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1. The Calculated and Determined Nutrients of Rations.
2. The Digestibility and Value of Emmer.
3. The Heat Producing Value of the Crude Fat of Fodders and Grains.

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THE CALCULATED AND DETERMINED NUTRIENTS OF RATIONS.

J. A. Hummel.

In the computation of a balanced ration, for the feeding of live-stock, the average composition and digestibility of the foods as given in the standard works on feeding are used for calculating the digestible nutrients of the ration. A large number of digestion experiments have been made to determine the digestibility of the various nutrients of our common farm grains and forage crops. It is known that there are a number of factors which influence digestibility, as mechanical composition, combination with other foods, and individualty of the animal. There are also a number of factors which influence the composition of foods, as soils, climatic condition, care of the forage or crop, and stage of maturity when cut. To what extent do these factors influence the amount of digestible nutrients in an average ration composed of a number of food materials? And to what extent do the nutrients of a ration determined by calculation in the usual way, compare with the actual digestible nutrients as determined by digestion experiments? It was the object of this investigation to obtain data upon these questions. If there is no general agreement between the actual and the calculated nutrients of rations, then the subject of the rational feeding of farm animals is not well founded, while, if there is a reasonable and a general agreement between the two, then the tables of digestible nutrients of foods as given in standard works on live stock feeding can be accepted as reasonably correct. The main problem of live stock feeding is then.—How much of the various nutrients is it desirable to feed for specific purposes? Fortunately for this investigation, the Division of Animal Husbandry had another, but related problem to investigate, which enabled this work to be conducted on a cooperative basis.

The Division of Animal Husbandry had for one of its objects the determination of the amounts of nutrients required to produce definite gains in weight, while the Division of Agricultural Chemistry had for its object, a comparison of the actual and calculated nutrients of the ration. The influence of the rations upon the gains in live weight will be discussed in a future bulletin by the Division of Animal Husbandry. The Division of Animal Husbandry attended to the feeding and care of the animals, collection and weighing of the excrements, while the Division of Agricultural Chemistry sampled and analysed all of the food materials, feces and urine. The digestion trials extended over a period of four days, beginning with March 6th, 1903. Six steers were used in the experiment. The ration consisted of bran, oats, cornmeal, oil cake, timothy hay and corn fodder. For several weeks prior to the digestion trials, the steers had been fed on this ration. A marker, consisting of a small weighed amount of whole corn was given each animal one-half hour before the first regular feed at the beginning of the experiment, to determine the time at which the collection of the feces should begin. At the close of the experiment, a similar marker was used. It was found that the corn given in this way proved a very satisfactory marker.

The foods consumed during the digestion trials were carefully weighed and analysed. Samples of the hay and concentrates were drawn at each feeding. In the case of the hay and corn fodder two sets of samples were taken. One was kept in an ordinary burlap bag during the experimental period, the other in a tightly covered can. The results of the dry matter determination of these two sets of composite samples are given in the following table:

Table No. LIV. Dry Matter Content of Hay and Corn Fodder.

Hay kept in Bag.		Hay kept in Can.	
1	82.14	1	83.13
2	83.52	2	83.97
3	81.86	3	81.53
4	81.74	4	83.10
5	81.24	5	81.40
6	81.45	6	80.87
Average	81.99	Average	82.33

There was considerable difference in the individual samples but the averages show very little difference in the dry matter content of the samples kept in the two ways.

The daily ration consisted of 14 lbs., of ground feed made up of four parts by weight of corn-meal, three parts of bran, two parts of oats, and one part of oil cake, ten pounds of timothy hay, and as much corn fodder as the animals would eat; this was usually about five pounds, and was always weighed. The corn fodder was not of the best quality, which accounts for the small amount eaten. The composition of the ground feed of the separate grains and milled products of the ground feed, of the timothy hay, and of the corn fodder, are given in the following table:

Table No. LV. Composition of Foods Consumed.

	Perct. Water	Perct. Protein	Perct. Fat	Perct. Ash	Perct. Fiber	Perct. Nitrogen Free Ex.
Ground Feed	8.99	13.81	4.71	3.73	11.17	57.59
Bran	10.42	13.80	5.45	4.49	18.87	46.97
Oats	7.47	8.47	4.98	3.63	21.78	53.67
Corn Meal	8.25	9.79	5.04	1.66	6.71	68.55
Oil Cake	8.24	32.41	8.31	4.51	13.66	32.87
Timothy Hay*		**7.47**	**2.09**	**5.17**	**40.62**	**44.65**
Corn Fodder		11.56	2.08	8.11	39.60	38.65

*Results on dry matter basis.

It was found that the composition of the ground feed agreed so closely with the computed composition, using the analysis of the separate grains and mill products, that the grain mixture or concentrates could be considered as one food material in making the calculations and computations.

EXPLANATION OF TERMS USED.

A brief explanation of the terms used in the discussion of the results of this work is given.

The term nutrient means any compound which can be digested and used for food purposes. Crude protein, fat, crude fiber, ash and nitrogen free extract, are the compounds ordinarily included in the term, nutrients.

Crude protein is a name given to a class of compounds which contain nitrogen as the characteristic element. Albumin, casein and fibrin, are examples of protein compounds. They are complex nitrogenous compounds. Crude protein is not the same in all foods, being more valuable in some than in others. In cereals for example, it is nearly all protein, while in roots and tubers it contains other nitrogenous substances besides protein, hence ,in comparing two or more foods, the same value cannot be assigned to the crude protein unless the foods are of the same general character. The function of protein in the food is to build up the muscular tissues, skin, hair, horn, hoof, connective tissue, and the tissues of the secretive and excretive organs of the animal body. It is also an important constituent of blood and milk. The protein found in the several organs of the animal body is derived from the protein of the food and is not built up from other nutrients. Besides the uses of protein as given above, it may, if present in sufficient amounts, serve also as fuel to keep the body warm. The protein or nitrogenous part of a food is a valuabe nutrient to the body. It is the most expensive nutriment when purchosed ,and the one most often lacking in foods and rations. Food stuffs as clover and alfalfa, oil cake and cottonseed cake, and wheat and bran, are rich in protein, while such food stuffs as straw, timothy, hay, corn stover, roots and tubers, are comparatively poor in protein.

The fat is made up of carbon, oxygen and hydrogen. It is used in the body to produce fat, and by its oxidation it supplies heat and energy to the body.

Nitrogen-free-extract is a name given to a class of compounds sometimes called carbohydrates. The nitrogen free extract compounds are composed of the elements: carbon, hydrogen and oxygen, and differ from the crude proteins by containing no nitrogen. The nitrogen-free-extract includes the sugars, starch, and other carbohydrate like bodies which serve as fuel, and when properly combined with the proteids produce fat.

The crude fiber is the cellulose or frame work of the plant. In most cases it is rather undigestible, although its value depends upon its physical condition, the crude fiber in a mature and dry plant being much more undigestible than the crude fiber in a young plant fed in a green condition. The digestible part of crude fiber serves the same nutritive function as nitrogen-free-extract.

The ash or mineral matter is the part of the food that cannot be burned. A portion is used to build up bone especially, and is also found in small amounts in the muscular tissues.

The dry matter of the solid excrements (feces) is for all practical purposes the undigested part of the food. It is that part of the food which passes entirely through the digestive tract of the body, subjected in this passage to the action of all the digestive juices secreted, and not being dissolved by these juices, it is useless to the body ,and is finally thrown out. With this undigested matter there is always more or less material which does not come directly from the food eaten, such as material from the bile and other digestive juices, but with normal rations this material is a small part of the solid excrement and so is usually disregarded. The several compounds such as protein, fat, etc., that make up a food material, are not all equally digestible, the sugar and fat being usually more completely digested than the portein and crude fiber.

The heat of combustion or caloric value of the foods was determined by means of an Atwater-Blakeslee bomb calorimeter, a description of which is given in a former bulletin of this station, No. 74. A Calorie is the unit of measurement of heat yielded by a substance when it burns, and is the heat required to raise the temperature of one pound of water 4 degrees Fahrenheit. This heat represented by a Calorie in the form of energy is equivalent to the work of lifting one ton 1.53 ft. When a given weight of food is oxidized or burned in the animal body it gives off almost as much heat as when burned in a calorimeter. When the carbohydrates are completely digested they leave no indigestible residue, but the proteids are not so completely digested,—they leave a residue (urea), which contains nitrogen, carbon and other elements. The difference between the total calories of the food and solid excrements or feces, does not represent the total amount of heat or energy which the animal has obtained from the food, because as stated, the oxidation of the protein in the body is not complete, and therefore does not yield as much heat as it does when burned in the calorimeter. In the body the protein is not completely burned, urea and compounds of a similar nature being found, which contained unburned carbon, while in the calorimeter the oxidation is complete. Hence it is necessary to deduct this energy which is not available to the body.

In the calculation of the results, the total weight of dry feces for the four days experimental period is multiplied by the percentage amounts of the various nutrients, as determined by analysis, and the products thus obtained are the amounts of the several nutrients which were excreted by the animal, and represent the undigested nutrient of the foods consumed. The amount of solid excrement voided by each steer and the composition of the dry matter are given in the following table:

Table No. LVI. Pounds of Solid Excrement, and Composition of Composite Samples of Feces.

	Lbs. of Solid Excrement	Dry Matter Perct	Perct Protein	Perct Fat	Perct Fiber	Perct NFE	Perct Ash	Cals Per Gm.
Steer 1	194.3	15.51	14.27	2.59	42.35	29.73	11.06	4,530
Steer 2	207.4	16.51	13.47	3.02	36.57	34.84	12.10	4,395
Steer 3	165.0	16.85	14.63	3.53	32.04	37.63	12.17	4,581
Steer 4	212.1	15.94	12.69	2.89	28.28	44.53	11.61	4,646
Steer 5	184.8	15.65	13.41	2.97	41.27	32.05	10.30	4,694
Steer 6	199.1	16.08	12.67	2.58	35.69	38.71	10.35	4,635

The nutrients consumed by the animals during the experimental period, and the amounts of indigestible matter in the feces, and also the percent of nutrients digested, are given in the following tables:

Table No. LVII. Results of Digestion Experiment No. 1.

	Dry Matter Pounds	Protein	Fat	Fiber	Carbohydrates	Ash	Cals.
Steer 1.							
In ground Feed	51.00	7.73	2.64	6.25	32.25	2.09	107,580
In Hay	33.05	2.30	.68	13.55	14.06	1.67	662,520
In Corn Fodder	9.39	1.11	.19	3.58	3.75	.76	18,322
Total in Food	93.44	11.14	3.51	23.38	50.06	4.52	188,422
In feces	30.10	4.30	.78	12.72	8.97	3.41	61,850
Digested	63.34	6.84	2.73	10.66	41.09	1.11	126,572
Perct. digested	67.81	61.40	77.78	45.60	82.08	....	67,17
Available calories						65.12	per cent.

Table No. LVIII. Results of Digestion Experiment No. 2.

	Dry Matter Pounds	Protein	Fat	Fiber	Carbohydrates	Ash	Cals.
Steer 2.							
In Ground Feed	51.00	7.78	2.64	6.25	32.25	2.09	107,580
In Timothy Hay	33.50	2.50	.62	13.58	15.11	1.71	63,370
In Corn Fodder	10.38	1.20	.21	4.06	4.07	.83	20,254
Total in Food	94.88	11.43	3.47	23.89	51.43	4.63	191,204
In feces	34.55	4.65	1.04	12.64	12.04	4.18	68,870
Digested	60.33	6.78	2.43	11.25	39.39	.45	122,334
Percent Digested	63.59	59.32	70.03	47.09	76.59	....	63,98
Available calories						61.97	per cent.

Table No. LIX. Results of Digestion Experiment No. 3.

	Dry Matter Pounds	Protein	Fat	Fiber	Carbo-hydrates	Ash	Cals.
Steer 3.							
In Ground Feed	51.00	7.73	2.64	6.25	32.25	2.09	107,580
In Hay	32.68	2.40	.77	12.90	14.79	1.80	61,820
In Corn Feed	8.32	.97	.20	3.19	3.28	.68	16,234
Total in Food	92.00	11.10	3.61	22.34	50.32	4.57	185,634
In feces	27.80	4.07	.98	8.91	10.46	3.38	57,770
Digested	64.20	7.03	2.63	13.43	39.86	1.19	127,864
Percent Digested	69.78	63.33	72.85	60.12	79.21	....	68.88
Available calories						66.73 per cent.	

Table No. LX. Results of Digestion Experiment No. 4.

	Dry Matter Pounds	Protein	Fat	Fiber	Carbo-hydrates	Ash	Cals.
Steer 4.							
In Ground Feed	51.00	7.73	2.64	6.25	32.25	2.09	107,580
In Timothy Hay	32.97	2.63	.77	13.61	14.34	1.71	62,370
In Corn Fodder	13.91	1.53	.28	5.81	5.18	1.10	27,142
Total in Food	97.88	11.79	3.69	25.67	51.77	4.90	197 092
In feces	33.84	4.29	.98	9.57	15.07	3.92	71,320
Digested	64.04	7.50	2.71	16.10	36.70	.98	125,772
Percent Digested	65.43	63.61	73.44	62.72	70.89	....	63,81
Available calories						61.65 per cent.	

Table No. LXI. Results of Digestion Experiment No. 5.

	Dry Matter Pounds	Protein	Fat	Fiber	Carbo-hydrates	Ash	Cals.
Steer 5.							
In Ground Feed	51.00	7.73	2.64	6.25	32.25	2.09	107,580
In Timothy Hay	32.53	2.47	.63	13.48	14.23	1.72	61,535
In Corn Fodder	11.66	1.40	.23	4.61	4.49	.92	22,752
Total in Food	95.19	11.60	3.50	24.34	50.97	4.73	191,867
In feces	28.87	3.87	.86	11.92	9.26	2.97	62,900
Digested	66.32	7.73	2.64	12.42	41.71	1.76	128,767
Percent Digested	69.67	66.64	75.43	51.03	81.83	....	67.11
Available calories						64.83 per cent.	

Table No. LXII. Results of Digestion Experiment No. 6.

	Dry Matter Pounds	Protein	Fat	Fiber	Carbo-hydrates	Ash	Cals.
Steer 6.							
In Ground Feed	51.00	7.73	2.64	6.25	32.25	2.09	107,580
In Timothy Hay	32.46	2.53	.65	12.98	14.70	1.60	61,400
In Corn Fodder	13.21	1.49	.26	5.37	4.95	1.13	25,776
Total in Food	96.67	11.75	3.55	24.60	51.80	4.82	194,756
In feces	32.00	4.05	.83	11.42	12.39	3.32	67,270
Digested	64.67	7.70	2.72	13.18	39.41	1.50	127,486
Percent Digested	66.90	65.53	76.62	53.58	76.08	....	65.46
Available calories						63.22 per cent.	

The urine voided by each steer was collected and weighed during the experimental period. After weighing the samples, about a litre of each was taken to the laboratory, and the determination of specific gravity, total nitrogen and heat of combustion made. The specific gravity was determined by means of a urinometer—the readings in all cases corrected to a temperature of 15 degrees C. Total nitrogen was determined on about five grams by oxidation by the ordinary Kjeldahl method. The heat of combustion was determined on about ten grams absorbed by a dried and weighed S and S absorption block placed in a nickel capsule. The block with the absorbed urine was dried in an air oven at 70 degrees C. When dry, the capsule was placed in the bomb-calorimeter, and the block and urine were burned in the usual way, correction being made in the calculation for the heat of combustion of the absorption block.

In Table No. LXIV are given the results of these determinations made on the urine. The calories per gram of nitrogen were calculated by dividing the calories per 100 grams by the total nitrogen per cent. An inspection of this column shows that with two or three exceptions, the calories per gram of nitrogen voided in the urine are quite uniform.

Table No. LXIII. Income and Outgo of Nitrogen.

Steer No. 1	Total nitrogen	in feces	.686	lbs.
	" "	in urine	.943	"
	" "	excreted	1.629	"
	" "	in food	1.429	"
		Loss	.2	"
Steer No. 2	" "	in feces	.743	"
	" "	in urine	.995	"
	" "	execrated	1.738	"
	" "	in food	1,476	"
		Loss	[illegible]	
Steer No. 3	" "	in feces	.651	"
	" "	in urine	.734	"
	" "	excreted	1.385	"
	" "	in food	1.423	"
		Gain	.038	"
Steer No. 4	" "	in feces	.687	"
	" "	in urine	.667	"
	" "	excreted	1.354	"
	" "	in food	1.532	"
		Gain	.178	"
Steer No. 5	" "	in feces	.618	"
	" "	in urine	.811	"

	"	"	excreted	1.429 "
	"	"	in food	1.503 "
			Gain	.074 "
Steer No. 6	"	"	in feces	.64 "
	"	"	in urine	.769 "
	"	"	excreted	1.409 "
	"	"	in food	1.526 "
			Gain	.117 "

Table No. LXIII shows the nitrogen balance for each steer or the amount of nitrogen taken into the body in the food as compared with that excreted with the urine and feces. There was a slight gain of nitrogen with steers, 3, 4, 5 and 6, and a slight loss of nitrogen with steers 1 and 2.

Table LXIV.

1st. day	Gms. urine voided	Sp. Gr.	Nit. per cent	Calories per Gm.	Cal. per. Gm. of N.
Steer 1	9525	1.022	1.05	.1641	15.6
Steer 2	5330	1.043	2.17	.3031	13.9
Steer 3	5332	1.040	1.95	.1856	9.5
Steer 4	2382	1.040	2.07	.3677	17.7
Steer 5	7144	1.032	1.45	.1949	13.4
Steer 6	4536	1.036	1.95	.2651	13.6
2nd. Day.					
Steer 1	6985	1.027	1.42	.2118	14.2
Steer 2	4763	1.044	2.35	.3245	13.8
Steer 3	6214	1.025	1.36	.1991	14.7
Steer 4	3856	1.038	2.08	.2952	14.2
Steer 5	6804	1.031	1.51	.2062	13.7
Steer 6	6124	1.026	1.36	.1914	14.0
3rd Day.					
Steer 1	10705	1.022	1.09	.1451	13.3
Steer 2	5488	1.045	2.25	.3156	14.0
Steer 3	6124	1.033	1.61	.2174	13.5
Steer 4	4400	1.040	1.98	.2753	13.9
Steer 5	6351	1.033	1.45	.1946	13.5
Steer 6	4173	1.044	2.18	.3018	13.8
4th Day.					
Steer 1	10841	1.018	.99	.1429	14.5
Steer 2	4536	1.043	2.20	.3125	14.2
Steer 3	4218	1.034	1.98	.2871	14.5
Steer 4	4082	1.037	2.10	.2963	14.1
Steer 5	5443	1.034	1.37	.2168	16.9
Steer 6	4717	1.033	1.82	.2290	12.6
Average					14.46

Table No. LXV. Summary Digestion Coefficients of Entire Ration as Determined By Digestion Trials.

	Dry Matter Perct.	Protein Perct.	Fat Perct.	Fiber Perct.	Carbohydrates Perct.	Cals. Perct.	Available Cals. Perct.
Steer 1	67.81	61.40	77.78	45.60	82.08	67.17	65.12
Steer 2	63.59	59.32	70.03	47.09	76.59	63.98	61.97
Steer 3	69.78	63.33	72.85	60.12	79.21	68.88	66.73
Steer 4	65.43	63.61	73.44	62.72	70.89	63.81	61.65
Steer 5	69.67	66.64	75.43	51.03	81.83	67.11	64.83

Steer 6	66.90	65.53	76.62	53.58	76.08	65.46	63.22
Average	67.19	64.97	74.36	53.36	77.78	66.07	63.92

In order to compare the actual amounts of nutrients consumed by the steers as determined by digestion trials with the calculated nutrients, tables LXVI, LXVII and LXVIII are given.

Table No. LXVI gives the actual amounts of nutrients consumed in each steer during the four days of the digestion trials. These amounts are obtained by multiplying the weights of nutrients in the foods consumed by the amounts digested of the several nutrients as given above.

Table No. LXVII gives the digestible nutrients based on the composition of the food as determined by actual analysis and average digestion coefficients; and Table No. LXVIII gives the estimated digestible nutrients based on the average composition and digestibility of American Feeding Stuffs.

Table No. LXVI. Digestible Nutrients as Determined By Digestion Trials.

	Dry Matter	Protein	Fat	Carbohydrates and Fiber	Ash
	Pounds	Pounds	Pounds	Pounds	Pounds
Steer No. 1	63.34	6.84	2.73	51.75	1.11
Steer No. 2	60.33	6.78	2.43	50.64	.45
Steer No. 3	64.20	7.03	2.63	53.29	1.19
Steer No. 4	64.04	7.50	2.71	52.80	.98
Steer No. 5	66.32	7.73	2.64	54.13	1.76
Steer No. 6	64.67	7.70	2.72	52.59	1.50
Average	63.82	7.26	2.64	52.53	1.17

Table No. LXVII. Digestible Nutrients Calculated From Actual Analysis of Food in Ration and Average Digestion Coefficients.

	Dry Matter	Protein	Fat	Carbohydrates and Fiber	Ash
Steer No. 1	63.78	7.88	3.03	49.07	1.30
Steer No. 2	64.71	7.42	3.00	50.26	1.34
Steer No. 3	62.89	7.25	3.08	48.52	1.32
Steer No. 4	66.38	7.60	3.14	51.64	1.42
Steer No. 5	64.94	7.51	3.03	50.30	1.36
Steer No. 6	65.93	7.58	3.05	51.11	1.40
Average	64.66	7.54	3.06	50.47	1.36

Table No. LXVIII. Digestible Nutrients Calculated from Average Composition of American Feeding Stuffs and Average Digestion Coefficients.

	Dry Matter	Protein	Fat	Carbohydrates and Fiber.
Steer 1	64.50	7.59	2.95	53.47
Steer 2	65.39	7.59	2.95	53.47
Steer 3	63.29	7.47	2.88	51.64
Steer 4	67.50	7.71	3.02	55.29
Steer 5	66.15	7.63	2.98	54.10
Steer 6	67.30	7.70	3.01	55.12
Average	65.69	7.62	2.97	53.84

Table No. LXIX. Summary of Results.

	Dry Matter Pounds	Protein Pounds	Fat Pounds	Carbohydrates Pounds
Digestible Nutrients as determined by actual trial, average, per day 6 steers	15.95	1.82	.66	13.13
Calculated digestible nutrients, using analysis of foods and average digestion coefficients average per day 6 steers	16.16	1.88	.76	12.62
Calculated digestible nutrients, using average composition of American feeding stuffs and average digestion coefficients—average per day 6 steers	16.40	1.90	.74	13.46

It will be observed there is a reasonably close agreement between the actual digestible nutrients of this ration, composed of a mixture of corn fodder and timothy hay, and bran, oats, oil meal and corn meal, and the calculated digestible nutrients. These results show that for all practical purposes the tables of digestible nutrients as recorded in standard works on feeding compiled from the average composition of American feeding stuffs and average digestion coefficients, are sufficiently accurate for the general calculation of rations. The difference between the actual and calculated nutrients as found in this investigation in which six steers of widely different types were used, was small ,amounting in one day to less than a quarter of a pound of dry matter, and less than one tenth of a pound per day of protein.

Similar results were obtained by Jordan & Jenter, Bulletin No. 141, New York State Experiment Station, in digestion trials, in which comparisons were made between the actual and the calculated nutrients of two rations, and a close agreement between the two was observed.

In the case of the individual steers, the digestibility of the protein ranged from 59.32 to 66.64 per cent, and the carbohydrates from 76.08 to 82.08 per cent. It is to be noted that in a mixed ration such as used in this investigation, only about two thirds of the dry matter was digested, and a little less than two thirds of the protein, and about three quarters of the fat and carbohydrates of the food consumed, were digested and utilized by the body. These results show that under the condition of the experiment in which a mixed ration was used from one third to one fourth of the nutrients were voided as indigestible matter in the feces.

An examination of the tables shows that from the grain part of the ration about seventy per cent of the protein was supplied, while the hay and corn fodder furnished about 30 per cent of the protein and fifty per cent of the carbohydrates of food consumed, were digested and utilized by the body.

These results emphasize the desirability of using coarse fodders that supply the maximum amount of protein. In this investigation an average of 63.92 per cent of the total energy of the ration measured in calories or heat units was available to to the body. In the daily ration the food supplies 47,875 calories and 30,600 calories were available to the body. While this is apparently a large loss it is a more economical use of the fuel value than a steam engine where only about 15 per cent of the energy is available.

COMPOSITION AND DIGESTIBILITY OF EMMER.

J. A. Hummel.

Emmer (Tr. sat. dicoccum Hackel) is a species of wheat which probably came originally from Russia . It is grown to a limited extent in Minnesota and other parts of the Northwest. There is another species called spelt (Tr. sat. spelta Hackel), very similar to Emmer and often confused with it: Probably most of the grain grown in Minnesota and called spelt is really emmer. Emmer resembles barley in many respects, having bearded heads. Each hull contains two kernels instead of one as in barley. In threshing, very few of the berries are removed from the hull. The hulled berries resemble ordinary wheat, but are longer and pointed at both ends. The yield of emmer is usually about the same as barley. It has proven to be a reliable crop and seems to be rust resistant. The table below gives the chemical composition of whole emmer, hulled emmer, spring wheat, barley and oats.

Table No. LXX. Chemical Composition of Whole and Hulled Emmer, Spring Wheat, Barley and Oats.

	(1) Whole Emmer Perct.	(2) Whole Emmer Perct.	(3) Barley Perct.	(3) Oats Perct.	(2) Hulled Emmer Perct.	(1) Spring Wheat Perct.
Water	10.88	8.88	10.9	11.0	10.03	10.4
Ash	3.89	4.33	2.4	3.0	1.84	1.9
Fat	2.32	2.55	1.8	5.0	2.8	2.2
Protein	10.5	9.81	12.4	11.8	11.69	12.5
Crude Fiber	11.7	10.09	2.7	9.5	2.94	1.8
Carbohydrates	60.71	64.34	69.8	59.7	70.70	71.2
	100.00	100.00	100.00	100.00	100.00	100.00

(1) Minnesota Analysis.
(2) North Dakota Analysis.
(3) Henry's "Feeds and Feeding."

It will be seen from the table that in composition, emmer is almost equal to barley and oats. The large amount of fiber in the hull makes it bulky and suitable for feeding with more concentrated foods. The hulled emmer compares quite favorably in composition with ordinary spring wheat.

DIGESTIBILITY. In order to obtain some data as to the digestibility of emmer when fed as part of a ration and also to determine the difference in digestibility of ground and unground emmer, three series of digestion experiments were made. Two mature sheep were used for this work,, and the digestion trial extended over a period of four days. The details of the feeding and care of the sheep generally were attended to by the Animal Husbandry Division. The weighing, sampling and analyzing of the liquid and solid excrements were carried out in the usual way.

In the first trial the ration consisted of four pounds of alfalfa hay per sheep, and of six and seven pounds of unground emmer for sheep No. 1 and No. 2 respectively for the entire period of four days.

In the second trial the ration consisted of three pounds of alfalfa hay per sheep, and the same amounts of ground emmer as in the first trial for the period of four days.

In the third trial the ration consisted of alfalfa hay alone: Sheep No. 1. consumed 8.5 pounds, and sheep No. 2, 9 pounds during the entire period, which in this trial was five days.

The composition of the alfalfa hay for each of the three trials and of the emmer is given in the following table:

Table No. LXXI. Composition of Alfalfa Hay and Emmer.

	Water Percent	Protein Percent	Fat Percent	Carbohydrates Percent	Fiber Percent	Ash Percent
Alfalfa, 1st trial	9.21	13.55	1.93	38.16	30.57	6.58
Alfalfa, 2nd trial	12.70	15.08	2.33	24.81	36.50	8.58
Alfalfa, 3rd trial	17.13	13.35	1.74	32.32	29.24	6.22
Emmer	10.88	10.50	2.32	60.71	11.70	3.89

Table No. LXXII. Digestion Experiment—Unground Emmer and Alfalfa.

	Dry Matter Lbs.	Protein Lbs.	Fat Lbs.	Fiber Lbs.	Carbohydrates Lbs.	Ash Lbs.
Sheep No. 1.						
In Alfalfa	3.632	.542	.077	1.223	1.895	.263
In Emmer	5.39	.963	.136	.719	3.992	.189
Total in Food	9.022	1.505	.213	1.942	5.887	.452
In Feces	2.015	.313	.077	.844	.488	.292
Digested	7.007	1.192	.136	1.098	5.399	.160
Per Cent Digested......	77.67	79.20	63.85	56.54	91.71	35.40

Sheep No. 2.						
In Alfalfa	3.632	.542	.077	1.223	1.895	.263
In Emmer	6.289	1.123	.159	.839	4.658	.221
Total in Food	9.921	1.665	.236	2.062	6.553	.484
In Feces	1.958	.299	.073	.718	.572	.297
Digested	7.963	1.366	.163	1.344	5.981	.187
Per Cent Digested	80.26	82.04	69.02	65.18	91.27	38.63

Table No. LXXIII. Digestion Experiment—Ground Emmer and Alfalfa.

	Dry Matter Lbs.	Protein Lbs.	Fat Lbs.	Fiber Lbs.	Carbohydrates Lbs.	Ash Lbs.
Sheep No. 1						
In Alfalfa	2.62	.452	.07	1.095	.744	.257
In Emmer	5.35	.63	.139	.702	3.643	.233
Total in Food	7.970	1.082	.209	1.797	4.387	.490
In Feces	1.386	.182	.047	.50	.447	.208
Digested	6.584	.900	.162	1.297	3.940	.282
Per Cent Digested......	82.61	83.18	77.51	72.17	89.81	57.55
Sheep No. 2.						
In Alfalfa	2.62	.452	.07	1.095	7.44	.257
In Emmer	6.24	.735	.162	.819	4.250	.272
In Total Food	8.860	1.187	.232	1.914	4.994	.529
In Feces	1.769	.213	.052	.597	.616	.290
Digested	7.091	.974	.180	1.317	4.378	.239
Per Cent Digested	80.04	82.06	77.58	68.81	87.67	45.18

Table No. LXXIV. Digestion Experiment—Alfalfa.

	Dry Matter Lbs.	Protein Lbs.	Fat Lbs.	Fiber Lbs.	Carbohydrates Lbs.	Ash Lbs.
Sheep No. 1						
In Alfalfa	6.73	1.090	.142	2.348	2.64	.506
In Feces	3.07	.357	.124	1.405	.80	.385
Digested	3.66	.733	.018	.943	1.84	.121
Per Cent Digested	54.38	67.25	12.68	40.16	69.70	23.92
Sheep No. 2.						
In Alfalfa	7.38	1.190	.154	2.600	2.88	.554
In Feces	3.30	.352	.125	1.496	.91	.416
Digested	4.08	.837	.029	1.104	1.97	.138
Per Cent Digested	55.28	70.38	18.83	42.47	68.40	24.91

Table No. LXXV. Digestibility of Emmer Alone.

	Dry Matter Lbs.	Protein Lbs.	Fat Lbs.	Fiber Lbs.	Carbohydrates Lbs.	Ash Lbs.
Sheep No. 1.						
In Emmer	5.39	.963	.136	.719	3.992	.189
In Alfalfa	3.632	.542	.077	1.223	1.895	.263
In Feces	2.015	.313	.077	.844	.488	.292
Undigested Alfalfa	1.64	.169	.064	.718	.379	.199

Undigested Emmer	.375	.144	.013	.126	.109	.093
Digested	5.015	.819	.123	.593	3.883	.096
Per Cent Digested	93.04	85.05	90.44	82.47	97.27	50.80
Sheep No. 2.						
In Emmer	6.289	1.123	.159	.839	4.658	.221
In Alfalfa	3.632	.542	.077	1.223	1.895	.263
In Feces	1.958	.299	.073	.718	.572	.297
Undigested Alfalfa	1.64	.169	.064	.490	.379	.199
Undigested Emmer	.318	.130	.009	.128	.193	.098
Digested	5.971	.993	.150	.711	4.465	.123
Per Cent Digested	94.94	88.42	94.32	84.74	95.86	55.66

Table No. LXXVI. Summary of Results of Digestion Trials.

Unground Emmer and Alfalfa Hay	Dry Matter Percent	Protein Percent	Fat Percent	Carbohy-Drates Percent	Fiber Percent	Ash Percent
Sheep 1	77.67	79.20	63.85	91.71	56.54	35.40
Sheep 2	80.26	82.04	69.07	91.27	65.18	38.63
Ground Emmer and Alfalfa Hay.						
Sheep 1	82.61	83.18	77.51	89.81	72.17	57.55
Sheep 2	80.04	82.62	77.58	87.67	68.81	45.18
Alfalfa Hay.						
Sheep 1	54.38	67.25	12.68	69.70	40.16	23.92
Sheep 2	54.83	70.38	18.83	68.40	42.47	24.91
Averages						
Unground Emmer and Alfalfa Hay	78.97	80.62	66.46	91.41	60.86	37.02
Ground Emmer and Alfalfa Hay	81.33	82.62	77.55	88.74	70.49	51.36
Alfalfa Hay	54.83	68.81	15.75	69.05	41.31	24.41

The results given in the tables show that a ration of emmer and alfalfa hay when fed to sheep has high digestibility, especially of protein and carbohydrates. The digestibility of this ration when fed to sheep is very much higher than the ration fed to steers recorded in Table No. LXV of the preceeding article. The results also show the influence of grinding the emmer. The grinding of the emmer materially increased the digestibility of the protein, fat, fiber and ash and caused a decrease in digestibility of the nitrogen free extract. When the crude fiber and nitrogen free extract are considered jointly as carbohydrates, there was no appreciable difference in digestibility between the ground and the unground emmer. In the case of sheep, the grinding of the emmer did not materially increase digestibility.

The urine was collected, weighed and analyzed in order to determine the income and outgo of nitrogen. In the first trial one of the samples was lost. The results of the calculation for the second and third trials are given in the following table:

Table No. LXXVII. Results of Digestion Trials.

SECOND TRIAL	Sheep 1 Lbs.	Sheep 2 Lbs.
Nitrogen in Feces	.029	.034
Nitrogen in Urine	.11	.153
Nitrogen in Total Excrements	.139	.187
Nitrogen in Food	.173	.19
Gain	.034	.003
THIRD TRIAL.		
Nitrogen in Feces	.057	.056
Nitrogen in Urine	.148	.200
Nitrogen in Total Excrements	.205	.256
Nitrogen in Food	.181	.192
Loss	.024	.064

It will be noticed that in every case the amount of nitrogen excreted in the urine is very much larger than that excreted in the feces. In the second trial in which the ration consisted of ground emmer and alfalfa hay, the nitrogen of the urine was four times that of the feces, and in the third trial in which the ration consisted of alfalfa hay alone, the nitrogen of the urine was about three times that of the feces.

In the first and second trials in which the ration contained emmer a little more than a fifth of the nitrogen of the food was found in the feces. In the third trial in which the ration was alfalfa hay alone, a little over a third of the nitrogen of the food was found in the feces. There was a much more complete digestion of the ration of hay and grain than of the ration of hay alone.

The digestibility of alfalfa hay when fed to sheep was determined in order to calculate the digestibility of the emmer alone. Using the digestion coefficients thus obtained for alfalfa hay, we find by calculation the digestion coefficients of the emmer alone, to be as follows:

Table No. LXXVIII. Digestion Coefficients of Emmer.

	Dry Matter Percent	Protein Percent	Fat Percent	Carbohydrates Percent	Fiber Percent	Ash. Percent
Sheep 1	93.04	85.05	90.44	97.27	82.47	50.80
Sheep 2	94.94	88.42	94.32	95.86	84.74	55.66
Average	93.99	86.73	92.38	96.56	83.60	53.23

These results show a high digestibility for emmer when fed to sheep. In localities where emmer can be grown successfully it will be found a valuable addition to the ration of growing or fattening cattle.

Table No. LXXIX. Digestible Nutrients in 100 Pounds.

	Protein	Fat	Carbohydrates
Emmer	9.11	2.14	68.40
Barley	8.7	1.6	65.6
Oats	9.2	4.2	47.3
Spring Wheat	10.2	1.7	69.2
Spring Wheat Bran	12.2	2.7	39.2

THE HEAT PRODUCING VALUE OF THE CRUDE FAT OF FODDERS AND GRAINS.

Harry Snyder.

Fat is characteristically a heat producing nutrient; a gram of fat when burned in the calorimeter yields about 9.5 calories, depending upon its source and composition, while a gram of starch yields about 4.2 calories. Any large admixture of non-fatty material in the ether extract or crude fat obtained in the analysis of fodders, must necessarily lower the caloric value. It is well known that the ether extract or crude fat from forage crops contains appreciable amounts of non-fatty bodies as chlorophyll, the green coloring matter in plants, also waxes, and nitrogenous fat-like bodies as lecithin. It was deemed advisable to determine by actual test, the heat of combustion of the ether extract from several coarse fodders, in order to ascertain the extent to which the non-fatty substances in the ether extract of forage crops influence the heat of combustion. Corn fodder, corn silage, timothy hay and clover hay, were selected for the purpose, and the heats of combustion were found to be as follows:

Table No. LXXX. Heat of Combustion.

Ether Extract from:	Calories per gram.
Corn Fodder,	8,047
Corn Silage,	7,545
Clover Hay,	8,036
Timothy Hay,	8,220

It will be observed that the heat of combustion ranges from 7,545 to 8,220 calories per gram. The foreign or non-fatty material in the ether extract lowered the caloric value from 11 to 20 per cent. In an average dairy ration containing about .75 pounds of crude fat, about two-thirds is derived from the corn fodder. From the ether extract of the coarse fodders, ordinarily about 2000 calories are derived. If the non-fatty materials in the ether extract reduce the heat producing power 15 per cent, it would be equivalent to a reduction of 300 calories. Since all of the nutrients of the ration supply about 30,000 calories per day, the non fatty materials of the ether extract affects the total energy value of the ration to the extent of about one per cent—not a very large factor, and which in the calculation of rations may be disregarded. While the chlorophyll reduces the heat of combustion of the ether extract, there are compensating factors; its presence in the fodder is a desirable characteristic, for the color of the fodder is due to chlorophyll and is an index of quality. Feeders justly give preference to well cured fodders of good color. When the fats of wheat and barley were extracted and burned in the calorimeter, they yielded 9.34 and 9.21 calories respectively, indicating that with these cereals the ether extract has practically the same caloric value as pure fat.

The nitrogen content of the ether extracts from several fodders and grains was determined with the following results:

Table No. LXXXI. Nitrogen content of Ether Extract.

	Ether Extract Per Cent	Nitrogen Content of Ether Extract. Per Cent
Clover Hay	2.45	.174
Timothy Hay	2.10	.153
Corn	4.20	.062
Oats	3.52	.063
Barley	2.16	.047
Wheat	2.41	.043

The nitrogenous matter in the ether extract from the grains was found to be much less than in that from the coarse fodders, as clover and timothy. In the case of wheat and barley, if all of the nitrogen of the ether extract is considered present as lecithin, there would be less than eight per cent of this material.

The heat of combustion of the ether extract of grains indicates that in the calculation of rations it may be regarded as having the same energy value as fat; in course fodders, however, the ether extract has an energy value of 11 to 20 per cent less than fat.