were of average weight or better and appeared normal in every respect. The first two were premature, having been dropped about ten days before the termination of the normal gestation period. They were subnormal in weight and composition. Since these analyses have not heretofore been published, they have been summarized in Table 5. They possess the same general significance as the analysis of other groups of lambs reported in this bulletin.

The second group of check lambs, used in the computations of this experiment, was slaughtered and analyzed according to the same scheme as the first group, the samples being composited in exactly the same manner. The results obtained are summarized in Tables 6, 7, 8, and 9.

These western lambs were in somewhat poorer condition than the younger grade lambs killed in the spring of 1925. Another noticeable difference between the western and the grade lambs relates to the ash content. The western lambs contained 4.79 percent of ash on the basis of the empty weight, while the grades contained only 3.32 percent. The calcium made up approximately the same percentage of the total ash in each group, i.e., 28.5 and 27.4. The greater ash content of the western lambs may be traced definitely to their greater bone content. No weights on the total skeleton are available, but the bones in the dressed

TABLE 1.—SLAUGHTER DATA FROM FIRST GROUP OF CHECK LAMBS
(All weights in pounds)

Lamb No.	1	21	25	12	22	30	Average
Live weight	47.4	50.1	47.8	54.4	50.9	49.7	50.1
Wool	1.76	1.65	1.08	1.71	1.54	1.11	1.48
Blood	1.94	2.19	2.25	2.19	2.31	2.38	2.21
Skin and feet	4.44	4.56	4.56	4.38	5.13	4.69	4.63
Caul fat	.56	.56	.50	.56	.19	.44	.47
Gut fat	.31	.31	.44	.56	.75	.44	.47
Contents of first three stomachs	6.25	4.63	6.38	6.06	4.31	4.69	5.39
Contents of 4th stomach and intestines	2.44	2.06	2.13	1.38	1.75	1.31	1.85
Contents of entire alimentary tract	8.69	6.69	8.51	7.44	6.06	6.00	7.23
Warm dressed carcass	20.81	25.38	21.06	27.31	24.50	24.25	23.89
Cold dressed carcass	20.05	24.85	20.90	26.53	23.50	23.50	23.22
Percent shrinkage	3.65	2.09	.76	2.86	4.08	3.09	2.76
Percent "fill"	18.3	13.3	17.8	13.6	11.9	12.1	14.5
Dressing percentage	42.7	49.6	43.8	48.8	46.2	47.2	46.4

TABLE 2.—WEIGHTS OF SAMPLES ANALYZED FROM FIRST GROUP OF CHECK LAMBS

Lamb No.	Empty weight	Dressed carcass composite				Offal	Wool
		Lean	Fat	Bone	Total		
	kgs.	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
1	17.58	5 988	1 391	1 736	9 115	6 740	798
21	19.69	7 352	2 035	1 722	11 109	6 730	748
25	17.81	6 035	1 432	1 783	9 250	7 140	490
12	21.30	7 672	2 286	1 998	11 956	7 161	776
22	20.35	6 876	1 706	2 028	10 610	7 561	699
30	19.84	6 748	2 011	1 808	10 567	7 224	503
Average	19.43	6 779	1 810	1 846	10 435	7 093	669

TABLE 3.—PERCENTAGE COMPOSITION AND ENERGY VALUE OF SAMPLES ANALYZED FROM FIRST GROUP OF CHECK LAMBS

Lamb No.	Dry substance	Crude protein	Ether extract	Ash	Calcium	Calcium in percent of total ash	Gross energy per grams
Carcass composite samples							
							sm. cals.
1	44.04	17.11	21.23	5.21	1.85	35.5	2 866
21	48.32	16.32	24.77	4.62	1.46	31.6	3 088
25	43.47	18.26	19.62	5.22	1.72	33.0	2 746
12	53.56	15.95	26.74	3.55	.99	27.9	3 306
22	44.02	16.87	22.15	3.90	1.28	32.8	2 897
30	44.74	16.46	23.32	3.55	1.01	28.5	2 951
Average	46.36	16.83	22.97	4.34	1.39	31.6	2 976
Offal samples							
1	32.08	16.89	12.10	2.47	.59	23.9	1 969
21	34.31	16.88	12.79	1.85	.47	25.4	2 086
25	29.76	17.07	9.93	2.10	.48	22.9	1 780
12	32.70	16.06	12.22	1.83	.40	21.9	2 112
22	28.93	16.37	9.52	1.89	.39	20.6	1 760
30	28.94	16.44	9.58	1.94	.41	21.1	1 743
Average	31.12	16.62	11.02	2.01	.46	23.5	1 908
Composite wool samples							
1-30	91.89	70.75	13.75	7.47	.28	3.75	4 938

TABLE 4.—PERCENTAGE COMPOSITION AND GROSS ENERGY CONTENT OF FIRST GROUP OF CHECK LAMBS

Lamb No.	Dry substance	Crude protein	Crude fat	Ash	Calcium	Calcium in percent of total ash	Gross energy per gram
			On basis of live weight				
							sm. cals.
1	32.11	15.15	13.29	3.25	.98	....	2 013
21	36.80	15.32	16.37	3.08	.86	....	2 290
25	30.46	15.00	11.95	3.09	.90	....	1 870
12	38.33	14.63	16.94	2.47	.60	....	2 370
22	32.47	15.24	13.72	2.64	.72	....	2 059
30	32.27	14.54	14.32	2.44	.61	....	2 050
Average	33.74	14.98	14.43	2.83	.78	....	2 109
			On basis of empty weight				
1	39.30	18.54	16.27	3.98	1.20	30.2	2 465
21	42.46	17.67	18.82	3.56	1.00	28.1	2 643
25	37.06	18.25	14.54	3.76	1.09	29.0	2 276
12	44.41	16.95	19.63	2.86	.70	24.5	2 746
22	36.86	17.30	15.58	3.00	.82	27.3	2 338
30	36.69	16.53	16.28	2.77	.70	25.3	2 331
Average	39.46	17.54	16.85	3.32	.92	27.4	2 467

TABLE 5.—PERCENTAGE COMPOSITION AND GROSS ENERGY OF NEW-BORN LAMBS

Breeding	Birth weight[1]	Dry substance	Crude protein	Ether extract	Ash	Gross energy per grams
	lbs.					*sm. cals.*
	6.0	18.99	11.38	2.32	2.35	1 011
	7.0	18.04	11.19	1.81	2.68	882
Rambouillet	9.75	23.02	14.94	2.82	3.36	1 148
Rambouillet	10.7	23.32	15.44	2.88	3.02	1 308
Southdown	6.6	24.69	15.19	2.76	3.84	1 324
Southdown	7.2	22.66	16.44	2.44	3.35	1 236
Average[2]	.....	23.42	15.50	2.72	3.39	1 254

[1]Sixteen Southdown lambs dropped from ewes in the University flock during the same year averaged 7.7 pounds in weight at birth; 24 Rambouillet lambs averaged 9.7 pounds. [2]Exclusive of first two lambs.

TABLE 6.—SLAUGHTER DATA FROM SECOND GROUP OF CHECK LAMBS

(All weights in pounds)

Lamb No.	156	29	64	44	83	78	80	81	Average
Live weight	59.7	60.6	57.5	58.4	60.6	57.4	58.1	55.8	58.5
Wool	3.38	3.38	2.81	3.06	3.69	2.63	3.13	3.13	3.15
Blood	3.44	2.81	2.63	2.25	2.75	3.00	2.75	2.63	2.78
Skin and feet	6.38	4.75	5.38	4.81	5.00	5.81	5.19	5.38	5.34
Caul fat	.25	.69	.38	.81	.44	.50	.56	.38	.50
Gut fat	.56	.44	.56	.50	.44	.44	.44	.44	.48
Contents of first three stomachs	5.19	6.81	4.81	5.31	9.81	6.56	6.06	5.69	6.28
Contents of 4th stomach and intestines	4.31	3.13	3.06	2.50	3.56	2.88	2.69	2.44	3.07
Contents of entire alimentary tract	9.50	9.94	7.87	7.81	13.37	9.44	8.75	8.13	9.35
Warm dressed carcass	26.19	28.19	27.94	27.56	26.25	26.38	27.56	25.88	26.99
Cold dressed carcass	25.61	27.60	27.20	26.86	25.49	25.68	26.66	25.03	26.27
Percent shrinkage	2.21	2.09	2.65	2.54	2.90	2.65	3.27	3.28	2.70
Percent "fill"	15.9	16.4	13.7	13.3	22.1	16.4	15.1	14.6	15.9
Dressing percentage	42.9	45.6	47.3	46.0	42.1	44.8	45.9	44.9	44.9

carcass averaged 1.846 grams for the grades and 2.588 grams for the western lambs, which is equal to 9.52 and 11.61 percent respectively of the empty weight and 11.45 and 13.52 percent of the fat-free empty weight.

TABLE 7.—WEIGHTS OF SAMPLES ANALYZED FROM SECOND GROUP OF CHECK LAMBS

Lamb No.	Empty weight	Dressed carcass composite				Offal	Wool
		Lean	Fat	Bone[1]	Total		
	lbs.	grams	grams	grams	grams	grams	grams
156	22 77	7 413	1 382	2 658	11 453	8 852	1 533
29	22 97	7 940	1 441	2 666	12 047	8 009	1 533
64	22 51	8 005	1 319	2 394	11 918	7 876	1 275
44	22 97	7 176	1 972	2 641	11 789	7 617	1 388
83	21 41	7 694	1 133	2 523	11 350	7 929	1 674
78	21 75	7 503	1 130	2 636	11 269	7 997	1 193
80	22 40	7 896	1 211	2 646	11 753	8 019	1 420
81	21 60	7 299	1 000	2 543	10 842	7 886	1 420
Average	22.30	7 616	1 349	2 588	11 553	8 023	1 430

[1]Exclusive of the bones of head and feet.

TABLE 8.—PERCENTAGE COMPOSITION AND ENERGY VALUE OF SAMPLES ANALYZED FROM SECOND GROUP OF CHECK LAMBS

Lamb No.	Dry substance	Crude protein	Ether extract	Ash	Calcium	Calcium in percent of total ash	Gross energy per gram
	Carcass composite samples						
							sm. cals.
156	41 56	17.31	16 32	7.32	2.54	34 7	2 440
29	45 84	17 63	20 27	5.56	1 86	33 5	2 786
64	44.57	17.19	21.57	4.85	1.66	34.2	2 866
44	46 97	16.56	23.88	6.40	2 23	34.4	3 116
83	41 33	17.31	18.93	4.77	1.56	32.7	2 613
78	44 19	17.88	18.76	6.44	2.19	34.0	2 664
80	42 15	18.56	17.20	5.88	2 08	35.4	2 477
81	42.45	18.13	17.76	5.90	1.82	30.8	2 565
Average	43 63	17.57	19.34	5.90	1.99	33.7	2 691
	Offal samples						
156	27.17	16.38	7.32	3.10	.71	22.9	1 687
29	32 63	16 38	12.63	2 68	.62	23 1	2 005
64	29 41	16.25	9.50	2.32	.53	22.8	1 701
44	32 69	16.75	13.15	3.09	.88	28.5	2 129
83	28 64	15 94	9.60	2 99	.69	23.1	1 709
78	30 00	16.44	9.63	3.13	.77	24.6	1 778
80	31.58	16.50	11.14	2.93	.77	26.3	1 914
81	29.93	16 88	9.91	2.72	.68	25.0	1 718
Average	30.26	16.44	10.36	2 87	.71	24.5	1 830
	Composite wool sample						
Entire group	91.57	70.19	6.47	10.88	.28	2.57	4 563

TABLE 9.—PERCENTAGE COMPOSITION AND GROSS ENERGY CONTENT OF SECOND GROUP OF CHECK LAMBS

Lamb No.	Dry substance	Crude protein	Ether extract	Ash	Calcium	Calcium in percent of total ash	Gross energy per gram
			On basis of live weight				
							cm cals.
156	31.66	16.66	9.68	4 73	1 32	27.9	1 843
29	34.73	16.42	12.92	3 82	1 01	26.4	2 081
64	33 74	16.18	13.04	3 45	94	27.3	2 047
44	35.08	15.84	14.75	4 34	1 26	29 0	2 236
83	30.98	16.02	10.99	3.49	1.23	35 2	1 851
78	32 54	16.02	11.37	4 26	1 20	28 2	1 909
80	33 33	17.06	11.41	4 10	1 18	28.8	1 932
81	32.66	16.96	11.07	3.99	1 01	25.3	1 892
Average	33 09	16.40	11 90	4.02	1 14	28 5	1 971
			On basis of empty weight				
156	37.64	19.81	11 51	5.62	1.57	. .	2 131
29	41 54	19.64	15.46	4.57	1.21	....	2 485
64	39 09	18.75	15 10	4.00	1.08	. .	2 371
44	40.49	18.29	17 02	5.01	1.45	. .	2 581
83	39.75	20.55	14.11	4.48	1.57	. .	2 375
78	38 95	19 17	13 61	5 10	1 43	.	2 284
80	39.24	20.09	13.44	4.82	1.38	. .	2 274
81	38.24	19.86	12.96	4.68	1.18	....	2 215
Average	39.37	19.52	14 15	4.79	1.36	. .	2 346

MAINTENANCE EXPERIMENT

The feeding of the eight maintenance lambs started on October 10, 1925. Their weekly weights from this date until February 6 or 13 are given in Table 10.

TABLE 10.—WEEKLY WEIGHTS OF LAMBS DURING MAINTENANCE FEEDING PERIOD[1]

(All weights in pounds)

Lamb No.	10	11	22	25	43	75	85	136
1925								
Oct. 10	65	63	65	66	62	63	65	56
17	62	64	65	65	59	61	61	59
24	66	67	68	66	65	62	68	63
31	64	65	65	66	65	62	65	62
Nov. 7	72	69	71	69	70	65	73	67
14	68	67	69	69	66	64	68	69
21	69	70	71	71	69	64	71	66
28	67	67	70	69	66	66	69	64
Dec. 5	67	66	70	71	67	65	69	65
12	67	67	70	70	68	67	69	64
19	66	65	68	68	66	65	68	66
26	68	69	73	72	71	68	72	70
1926								
Jan. 2	70	70	73	74	74	70	73	68
9	70	70	72	73	72	69	74	69
16	69	71	72	74	72	73	75	70
23	71	74	75	74	75	73	75	73
30	71	73	74	76	74	73	74	71
Feb. 6	73	79	77	77	79	75	79	72
13	..	76	..	..	75	..	..	..
Final weight	69.4	73.2	71.7	71.6	74.9	69.0	72.4	72.8
Average weight	68.2	69.2	70.6	70.6	69.3	67.1	70.6	66.5

[1]No. 136 was slaughtered on February 8. Nos. 10, 22, 25, 75, and 85 on February 18, and Nos. 11 and 43 on March 4. Some of the weekly weights taken in February are omitted from the table and from the averages because of irregularities incident to metabolism trials.

Body Weight Changes

The weight records in Table 10 indicate that the feeding was appreciably more liberal than a maintenance ration. All lambs increased in weight slowly. They were started on .8 pound of alfalfa hay and .8 pound of corn per head daily. On November 21 this allowance was decreased to .7 pound of each feed daily for all of the lambs except Nos. 75 and 136. The same reduction was made for Lamb 75 on November 28; Lamb 136 was carried thruout at the higher level. The chemical composition of the different samples of feeds collected at the sheep barn and at the Nutrition Laboratory, where the metabolism tests were run, is given in Table 11.

Results of Digestion and Metabolism Trials

In the last few weeks of the experiment each of the maintenance lambs was subjected to a digestion and metabolism trial during which feces and urine were quantitatively collected for 10 days. In each case the lambs had been consuming for several weeks prior to the collection period a constant daily amount of feed, the same as that consumed during the time of collection of excreta. The excreta passed during the first day in the metabolism crate were rejected. The metabolism crates used have been described in Bulletin 283 from this Station. The coefficients of digestibility for the different nutrients, computed according to the ordinary method, have been summarized in Table 12.

In addition to the routine analyses of feed and feces, the gross energy was also determined in these samples, as well as in the urine, by combustion in the bomb calorimeter. These determinations permitted the computation of the metabolizable energy in the maintenance rations (Table 13). The nitrogen balances of the lambs during the metabolism trials are shown in Table 14. All lambs were storing nitrogen.

An average of 59.7 percent of the gross energy of the ration was metabolizable. Armsby has computed[1] from his own experiments on steers that the gross energy of alfalfa is 44 percent metabolizable and that of corn 75 percent metabolizable. For a ration containing approximately equal amounts of gross energy from these two feeds, as was true of the ration fed the maintenance lambs, one would expect with steers that 59.5 percent (average of 44 and 75) of the gross energy would be metabolizable, a value practically identical with the average percentage actually obtained with the maintenance lambs. Forbes and associates have recently reported[2] some energy metabolism studies on two steers receiving a ration containing equal parts of alfalfa

[1]Armsby, H. P. The nutrition of farm animals, 661. Macmillan, 1917.
[2]Forbes, E. B., *et al.* Amer. Soc. Anim. Prod. Proc., 1927.

TABLE 11.—CHEMICAL COMPOSITION OF FEEDS CONSUMED BY THE MAINTENANCE LAMBS

Date	Description of feed sample	Dry substance	Crude protein	N-free extract	Crude fiber	Ether extract	Ash	Calcium	Gross energy per gram
				Alfalfa hay					
		perct.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*sm. cals.*
Oct. 10-Jan. 5	Fed at barn	91.95	16.63	43.99	20.52	2.83	7.98	.....	4 119
Jan. 23-Feb. 2	Metabolism trial[1]	93.98	15.19	42.69	26.93	1.98	7.19	.....	4 207
Feb. 2-17	Metabolism trials[2]	94.52	14.38	40.07	30.72	2.27	7.08	1.46	4 141
Feb. 17-Mar. 3	Metabolism trials[3]	94.87	14.19	40.43	31.72	1.69	6.84	.....	4 225
Jan. 5-Mar. 4	Fed at barn	86.20	13.84	37.29	26.86	1.60	6.61	1.54	3 849
				Corn					
Oct. 10-Jan. 5	Fed at barn	87.03	8.63	71.53	2.26	3.31	1.30	.028	3 869
Jan. 23-Feb. 2	Metabolism trial[1]	88.67	9.06	72.82	2.31	3.21	1.27	.....	3 938
Feb. 2-17	Metabolism trials[2]	90.54	9.31	72.93	3.18	3.39	1.73	.031	4 065
Feb. 17-Mar. 3	Metabolism trials[3]	91.04	9.25	73.69	2.84	3.95	1.31	.....	4 075
Jan. 5-Mar. 4	Fed at barn	88.96	8.94	72.72	2.72	3.31	1.27	.027	3 981

[1]These samples were used for Lamb 136 only. [2]These samples represent the metabolism trials of Lambs 10, 22, 25, 75, and 85. [3]These samples refer to the metabolism trials of Lambs 11 and 43.

TABLE 12.—DIGESTION COEFFICIENTS OBTAINED WITH THE MAINTENANCE LAMBS

Lamb No.	Dry substance	Crude protein	N-free extract	Crude fiber	Ether extract
	per cent	per cent	per cent	per cent	per cent
126	74	71	83	43	58
20	74	63	85	45	68
22	74	63	84	46	69
23	62	60	84	30	60
24	78	72	89	51	72
25	75	58	86	47	66
27	77	67	85	48	74
29	70	47	87	41	59
Average	73.5	61.8	86.0	44.5	65.8

hay and corn. For one of these steers 61.4 percent of the gross energy consumed in a maintenance ration was metabolizable, and for the other steer 60.3 percent. These values also agree closely with those found for the lambs on a ration of the same character.

Average Daily Intake of Feed and Energy

The daily intake of feed and of metabolizable energy by the lambs during the maintenance feeding period, both per head and per 100 pounds live weight, are given in Table 15. The computation to the 100-pound weight has been made in accordance with the ratio of the weight of each lamb to 100 and in accordance with the ratio of the two-thirds power of the weight of the lamb to the two-thirds power of 100. The latter method is the better for equalizing differences in body size with reference to the basal metabolism, while the former method is the better for equalizing differences in body size with reference to muscular activity involving the moving of the body against gravity or horizontally. Since the maintenance of these lambs involved both the basal metabolism and an unknown amount of muscular movement, it is difficult to decide which method is the better to use.

The metabolizable energy values given in Table 15 should be corrected for the storage or loss of energy in the body during the period of feeding before they can be interpreted as estimates of maintenance requirements. A secure basis for making such a correction could be obtained only by slaughtering and analyzing the maintenance lambs and comparing their content of energy with that of the check lambs, which presumably had the same composition as the maintenance lambs at the start of the period of feeding.

Composition of the Maintenance Lambs

The data from the slaughter, sampling, and analysis of the maintenance lambs are given in Tables 16, 17, 18, and 19. With this group

TABLE 13.—LOSSES OF ENERGY AND THEIR PERCENTAGE DISTRIBUTION: METABOLIZABLE ENERGY OF RATION CONSUMED BY THE MAINTENANCE LAMBS

Lamb No.	Dry matter eaten per day and head		Energy per kilogram of dry matter					Losses			Metabolizable		Percentage metabolizable
	Coarse feed	Concentrates	Total	Losses: In feces	Losses: In urine[1]	Losses: In methane[2]	Metabolizable	In feces	In urine	In methane	Per kg. digestible organic matter	Per kg. total digestible nutrients	
	kgs.	*kgs.*	*therms*	*therms*	*therms*	*therms*	*therms*	*perct.*	*perct.*	*perct.*	*therms*	*therms*	*perct.*
136	.342	.323	4.457	1.224	.203	.365	2.666	27.44	4.55	8.19	3.717	3.611	59.81
10	.301	.288	4.431	1.102	.190	.370	2.679	26.90	4.29	8.35	3.722	3.595	60.46
22	.301	.288	4.431	1.219	.200	.367	2.645	27.51	4.51	8.28	3.701	3.595	59.70
25	.301	.288	4.431	1.186	.185	.363	2.700	26.77	4.18	7.76	3.744	3.624	60.93
75	.301	.288	4.431	1.027	.211	.382	2.811	24.18	4.76	8.62	3.738	3.608	63.44
85	.301	.288	4.431	1.254	.183	.380	2.617	28.23	4.13	8.58	3.600	3.479	59.06
11	.302	.290	4.459	1.167	.193	.375	2.724	26.17	4.33	8.41	3.717	3.584	61.09
43	.302	.290	4.459	1.226	.184	.367	2.682	27.49	4.13	8.24	3.703	3.642	60.15
Average	.306	.293	4.441	1.224	.194	.371	2.654	27.56	4.36	8.30	3.671	3.557	59.74

[1]Corrected to nitrogen equilibrium. [2]Estimated at 4.5 grams per 100 grams of digestible carbohydrates.

TABLE 14.—DAILY NITROGEN BALANCES OF THE MAINTENANCE LAMBS DURING METABOLISM PERIODS

Lamb No.	Nitrogen of feed consumed	Nitrogen of feces	Nitrogen of urine	Total nitrogen excreted	Nitrogen balance
	grams	*grams*	*grams*	*grams*	*grams*
136	14.18	4.16	6.69	10.85	+3.33
10	12.05	4.70	5.94	10.10	+1.95
22	12.05	4.19	6.14	10.32	+1.73
25	12.05	4.77	6.43	11.20	+0.85
75	12.05	3.90	7.60	10.90	+1.15
85	12.05	5.10	6.72	11.82	+0.23
11	11.91	4.94	6.28	10.22	+1.70
43	11.92	4.90	6.47	10.37	+1.55

TABLE 15.—DAILY FEED AND METABOLIZABLE ENERGY CONSUMPTION OF MAINTENANCE LAMBS

Lamb No.	10	11	22	25	43	75	85	136	Average
Days on experiment	131	145	131	131	145	131	131	120.5	133.2
Average live weight, pounds	68.2	69.2	70.6	70.6	69.3	67.1	70.6	66.5	69.0
Total weight of corn consumed, pounds	95.55	105.35	95.55	95.40	105.35	96.70	95.55	97.20	98.33
Total weight of alfalfa consumed, pounds	95.55	105.35	95.55	95.15	105.35	96.70	95.55	97.20	98.30
Total feed consumed, pounds	191.10	210.70	191.10	190.55	210.70	193.40	191.10	194.40	196.63
Average feed consumed daily, pounds	1.46	1.45	1.46	1.45	1.45	1.48	1.46	1.61	1.48
Average feed consumed daily, per 100 pounds live weight:									
Computed by weight ratio, pounds	2.14	2.10	2.07	2.05	2.09	2.21	2.07	2.42	2.14
Computed by surface ratio, pounds	1.88	1.86	1.87	1.86	1.86	1.94	1.87	2.17	1.91
Metabolizable energy per day per 100 pounds live weight:									
Computed by weight ratio, calories	2 416	2 414	2 301	2 123	2 373	2 609	2 275	2 683	2 399
Computed by surface ratio, calories	2 123	2 138	2 080	1 918	2 105	2 293	2 057	2 008	2 140

TABLE 16.—SLAUGHTER DATA FROM THE MAINTENANCE LAMBS
(All weights in pounds)

Lamb No.	136	85	75	22	10	25	11	43	Average
Live weight	72.8	72.4	69.0	71.7	69.4	71.6	73.2	74.9	71.9
Wool	2.80	4.00	3.90	5.25	4.50	6.65	4.75	4.91	4.60
Blood	2.80	3.25	4.10	3.70	2.90	3.20	3.00	3.17	3.27
Skin and feet	8.50	7.20	5.70	6.50	5.15	6.35	6.66	6.83	6.61
Caul fat	.80	1.60	1.50	1.55	1.35	1.75	1.69	1.46	1.46
Gut fat	.80	1.10	1.35	1.25	1.40	1.10	1.24	1.02	1.16
Contents of first three stomachs	5.15	5.15	4.70	5.40	3.65	5.05	5.29	5.45	4.98
Contents of 4th stomach and intestines	3.90	2.55	3.05	2.55	2.00	2.15	3.07	3.40	2.83
Contents of entire alimentary tract	9.05	7.70	7.75	7.95	5.65	7.20	8.36	8.85	7.81
Warm dressed carcass	37.00	37.50	35.50	35.75	39.50	37.25	36.75	37.75	37.13
Cold dressed carcass	36.08	36.90	34.60	34.86	38.91	36.55	35.03	36.86	36.22
Percent shrinkage	2.49	1.60	2.54	2.49	1.49	1.88	4 68	2.36	2.44
Percent "fill"	12.4	10.6	11.2	11.1	8.1	10.1	11.4	11.8	10.8
Dressing percentage	49.5	51.0	50.2	48.6	56.1	51.1	47.8	49.2	50.4

TABLE 17.—WEIGHTS OF SAMPLES ANALYZED FROM THE MAINTENANCE LAMBS

Lamb No.	Empty weight	Edible flesh			Bone	Offal	Wool
		Lean	Fat	Total			
	kgs.	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
136	28.94	10 767	2 614	13 381	3 998	8 838	1 270
85	29.34	9 989	2 960	12 949	3 970	8 155	1 814
75	27.76	10 677	1 740	12 417	4 178	8 672	1 769
22	28.94	10 427	2 125	12 552	4 116	8 915	2 381
10	28.91	10 399	4 051	14 450	3 529	7 725	2 041
25	29.21	10 136	3 304	13 440	3 791	8 530	3 016
11	29.43	9 598	3 262	12 860	4 248	8 528	2 155
43	29.96	9 944	3 462	13 406	4 311	8 610	2 227
Average	29.08	10 242	2 940	13 182	4 018	8 497	2 084

three instead of two samples were taken from each carcass besides the composite wool sample for the group. The sample of edible flesh represented the lean, including the kidneys, and the fat from the dressed carcass. The bone sample included the bones of the dressed carcass and the bones of the head and feet, as roughly cleaned with a butcher knife. The offal sample contained the blood, the shorn skin, and the flesh, brain, and eyes from the head, together with all viscera and visceral fat.

It is evident from Tables 9 and 19 that the carcasses of the maintenance lambs were appreciably fatter than those of the check lambs. On the live-weight basis the maintenance lambs contained 19.25 percent of fat as compared with 11.90 percent for the check lambs; on the basis of the empty weight these percentages were 21.57 and 14.15 respectively. The increase in weight of the maintenance lambs thruout their feeding period increased still further the storage of energy in their bodies. Evidently the ration fed was appreciably greater in energy value than the lambs required for the maintenance of energy equilibrium. An attempt to correct the ration fed to energy equilibrium has been made in Table 20.

TABLE 18.—PERCENTAGE COMPOSITION AND ENERGY VALUE OF SAMPLES ANALYZED FROM THE MAINTENANCE LAMBS

Lamb No.	Dry substance	Crude protein	Ether extract	Ash	Calcium	Calcium in percent of total ash	Gross energy per gram
			Edible flesh samples				
							sm. cals.
136	49.53	15.38	26.68	.91	.025	2.75	3374
85	49.49	15.13	27.83	.82	.027	3.29	3612
75	41.32	16.63	21.91	.89	.026	2.92	3033
22	39.61	16.56	22.57	.87	.027	3.10	3066
10	47.36	14.88	32.03	.77	.025	3.25	3777
25	45.47	15.38	30.31	.79	.030	3.80	3706
11	49.04	15.00	32.81	.76	.026	3.42	3820
43	49.24	15.31	28.63	.83	.023	2.77	3551
Average	46.38	15.53	27.85	.83	.026	3.16	3492
			Bone samples				
136	60.79	19.17	17.96	20.90	7.84	37.5	2862
85	59.90	19.52	19 77	18.78	7.09	37.8	3115
75	58.66	19.51	18.44	18.64	7.03	37.7	2905
22	58.24	19.38	17.31	18.73	7.00	37.4	2781
10	57.84	18.96	16 71	19.55	7.33	37.5	2679
25	60.40	19.38	20.86	18.21	6.72	36.9	3092
11	55.74	18.02	19.77	16.41	6.14	37.4	2816
43	57.74	19.31	18.59	18.35	6.99	38.1	2802
Average	58.66	19.16	18.68	18.70	7.02	37.5	2882
			Offal samples				
136	31.89	15.25	15.51	.91	.026	2.86	2319
85	35.99	15.25	18.43	1.09	.030	2.75	2650
75	36.53	13.19	21.04	.97	.035	3.61	2674
22	35.99	13.81	18.74	1.09	.023	2.11	2639
10	43.01	14.38	21.50	.99	.034	3.43	2914
25	38.94	14.56	20.51	.94	.026	2.77	2889
11	39.08	13.94	21.21	.98	.022	2.24	2811
43	36.38	15.00	18.04	1.05	.029	2.76	2524
Average	37.23	14.42	19.37	1.00	.028	2.82	2678
			Wool samples				
136-43	91.57	60.63	8.60	11.6	.177	1.53	4460

Changes in Energy Content of the Maintenance Lambs

The carcasses of the maintenance lambs contained an average of 89.9 therms of gross energy. Assuming that their energy content at the beginning of the feeding period was the same as that of the check lambs at slaughter, i.e., 894 calories per pound, the initial energy content of the maintenance lambs may be estimated; this has been done in Table 20, giving an average estimate of 56.4 therms. Hence during the period of feeding, the maintenance lambs added some 33.5 therms of gross energy to their bodies at the rate of 252 calories per day. The daily ration therefore provided 252 calories of net energy in excess of the maintenance requirements. It may be estimated from Armsby's data[1] that the metabolizable energy of a ration consisting of equal

[1]The average gross energy of the alfalfa hay consumed by the maintenance sheep was 4,108 calories per kilogram and that of the corn, 3,986 calories per

TABLE 19.—PERCENTAGE COMPOSITION AND GROSS ENERGY CONTENT OF THE MAINTENANCE LAMBS

Lamb No.	Dry substance	Crude protein	Ether extract	Ash	Calcium	Calcium in percent of total ash	Gross energy per gram
			On basis of live weight				
							sm. cals.
136	39.47	14.96	17.46	3.58	.97	28.0	2 504
85	41.42	15.75	18.76	3.53	.88	24.8	2 754
75	39.55	16.29	17.48	3.77	.97	25.5	2 586
22	39.19	17.05	16.65	3.85	.92	23.6	2 583
10	44.73	16.42	22.42	3.54	.85	23.7	3 039
25	44.61	18.09	21.17	3.78	.82	21.5	3 068
11	42.07	15.62	21.23	3.40	.81	23.6	2 849
43	41.97	16.26	18.79	3.68	.91	24.5	2 688
Average	41.63	16.31	19.25	3.64	.88	24.4	2 759
			On basis of empty weight				
136	45.06	17.08	19.93	4.09	1.11	....	2 859
85	46.35	17.62	20.99	3.95	.99	....	3 082
75	44.56	18.36	19.70	4.25	1.09	....	2 914
22	44.08	19.18	18.73	4.33	1.03	....	2 905
10	48.69	17.87	24.40	3.85	.93	....	3 308
25	49.59	20.11	23.53	4.20	.91	....	3 410
11	47.51	17.64	23.97	3.84	.92	....	3 217
43	47.60	18.44	21.31	4.17	1.03	....	3 049
Average	46.68	18.29	21.57	4.09	1.00	....	3 093

parts of alfalfa hay and corn is 53 percent net available. Forbes and associates (*loc. cit.*) have more recently investigated directly the utilization of the energy of this ration on two steers. From the data obtained it may be computed that the metabolizable energy equivalent to one-half the maintenance requirement of steers, when added to a maintenance ration, increased the energy balance by an amount equal to 55.4 and 55.7 of the added metabolizable energy. In other words, between a maintenance level of feeding and a level 50 percent higher, the metabolizable energy appeared to have a net availability of a little over 55 percent. This percentage is in close agreement with the value obtained from Armsby's data and has been used in the calculations of Table 20.

Corrected Maintenance Requirements

Assuming, therefore, that the metabolizable energy consumed by these lambs above their maintenance requirements possessed a per-

kilogram. Of the gross energy of alfalfa hay 44 percent is available as metabolizable energy, and of corn 75 percent is available (see page 38). Of the metabolizable energy in these feeds the percentage available as net energy for fattening is (Armsby, "The Nutrition of Farm Animals," page 661) for alfalfa hay 39 percent and for corn 61 percent. Each kilogram of alfalfa hay therefore contained 4,108 × .44, or 1,808 calories of metabolizable energy, and 1,808 × .39, or 705 calories of net energy: and each kilogram of corn contained 3,986 × .75, or 2,900 calories of metabolizable energy, and 2,900 × .61, or 1,769 calories of net energy. The average net availability of the metabolizable energy of a ration containing equal parts of these two feeds is therefore $\frac{705 + 1{,}769}{1{,}808 + 2{,}900} = 52.55$ percent.

TABLE 20.—ESTIMATION OF MAINTENANCE REQUIREMENTS OF METABOLIZABLE ENERGY FOR THE MAINTENANCE LAMBS

Lamb No.	10	11	22	25	43	75	85	136	Average
Feeding period, days	131	145	131	131	145	131	131	120	133
Average body weight, pounds	68.2	69.2	70.6	70.6	69.3	67.1	70.6	66.5	69.0
Gross energy content, therms									
Final	95.6	94.7	84.1	99.6	91.3	80.9	90.4	82.7	89.9
Initial[1]	58.1	56.3	58.1	59.0	55.4	56.3	58.1	50.1	56.4
Gain	37.5	38.3	26.0	40.6	35.9	24.6	32.3	32.7	33.5
Daily intake of metabolizable energy, calories[2]	1555	1570	1555	1551	1570	1584	1555	1747	1586
Daily storage of energy, calories	286	264	198	310	248	188	247	273	252
Assumed availability of metabolizable energy of the ration, percent	55	55	55	55	55	55	55	55	55
Metabolizable energy equivalent of daily stored energy,[3] calories	520	480	360	564	451	342	449	496	458
Maintenance requirements of metabolizable energy daily, calories									
Per head[4]	1035	1090	1195	987	1119	1242	1106	1251	1128
Per 100 pounds live weight:									
Weight ratio	1518	1575	1692	1398	1615	1851	1567	1881	1637
Surface ratio	1336	1395	1530	1263	1432	1628	1416	1689	1461
Maintenance requirements of ration, in pounds per 100 pounds live weight:									
Weight ratio	1.42	1.46	1.59	1.31	1.49	1.73	1.47	1.73	1.53
Surface ratio	1.25	1.29	1.44	1.19	1.33	1.52	1.33	1.56	1.36

[1]Assuming that the maintenance sheep at their initial weight had the same gross energy per kilogram live weight as the check sheep had. The average gross energy of the check sheep was 1971 calories per kilogram of live weight, or 894 calories per pound. [2]During the metabolism trials of the maintenance sheep it was found that an average of 59.8 percent of the gross energy consumed was available as metabolizable energy. The total gross energy consumed by the maintenance lambs, divided by the number of days on experiment gives the daily intake of gross energy, which when multiplied by .598 gives the daily metabolizable energy intake. [3]Daily energy storage divided by .55 = metabolizable energy equivalent. [4]Daily metabolizable energy intake less metabolizable energy equivalent of stored energy.

centage availability of 55, the daily net energy stored, averaging 252 calories, may be taken as equivalent to 458 calories of metabolizable energy. The daily intake of metabolizable energy averaged 1,586 calories, so that the maintenance requirement becomes 1,586 — 458 =1,128 calories per head, or 1,637 calories per 100 pounds body weight computed in proportion to weight, or 1,461 calories per 100 pounds computed in proportion to the two-thirds power of the weight (body surface). The quantity of feed has been computed from these values by means of the average metabolizable energy content of the ration (1,074 calories per pound).

The choice between the two estimates of the maintenance requirement of metabolizable energy is a difficult one, depending as explained above on the proportions of energy used for the basal metabolism and for muscular activity. These are unknown. It would be expected that the more significant method of reducing these estimated requirements to a body weight of 100 pounds would give the less variable set of values. The standard deviation of the estimates made in accordance with the ratio of weights is 226 calories, while that of the estimates made in accordance with the ratio of surfaces is 203 calories. However, the coefficients of variation are practically the same, 14.4 and 14.5 percent respectively, so that a choice between the two methods on this basis can hardly be made.

On a ration of alfalfa hay alone it was found in the preceding investigation with older sheep (see Illinois Bulletin 283), that the maintenance requirement averaged, for 12 sheep, 1,820 calories of metabolizable energy per 100 pounds live weight by using the ratio of weights, and 1,733 calories by using the ratio of surfaces. These figures are appreciably higher than those computed in the present experiment, a fact that may reasonably be accounted for by the known poorer utilization of the metabolizable energy of alfalfa hay than of corn.

Net Energy Required for Maintenance

Forbes and associates (*loc. cit.*) found that the metabolizable energy of a maintenance ration of equal parts of alfalfa hay and corn was 80.8 percent net available for one of their steers (No. 47) and 81.4 percent net available for the other. If lambs may be assumed to be equally efficient in the utilization of the metabolizable energy of a similar maintenance ration, the net energy requirement of the lambs may be computed for "economic maintenance." Applying the average of the two percentages obtained with steers to the average metabolizable energy requirements given in Table 20 gives a net energy requirement of 1,326 calories per 100 pounds live weight according to the ratio of weights and 1,183 calories according to the ratio of surfaces.

Wood and Capstick[1] have recently calculated by an indirect mathe-

[1]Wood, T. B., and Capstick, J. W. Jour. Agr. Sci. 16, 325. 1926.

matical method that a sheep weighing 100 pounds requires daily for maintenance 1.26 pounds of starch equivalent, or 1,348 calories of net energy. This value was computed in proportion to the surface of the sheep and is therefore to be compared with the estimate of 1,183 calories in this experiment. Wood and Capstick obtained their value by a mathematical analysis of data concerning the feed consumption and the variations in weight of twenty-eight sheep. The starch values of the feed consumed were apparently calculated from the average tables of Kellner for fattening steers.

THE FATTENING EXPERIMENT

On September 30, 1925, eight lambs averaging 66 pounds in weight were put upon such amounts of alfalfa hay and corn in equal proportions as they would readily clean up. On October 24 a ninth lamb was added to this group. These lambs were slaughtered at approximately 90 pounds in order to determine the nature of the gains made during fattening to a popular slaughter weight and the utilization of the metabolizable energy consumed and used for that purpose. The weekly weights of these lambs will be found in Table 21. The average daily gains varied from .18 to .36 pound and averaged .25 pound.

The feed consumption of the lambs has been summarized and averaged in Table 22. The feeds fed at the barns were sampled along with the feeds of the maintenance lambs, and the analyses of these samples have been given in Table 11.

TABLE 21.—WEEKLY WEIGHTS OF LAMBS DURING FATTENING PERIOD[1]
(All weights in pounds)

Lamb No.	33	69	151	169	67	49	54	90	143
1927									
Sept. 30	...	70	67	69	66	65	66	65	65
Oct. 10	...	69	69	73	69	55	67	69	66
17	...	68	71	68	70	55	67	66	66
24	65	73	71	72	76	61	71	70	67
31	66	72	71	71	73	60	70	70	69
Nov. 7	71	73	80	72	81	71	76	79	75
14	70	80	77	78	78	69	78	76	72
21	73	80	78	76	78	69	75	74	73
28	73	85	77	79	80	66	76	77	73
Dec. 5	74	87	79	81	83	70	79	82	72
12	80	85	81	84	85	74	84	84	72
19	85	90	88	88	90	77	86	85	73
26	85	...	86	88	...	78	89	87	79
1926									
Jan. 2	91	...	90	91	...	82	92	91	82
9	...	...	...	...	...	83	...	...	83
16	...	...	...	...	...	86	...	...	86
23	...	...	...	...	...	86	...	...	85
30	...	...	...	...	...	83	...	...	86
Feb. 6	...	...	...	...	...	85	...	...	90
13	...	...	...	...	...	87	...	...	...
17	...	...	...	...	...	90	...	...	...
Average weights	75.7	77.7	77.5	77.9	77.4	73.9	76.9	76.8	75.5
Average daily gains	.36	.24	.24	.23	.29	.18	.27	.27	.19
Length of feeding period in days	73	82	97	97	82	141	97	97	131

[1]Lambs 67 and 69 were slaughtered on December 21, 1925, after 82 days of feeding; Lambs 151, 169, 54, 33, and 90 were slaughtered on January 5, 1926, after 97 days of feeding; Lamb 143 was killed on February 8, and Lamb 49 on February 18, after 131 and 141 days of feeding, respectively.

TABLE 22.—TOTAL AND AVERAGE DAILY FEED CONSUMPTION OF THE FATTENING LAMBS

(All weights in pounds)

Lamb No.	33	69	151	169	67	49	54	90	143	Average
Total weight of corn consumed	84.1	89.3	102.3	107.9	88.6	142.4	102.7	105.7	131.1	105.9
Total weight of alfalfa consumed	84.1	88.8	102.0	107.2	88.2	141.9	102.4	105.2	130.1	105.4
Total weight of feed consumed	168.2	178.2	204.3	215.1	176.9	284.3	205.2	211.0	261.3	211.4
Average daily feed consumed	2.30	2.17	2.13	2.22	2.16	2.02	2.11	2.18	1.99	2.14
Average daily feed per 100 pounds live weight	3.13	2.76	2.71	2.82	2.74	2.71	2.71	2.80	2.61	2.77

Results of the Digestion and Metabolism Trials

During the period from October 29 to December 5 digestion and metabolism trials were made upon five of the nine fattening sheep. As with the maintenance lambs, the collection periods were of 10 days duration. For two of the lambs (Nos. 69 and 169) no change in feed had been made for 29 days before the collection period. For Lamb 33 the feed had been constant for nine days preceding the digestion experiment, while for Lambs 67 and 151, it had been raised from 2.0 to 2.4 pounds daily on the second day preceding the collection period. The latter two lambs should not have been put on a digestion experiment so soon after a change of feed, but nevertheless the results obtained in these cases agreed well with the results obtained upon the other lambs. Except on the final day of collection with Lamb 67, there was no refused feed in these digestion experiments.

The chemical composition of samples of feed taken during the digestion and metabolism trials is given in Table 23. The alfalfa hay fed in these trials was somewhat drier than that fed at the barn (see Table 11) and somewhat higher in protein, but the corn fed was very similar in composition to the composite samples taken at the barns.

In Table 24 the coefficients of digestibility of the nutrients in the ration, as computed in the ordinary way, have been summarized. A comparison of the average coefficients obtained with these fattening lambs and those obtained with the maintenance group consuming the

TABLE 23.—CHEMICAL COMPOSITION OF FEED CONSUMED BY THE FATTENING LAMBS DURING DIGESTION AND METABOLISM TRIALS

Lamb No.	Dry substance	Crude protein	N-free extract	Crude fiber	Ether extract	Ash	Calcium	Gross energy per gram
				Alfalfa hay				
	perct.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*sm. cals.*
69, 169	92.67	18.25	41.97	22.03	2.34	8.08	....	4172
67, 151	93.54	17.38	39.67	25.11	2.17	9.21	1.44	4215
33	93.51	17.06	43.61	22.98	2.37	7.49	1.52	4158
				Corn				
69, 169	88.93	8.56	73.55	2.19	3.37	1.26	....	3984
67, 151	87.54	8.73	71.86	2.50	3.18	1.27	....	3935
33	87.56	8.56	72.09	2.23	3.54	1.14	....	3918

TABLE 24.—DIGESTION COEFFICIENTS OBTAINED WITH THE FATTENING LAMBS

Lamb No.	Dry substance	Crude protein	N-free extract	Crude fiber	Ether extract
	perct.	*perct.*	*perct.*	*perct.*	*perct.*
69	77	73	89	36	66
169	75	71	88	28	65
67	76	70	89	35	62
151	76	72	89	36	62
33	75	68	87	42	60
Average	75.8	70.8	88.4	35.4	63.0

same ration at a different level may be made by turning to Table 12. In general a higher digestibility was obtained with the fattening lambs.

The determination of the gross energy of feed and excreta in these digestion experiments permits the calculation of the metabolizable energy content of the ration, the methane excretion being estimated, according to Armsby's method for steers, from the digestible carbohydrates consumed. These calculations will be found in Table 25. For the fattening lambs the ration contained 2.794 therms per kilogram of dry matter, as compared with an average of 2.653 therms obtained with the maintenance lambs (Table 13). For the fattening lambs the gross energy of the ration was 62.27 percent metabolizable on the average, as compared with 59.74 percent, for the maintenance lambs.

The fattening lambs were all storing nitrogen during the collection periods according to the data assembled in Table 26.

Composition of the Fat Lambs

At the end of feeding periods varying in length from 73 days to 141 days, the nine fattened lambs were slaughtered at weights of approximately 90 pounds. The method of sampling was essentially the same as that followed with the maintenance lambs. For each lamb there were three samples consisting of edible flesh, bone, and offal, and for all lambs slaughtered on the same day a composite sample of wool was taken. Slight irregularities in the disposition of the bones of the head and feet, as between the bone and the offal samples, resulted thru inadvertance, but these did not affect the accuracy of the final computations. These irregularities are all noted in the tables. The slaughter data for these lambs, the weights of samples, the results of the analysis of the samples, and the estimated composition of the total animals on the live-weight and empty-weight basis are given in Tables 27 to 30. The latter computations, as for all preceding groups of lambs, include all possible corrections for losses of moisture during slaughtering and sampling.

The fat lambs contained an average "fill" of 11.1 percent, as compared with averages of 15.9 for the check lambs and 10.8 for the maintenance lambs. On the basis of the empty weight the fat lambs contained an average of 24.89 percent of fat, the maintenance lambs 21.57 percent, and the check lambs 14.15 percent. The average ash percentages for the three groups of lambs on the same basis were 4.17, 4.09, and 4.79 respectively. The percentage of calcium in the ash of the empty carcass averaged 22.3 for the fat lambs, 24.4 for the maintenance lambs, and 28.5 for the check lambs. The first group of check lambs also showed a high average for this value, i.e., 27.4 percent. In the case of rats, Buckner and Peter[1] obtained fairly constant percent-

[1]Buckner, G. D., and Peter, A. M. Jour. Biol. Chem. 54, 5. 1922.

TABLE 25.—LOSSES OF ENERGY AND THEIR PERCENTAGE DISTRIBUTION, AND CALCULATION OF METABOLIZABLE ENERGY FOR THE FATTENING LAMBS

Lamb No.	Dry matter eaten per day and head		Energy per kilogram of dry matter					Percentage losses			Metabolizable		Percentage metabolizable
			Total	Losses			Metabolizable				Per kg. digestible organic matter	Per kg. total digestible nutrients	
	Coarse feed	Concentrates		In feces	In urine[1]	In methane[2]		In feces	In urine	In methane			
	kgs.	*kgs.*	*therms*	*therms*	*therms*	*therms*	*therms*	*perct.*	*perct.*	*perct.*	*therms*	*therms*	*perct.*
69....	.421	.404	4.488	.998	.205	.370	2.915	22.24	4.57	8.24	3.914	3.782	64.95
169....	.421	.404	4.488	1.159	.201	.360	2.768	25.82	4.48	8.02	3.825	3.694	61.68
67....	.509	.476	4.502	1.131	.189	.361	2.821	25.12	4.20	8.02	3.910	3.790	62.66
151....	.509	.476	4.502	1.105	.204	.363	2.830	24.54	4.53	8.06	3.881	3.763	62.87
33....	.425	.398	4.456	1.231	.220	.368	2.637	27.63	4.94	8.26	3.618	3.500	59.17
Average	.457	.432	4.487	1.125	.204	.364	2.794	25.07	4.54	8.12	3.830	3.706	62.27

[1]Corrected to nitrogen equilibrium. [2]Estimated at 4.5 grams per 100 grams of digestible carbohydrates consumed.

TABLE 26.—DAILY NITROGEN BALANCES OF THE FATTENING LAMBS DURING METABOLISM TRIALS

Lamb No.	Nitrogen of feed consumed	Nitrogen of feces	Nitrogen of urine	Total N excreted	Nitrogen balance
	grams	*grams*	*grams*	*grams*	*grams*
69	19.49	5.20	10.15	15.35	+4.14
169	19.49	5.70	10.39	16.09	+3.40
67	22.72	6.90	11.17	18.07	+4.65
151	22.72	6.26	12.53	18.79	+3.93
33	18.62	5.89	9.72	15.61	+3.01

TABLE 27.—SLAUGHTER DATA FOR THE FATTENED LAMBS
(All weights in pounds)

Lamb No.	67	69	151	169	54	33	90	143	49	Aver.
Live weight	87.4	88.7	85.5	87.8	87.8	84.9	88.8	85.4	84.1	86.7
Wool	5.13	5.94	4.74	6.26	4.84	4.39	4.76	5.35	5.60	5.22
Blood	3.56	3.50	3.80	7.67	3.72	2.94	3.56	3.20	3.05	3.89
Skin and feet	7.44	7.00	8.55	6.35	9.19	7.56	8.13	6.65	7.00	7.54
Caul fat	1.75	2.69	1.85	2.34	1.39	1.65	2.18	2.20	2.90	2.11
Gut fat	.81	.81	.80	.95	.70	1.00	1.02	1.65	1.45	1.02
Contents of first three stomachs	8.44	8.81	6.25	4.86	7.94	7.58	5.94	4.55	6.80	6.80
Contents of 4th stomach and intestines	2.56	3.00	2.85	3.01	3.41	2.85	3.25	2.80	2.10	2.87
Contents of entire alimentary tract	11.00	11.81	9.10	7.87	11.35	10.43	9.19	7.35	8.90	9.67
Warm dressed carcass	46.38	44.94	44.75	45.75	43.75	43.50	46.50	47.00	46.00	45.40
Cold dressed carcass	45.90	44.35	43.33	44.20	42.26	41.85	44.88	45.93	45.07	44.20
Percent shrinkage	1.03	1.31	3.17	3.39	3.41	3.79	3.48	2.28	2.02	2.65
Percent "fill"	12.6	13.3	10.6	9.0	12.9	12.3	10.4	8.6	10.6	11.1
Dressing percentage	52.5	50.0	50.7	50.4	48.1	49.3	50.6	53.8	53.6	51.0

TABLE 28.—WEIGHTS OF SAMPLES ANALYZED FROM THE FATTENED LAMBS

Lamb No.	Empty weight	Edible flesh			Bone	Offal	Wool
		Lean	Fat	Total			
	kgs.	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
67	34.65	12 108	5 640	17 748	2 703[1]	10 989	2 327
69	34.87	12 021	4 974	16 995	2 753[1]	10 747	2 694
151	34.65	11 726	4 215	15 941	4 008[2]	10 657	2 150
169	36.24	10 738	5 682	16 420	3 888[2]	11 101	2 839
54	34.70	12 025	3 452	15 477	4 007[2]	10 978	2 195
33	33.77	11 433	3 737	15 170	4 070[2]	10 635	1 991
90	36.09	11 918	4 452	16 370	4 014[2]	10 890	2 159
143	35.43	12 368	5 175	17 543	4 514	9 420	2 427
49	34.11	10 584	5 885	16 469	3 825	9 910	2 540
Average	34.95	11 658	4 801	16 459	.....	.....	2 369

[1]Exclusive of bones of head and of feet, which were put in the offal sample. [2]Not including bones of feet, which were put in offal sample.

ages of 25 to 26 thruout the growing period. The bone samples of both the fat lambs and the maintenance lambs contained normal average percentages of calcium in the ash (37.6 and 37.5 respectively). The low ash content of the bone samples as compared with that of well-calcified bone itself is to be expected in view of the imperfect separation of bone from soft tissues in the preparation of these samples.

TABLE 29.—PERCENTAGE COMPOSITION AND ENERGY VALUE OF SAMPLES ANALYZED FROM THE FATTENED LAMBS

Lamb No.	Dry substance	Crude protein	Ether extract	Ash	Calcium	Calcium in percent of total ash	Gross energy per gram
			Edible flesh samples				
							sm. cals.
67	51.69	13.56	36.86	1.31	.020	1.53	4 196
69	51.66	13.19	35.84	1.18	.021	1.78	4 061
151	53.61	14.00	37.60	1.03	.018	1.75	4 292
169	52.14	14.56	34.23	.98	.017	1.73	4 000
54	54.19	15.56	28.60	1.07	.027	2.52	3 421
33	53.38	15.63	28.11	1.41	.021	1.49	3 422
90	51.39	14.31	32.94	1.03	.020	1.94	3 794
143	48.88	15.13	33.54	.83	.021	2.53	3 968
49	58.59	14.13	39.64	.73	.025	3.42	4 398
Average	52.84	14.45	34.15	1.06	.021	2.08	3 950
			Bone samples[1]				
67	70.42	19.81	22.59	24.75	9.34	37.7	3 349
69	69.66	18.86	21.79	24.26	9.22	38.0	3 391
151	57.67	17.69	18.95	19.35	7.25	37.5	2 854
169	60.79	18.52	18.87	20.32	7.75	38.1	2 904
54	58.19	18.30	16.56	21.02	7.88	37.5	2 643
33	58.09	16.51	19.00	19.35	7.24	37.4	2 830
90	59.32	18.30	17 93	20.80	7.76	37.3	2 796
143	60.69	20.41	16.23	21.79	8.20	37.6	2 742
49	60.42	21.27	16.25	21.81	8.17	37.5	2 720
Average	61.69	18.85	18.69	21.49	8.09	37.6	2 914
			Offal samples[2]				
67	39.35	14.50	20.05	2.24	.519	23.2	2 759
69	38.06	14.56	17.13	2.39	.559	23.4	2 527
151	36.99	14.69	19.87	1.16	.061	5.26	2 576
169	37.94	14.13	21.98	1.14	.061	5.35	2 669
54	34.48	15.75	17.00	1.28	.076	5.94	2 327
33	35.99	15.50	19.08	1.31	.102	7.79	2 563
90	38.46	14.69	20.63	1.14	.090	7.89	2 658
143	41.27	14.94	23.64	.92	.021	2.28	3 027
49	42.99	14.69	24.83	.95	.023	2.42	3 166
Average	.....	.....	.....	....	....	....	.....
			Wool samples				
67, 69	89.35	60.75	9.05	11.34	.20[3]	....	4 344
151, 169, 54, 33, 90	89.73	60.88	8.83	15.54	.20[3]	....	4 366
143, 49	89.62	60.84	8.89	14.34	.20[3]	....	4 374

[1]The samples for Lambs 67 and 69 contained only the bones from the dressed carcass; those for Lambs 151, 169, 54, 33, and 90 contained in addition the bones of the head; while those for Lambs 143 and 49 contained the bones of head and feet. [2]The samples for Nos. 67 and 69 contained the bones from the head and feet; those for Nos. 151, 169, 54, 33, and 90 contained the bones of the feet; while those for Nos. 143 and 49 contained only the viscera and other waste. [3]The average calcium content of a composite sample of wool from all fat sheep.

In Table 30, the nine fat lambs are arranged in the order of their slaughter. No progressive differences in composition are evident, so that the data obtained do not indicate that the rapid gains are appreciably different in composition from the slow gains.

Composition of the Gains in Weight

On the assumption that the fat lambs at their initial weights possessed the same composition on the live-weight basis as the second

TABLE 30.—PERCENTAGE COMPOSITION AND GROSS ENERGY CONTENT OF THE FATTENED LAMBS[1]

Lamb No.	Dry substance	Crude protein	Ether extract	Ash	Calcium	Calcium in percent of total ash	Gross energy per gram
			On basis of live weight				
							sm. cals.
67	44.10	15.01	24.14	3.56	.80	....	2 492
69	42.74	14.82	21.82	3.56	.80	....	2 914
151	43.14	15.00	23.37	3.61	.78	....	3 010
169	44.43	16.10	22.47	3.82	.79	....	2 988
54	41.34	15.58	17.96	3.74	.84	....	2 476
33	41.76	15.33	18.82	3.77	.81	....	2 582
90	42.02	14.89	21.24	3.61	.82	....	2 775
143	44.84	16.65	23.37	4.03	.98	....	3 125
49	48.49	16.10	25.78	3.70	.85	....	3 285
Average	43.65	15.50	22.10	3.71	.83	....	2 849
			On basis of empty weight				
67	50.45	17.17	27.61	4.07	.92	22.6	2 851
69	49.31	17.10	25.17	4.10	.93	22.7	3 361
151	48.28	16.78	26.15	4.04	.87	21.6	3 368
169	48.80	17.68	24.96	4.19	.87	20.7	3 284
54	47.48	17.88	20.61	4.29	.96	21.9	2 844
33	47.61	17.48	21.45	4.29	.93	21.7	2 943
90	46.88	16.60	23.69	4.03	.91	22.2	3 095
143	49.06	18.23	25.57	4.41	1.07	24.3	3 419
49	54.22	18.01	28.84	4.14	.95	22.9	3 674
Average	49.12	17.43	24.89	4.17	.94	22.3	3 205

[1]Nos. 67 and 69 were killed after 82 days of feeding; 151, 169, 54, 33, and 90 after 97 days; 143 after 131 days; and 49 after 141 days of feeding.

group of check lambs (Table 9), it is possible to compute the composition of the gains put on during the fattening period. The results of such a calculation, expressed as percentages of the estimated increase in empty weight, are given in Table 31. The great variation among the individual estimates is due not only to the differences in the actual composition of gains but also to the not inconsiderable error in the method of estimation, according to which all of the lambs are assumed to possess the same initial composition.

The average gain in empty weight from about 65 to about 90 pounds contained 75.1 percent of dry matter, 11.9 percent of crude

TABLE 31.—ESTIMATED PERCENTAGE COMPOSITION AND ENERGY VALUE OF GAINS IN EMPTY WEIGHT PUT ON BY THE FATTENED LAMBS

Lamb No.	Dry substanee	Crude protein	Ether extract	Ash	Gross energy per pound
					therms
67	79.8	10.9	63.4	2.1	3.11
69	81.8	9.2	61.2	1.8	3.03
151	73.3	9.1	59.9	2.0	2.83
169	73.7	12.9	53.7	2.6	2.62
54	68.8	13.5	37.6	3.0	1.89
33	70.3	11.8	41.5	2.9	2.08
90	63.3	10.2	44.6	2.3	2.15
143	71.5	15.3	52.2	3.6	2.68
49	93.3	14.0	67.8	2.5	3.27
Average	75.1	11.9	53.6	2.5	2.63

protein, 53.6 percent of fat, and 2.5 percent of ash. The computations for calcium indicated no increase in the store of this mineral. The nine lambs contained an average of 327 grams of calcium at slaughter and were estimated to have contained an average of 344 grams initially. It seems improbable that no calcium was stored during the fattening period. A slight storage, however, may have been obscured by the possible error in the estimation of the initial calcium composition of the lambs.

Each pound of gain in empty weight contained on the average 2.63 therms of gross energy. This value is less than the average value of 3.25 therms given by Armsby to the energy content of a pound of gain by fattening animals, but is almost identical with the value reported by Wood[1] for two sheep gaining from an average of 87 to one of 124 pounds in body weight, i.e., 2.64 therms. In Bulletin 283 from this Station the average energy value of a pound of gain in empty weight from 87 to 117 pounds was found to equal 2.58 therms. Apparently the weight increase of sheep is remarkably constant in energy content, largely because it is fairly constant in fat content. In this experiment the average fat content was 53.6 percent; in the preceding experiment at this Station it was found to be 47.7 percent, and in the experiment of Wood it averaged 50.7 percent (on the increase in live weight). The crude protein percentages were not so constant, averaging 11.9, 13.2, and 17.6 respectively for the three experiments.

Distribution of Added Nutrients in the Carcasses

It is of interest to compute the distribution of the added nutrients among the dressed carcass, the offal, and the wool. Such calculations are complicated somewhat by the different methods of making up the samples for the check and fat lambs, but satisfactory results may be obtained on the assumption that the head and feet bones possessed the same chemical composition as the bones of the dressed carcass.

TABLE 32.—PERCENTAGE DISTRIBUTION OF GAINS IN CHEMICAL CONSTITUENTS OF THE FAT LAMBS AMONG DRESSED CARCASS, WOOL, AND OFFAL

	Dry substance	Crude protein	Fat	Ash	Gross energy
Dressed carcass	66.7	54.8	71.4	15.3	69.6
Wool	8.8	26.3	2.1	64.9	5.2
Offal	24.5	18.9	26.5	19.8	25.2
Total	100.0	100.0	100.0	100.0	100.0

The weights of head and feet bones were obtained for the fat lambs, so that the composition of the dressed carcass can be approximated. The results obtained on this question are assembled in Table 32.

[1]Wood, T. B. Jour. Min. Agr. [Gr. Brit.] 34, 295. July, 1927.

With the exception of the added mineral matter the dressed carcass received most of the nutrient material added to the bodies of the lambs during their fattening period. An average of 66.7 percent of the added dry matter, 54.8 percent of the added protein, 71.4 percent of the added fat, 15.3 percent of the added mineral matter, and 69.6 percent of the added gross energy were found in the dressed carcasses of these lambs. The added wool contained about two-thirds of the added mineral matter and about one-fourth of the added protein but very little of the added energy. The mineral matter found in the wool contained only a trace of calcium and probably consisted of dirt to a large extent. The failure of these lambs to increase in calcium content altho increasing in mineral content is thus partially explained.

The main difference in the disposition of added nutrients in the carcass between these young lambs and the more mature sheep of the preceding experiment[1] relates to the protein. In the former experiment 60 percent of the added protein was found in the wool, the growth of the carcass being largely completed. In the present experiment less than 20 percent of the added protein was found in the wool, the dressed carcass alone containing about 55 percent and the offal parts over 25 percent.

With the more mature sheep, wool growth accounted for greater percentages of all added nutrients than with the growing lamb. It was also formed at a much more rapid rate, being equivalent to a daily growth of .149 pound of protein and 566 calories of gross energy per day per 1,000 pounds live weight. In the experiment on growing lambs the daily growth of wool contained an average of only .086 pound of protein and 377 calories per 1,000 pounds live weight.

Utilization of Feed Energy in Fattening

The relation between the feed energy consumed by the fattening lambs and their average daily retention of energy is of interest in throwing light upon the efficiency of utilization of energy by sheep. The calculations given in Table 33 are concerned with this relation. The average energy content of the lambs at slaughter was 114.8 therms. Their initial content, as computed from the initial weights and the average energy content of the second group of check lambs per unit of live weight, averaged 59.4 therms. The gain in energy therefore averaged 55.4 therms, or 568 calories, daily. The average daily intake of metabolizable energy was 2,427 calories, of which 1,254 calories were estimated to have been used for maintenance. This estimate is based upon the average weight of the lambs during the feeding period and the average metabolizable energy requirements for maintenance as previously determined, i.e., 1,637 calories per 100 pounds live weight,

[1]Ill. Agr. Exp. Sta. Bul. 283, 243, Table 25.

TABLE 33.—CALCULATION OF NET AVAILABILITY OF METABOLIZABLE ENERGY CONSUMED ABOVE ESTIMATED MAINTENANCE REQUIREMENTS BY THE FATTENED LAMBS

Lamb No.	67	69	151	169	54	33	90	143	49	Average
Final energy content, therms	123.9	117.2	116.7	119.0	98.7	99.4	111.7	121.1	125.3	114.8
Estimated initial energy content, therms	59.0	62.6	59.9	61.7	59.0	58.1	58.1	58.1	58.1	59.4
Gain in energy, therms	64.9	54.6	56.8	57.3	39.6	41.2	53.6	63.0	67.2	55.4
Average daily storage of energy, calories	792	666	586	591	408	564	553	481	476	568
Intake of metabolizable energy daily, calories	2450	2467	2393	2516	2400	2614	2470	2251	2283	2427
Estimated maintenance requirements of metabolizable energy, calories	1267	1272	1269	1275	1259	1239	1257	1236	1210	1254
Metabolizable energy available for production, calories	1183	1195	1124	1241	1141	1375	1213	1015	1073	1173
Percentage availability of metabolizable energy	67.0	55.7	52.1	47.6	35.8	41.0	45.6	47.4	44.4	48.5

the direct ratio of weights being used. Hence, according to these figures 1,173 calories of metabolizable energy may be considered as available for production. The production secured averaged 568 calories daily, or an average of 48.5 percent of the metabolizable energy available.

As previously mentioned (page 45), experimental work with steers indicates a percentage availability of metabolizable energy of 53 to 55 for a ration of equal parts of corn and alfalfa hay. The results of this experiment point, therefore, to a somewhat less efficiency on the part of the sheep as compared with the steer in the utilization of metabolizable energy. For alfalfa hay alone results have been reported previously for sheep (Bulletin 283) that are equal to several reported by Armsby for steers but inferior to some of the later results.

SUMMARY

The digestibility of a ration consisting of equal parts by weight of alfalfa hay and shelled corn was investigated at two levels of feeding, one representing but little more than a maintenance ration (eight lambs) and the other representing full feed (five lambs). The coefficients of digestibility at the higher level were generally greater than those at the lower, altho the differences were not large. At the higher level 62.3 percent of the gross energy of the ration was found to be metabolizable, while at the lower only 59.7 percent was metabolizable. The metabolizable energy of the ration per kilogram of dry matter was 2.794 therms at the higher level, and 2.653 therms at the lower. For steers the gross energy in a ration of equal parts of corn and alfalfa hay has been found to be 60 to 61 percent metabolizable.

In feeding tests upon eight lambs averaging 69 pounds in weight, the maintenance requirements in terms of pounds of feed and of metabolizable energy per 100 pounds of weight have been determined for a ration containing equal parts of alfalfa hay and corn. The data of feed consumption, feed analyses, and digestion and metabolism trials have been supplemented by carcass analyses of check lambs and of the maintenance lambs at the end of their feeding period, in order to correct for a storage of energy in the body. It was found that 1.53 pounds of feed and 1,637 calories of metabolizable energy were required per 100 pounds weight for the maintenance of energy equilibrium. These values may be compared with those determined in a previous experiment for a ration of alfalfa hay alone, i.e., 2.29 pounds and 1,820 calories of metabolizable energy.

Nine lambs were used in a fattening experiment to determine the efficiency in the use of metabolizable energy for production. These lambs were fattened from about 65 pounds in weight to about 90

pounds, at which weight they were slaughtered and analyzed. Digestion and metabolism experiments were run upon five of these lambs.

Altho the daily rate of gain varied from .18 to .36 pound, no relation could be detected between the rate of gain and the composition of the carcass. On the average the fat content of the empty carcass increased from 14.15 percent, as determined by the analysis of eight check lambs at approximately the initial weight, to 24.89 percent.

The average gain in empty weight was calculated to possess the following composition: 75.1 percent of dry matter, 11.9 percent of protein, 53.6 percent of fat, and 2.5 percent of ash. Its gross energy value was 2.63 therms per pound.

Altho the ash content of the lambs increased during fattening, no increase in the calcium content could be demonstrated. A small increase might well have been obscured by the possible error in the slaughter experiment. The absence of any indication of a large increase in calcium was due to two factors. In the first place, 65 percent of the increase in ash occurred in the wool, and largely represented outside contamination. Again, the percentage of calcium in the ash of the entire carcass decreased from 27.4 to 28.5 in the check lambs to 22.3 in the fattened lambs, the maintenance lambs showing an average of 24.4.

The gains in nutrients by the fat lambs were largely added to the dressed carcass. Thus 66.7 percent of the dry matter of the gains, 54.8 percent of the protein, 71.4 percent of the fat, and 69.6 percent of the gross energy gained were deposited in the dressed carcass. The wool growth accounted for 8.8 percent of the dry matter gained, 26.3 percent of the protein, 2.1 percent of the fat, and 5.2 percent of the energy.

The daily wool growth of these young lambs contained per 1,000 pounds live weight .086 pound of protein and 377 calories. These values are only about 60 percent as large as those obtained with larger and older sheep in a previous experiment.

The daily gain of energy by the fattening lambs averaged 568 calories. The average intake of metabolizable energy was 2,427 calories daily, of which 1,254 calories were estimated to have been required for maintenance. The difference, 1,173 calories, may therefore be compared with the energy storage to determine the efficiency of utilization of the metabolizable energy consumed in excess of the maintenance requirements. The daily storage of 568 calories is 48.5 percent of the metabolizable energy apparently available for this purpose. We may say, therefore, that between a maintenance level of feeding and the full-feed level attained by the fattening lambs, the metabolizable energy of the ration of alfalfa hay and corn was 48.5 percent net available. For steers a utilization of 53 to 55 percent would be expected for this ration.