

UNIVERSITY OF MINNESOTA.

---

**Agricultural Experiment Station.**

---

BULLETIN No. 92.

---

DIVISION OF AGRICULTURAL CHEMISTRY.

---

MAY, 1905.

---

THE DIGESTIBILITY AND NUTRITIVE VALUE  
OF COTTAGE CHEESE, RICE, PEAS  
AND BACON.

---

*ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.*

MCGILL-WARNER Co., PRINTERS, ST. PAUL.

# UNIVERSITY OF MINNESOTA.

## BOARD OF REGENTS:

CYRUS NORTHROP, I. L. D., MINNEAPOLIS, - - - -	<i>Ex-Officio</i>
The President of the University.	
The HON. JAMES T. WYMAN, MINNEAPOLIS, - - - -	1907
President of the Board.	
The HON. JOHN A. JOHNSON, ST. PETER, - - - -	<i>Ex-Officio</i>
The Governor of the State.	
The HON. JOHN W. OLSEN, ALBERT LEA, - - - -	<i>Ex-Officio</i>
The State Superintendent of Public Instruction.	
The HON. STEPHEN MAHONEY, B. A., MINNEAPOLIS, - -	1907
Secretary of the Board.	
The HON. O. C. STRICKLER, M. D., NEW ULM, - - - -	1907
The HON. S. G. COMSTOCK, MOORHEAD, - - - -	1909
The HON. THOMAS WILSON, ST. PAUL, - - - -	1909
The HON. B. F. NELSON, MINNEAPOLIS, - - - -	1909
The HON. A. E. RICE, WILLMAR, - - - -	1909
The HON. EUGENE W. RANDALL, MORRIS, - - - -	1910
The HON. DANIEL R. NOYES, ST. PAUL, - - - -	1910

The HON. GREENLEAF CLARK, LL. D., Died, Dec. 7, 1904.

## THE AGRICULTURAL COMMITTEE.

The HON. A. E. RICE, Chairman.  
 The HON. J. T. WYMAN.  
 The HON. B. F. NELSON,  
 The HON. S. G. COMSTOCK,  
 The HON. E. W. RANDALL.

## STATION OFFICERS.

WM. M. LIGGETT;	Director.
J. A. VYE.	Secretary.
SAMUEL B. GREEN, B. S.,	Horticulturist.
HARRY SNYDER, B. S.,	Chemist.
T. L. HÆCKER,	Dairy Husbandry.
M. H. REYNOLDS, M. D., V. M.,	Veterinarian.
ANDREW BOSS,	Agriculturist and Animal Husbandry.
FREDERICK L. WASHBURN, M. A.,	Entomologist.
T. A. HOVERSTAD, B. Agr.,	Superintendent, Crookston.
A. J. McGUIRE, B. Agr.	Superintendent, Grand Rapids.
J. A. HUMMEL, B. Agr.,	Assistant Chemist.
COATES P. BULL, B. Agr.,	Asst. in Agriculture.
A. G. RUGGLES, M. A.,	Assistant Entomologist.
D. A. GAUMNITZ, B. Agr.,	Asst. in Animal Husbandry.

The bulletins of this Station are mailed free to all residents of this State who make application for them.

# THE DIGESTIBILITY AND NUTRITIVE VALUE OF COTTAGE CHEESE, RICE, PEAS AND BACON.

HARRY SNYDER.

---

This investigation forms part of a series undertaken in 1895 to determine the digestibility, nutritive value, relative cost and loss in the preparation of the more common human foods. In former reports are given the results of experiments with potatoes,<sup>1</sup> bread,<sup>2</sup> milk, eggs, cheese, beans, butter,<sup>3</sup> oleomargarine, oatmeal, toast and sugar,<sup>4</sup> and the comparative digestibility of bread made from graham, entire wheat and straight grade flours.<sup>5</sup>

This Bulletin contains the results of five series of digestion experiments carried on during the year 1904 with working men as subjects. The foods, bread, milk, rice, cottage cheese, bacon, peas and sugar, were combined in various ways and the actual digestibility of the rations determined. Each experiment was carried on for a period of three days and three men were experimented upon in each test, making in all fifteen separate digestion experiments.

The general plan followed in this work is outlined in former bulletins of this station, to which the reader is referred for more explicit information, including the definition of terms.<sup>6</sup> In brief, the plan has been as follows: One or more foods have been fed for a period of three to four days. All of the food consumed has been weighed and analyzed and all of the excretory products from the body have also been weighed and analyzed. The amount digested and utilized by the body is obtained by subtracting from the nutrients in the food those that are present in the excretory products. The amount digested is expressed in percentage of the nutrients in the total food.

---

<sup>1</sup>Minn. Agr. Expt. Station Bulletin No. 42.

<sup>2</sup>Minn. Agr. Expt. Station Bulletin No. 54.

<sup>3</sup>Minn. Agr. Expt. Station Bulletin No. 74.

<sup>4</sup>Minn. Agr. Expt. Station Bulletin No. 86.

<sup>5</sup>Minn. Agr. Expt. Station Bulletin No. 85.

<sup>6</sup>Minn. Agr. Txpt. Station Bulletin No. 74.

## DIGESTION EXPERIMENTS WITH COTTAGE CHEESE.

## NOS. 1, 2 AND 3, SERIES 1.

In this series of experiments the ration consisted of cottage cheese, bread, milk and sugar. The experiments commenced July 14, 1904, and each one continued for three days, during which time approximately 1.1 lbs. of cottage cheese, 1.16 lbs. bread, 4.12 lbs. of milk and .06 lb. of sugar were consumed per day by each man.

The cottage cheese was prepared in the following way: Separator skim milk was allowed to sour in a warm room. The milk was then heated to a temperature of about 100°F., and hot water 175°F. added at the rate of about one pint per gallon of milk. The addition of the hot water resulted in more complete coagulation of the milk. After stirring for one or two minutes, the coagulated mass was allowed to settle and then the whey was drained off and the curd collected by straining through cheese cloth. If too much hot water is used, a tough curd results: if the milk is not sour enough, it fails to properly curdle. When of medium acidity and favorable temperature, a soft, fine grained curd is secured. The curd was salted and mixed with cream. The cottage cheese prepared in this way was found to be very palatable and contained a large amount of nutrients in the form of proteids and fats.

The bread used in these experiments was prepared from high grade patent flour similar to that used in former investigations. About an ounce per day of sugar was used in the ration and it was sprinkled over the cottage cheese. The milk was obtained from the Dairy Division of the Experiment Station.

In the first series of experiments, the foods,—milk, sugar, bread and cottage cheese,—were combined so as to supply about 0.4 of a pound of protein, .3 of a pound of fat and 1.1 pounds of carbohydrates per day. While there was no intention of making the ration conform to any dietary standard, incidentally it is to be noted that it practically conforms to the requirements of a ration for a man at active muscular work, as suggested by Atwater, Voit and others.

In this series of experiments, the main object was to determine the digestibility of the cottage cheese and its influence upon the digestibility of other foods.

The men consumed on an average 1.1 pounds per day of the moist cheese, about six ounces per meal. The cheese supplied over 40 per cent of the total protein, and about 28 per cent of

the total fat of the ration. No digestion disorders were experienced by any of the subjects on account of consuming such a large amount of cottage cheese per day. The men were all employed at hard farm labor, and the ration of which cottage cheese formed an essential part gave entire satisfaction.

The amounts of food consumed during the experiments, and the nutrients which they contained, together with the indigestible nutrients in the feces, are given in Tables Nos. 15, 16 and 17. The weights are recorded in grams, and the approximate amount in pounds, if desired, can be determined by dividing the weight in grams by 453. The tables also give the percentage of nutrients of the entire ration which were digested and utilized by the body.

Table XV. Results of Digestion Experiment No. 1. Man 1.

Food Consumed	Weight of Material Grams	Protein (n x 6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Com- bustion Calories
Sugar.....	90	.....	.....	90.	.....	359.5
Bread.....	1490	132.0	10.66	857.4	5.73	4414.0
Cheese.....	1530	222.7	96.30	100.2	10.35	2994.9
Milk.....	5000	158.5	243.50	241.7	43.50	4275.0
Total.....		513.2	350.46	1289.3	59.58	12043.4
Feces (water free).....		22.25	12.99	26.58	21.69	433.3
Total amount digested.....		490.95	337.47	1262.72	37.89	11610.1
Total percent digested.....		95.66	96.28	97.94	63.60	96.40
Available energy total food.....						91.08

Table XVI. Results of Digestion Experiment No. 2. Man 2.

Food Consumed	Weight of Material Grams	Protein (n x 6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Com- bustion Calories
Sugar.....	90	.....	.....	90.00	.....	359.5
Bread.....	1624	143.80	11.62	934.30	6.25	4811.0
Cheese.....	1550	225.60	97.56	101.50	10.39	3034.0
Milk.....	5950	188.60	289.80	287.60	51.77	5087.0
Total.....		558.	398.98	1413.40	68.41	13291.5
Feces (water free).....		29.85	20.97	42.15	31.04	695.9
Total amount digested.....		528.15	378.01	1371.25	37.37	12595.6
Total percent digested.....		94.65	94.74	97.02	54.63	94.76
Available energy total food.....						89.52

Table XVII. Results of Digestion Experiment No. 3. Man 3.

Food Consumed	Weight of Material Grams	Protein (x 6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Com- bustion Calories
Sugar.....	90			90.		369.5
Bread.....	1592	141.00	11.39	916.10	6.13	4714.0
Cheese.....	1550	225.60	97.56	101.50	10.39	3034.0
Milk.....	5900	187.10	287.30	285.20	51.33	5045.0
Total.....		513.70	396.25	1392.80	67.85	13152.5
Feces (water free).....		24.42	18.53	32.52	27.53	560.6
Total amount digested.....		529.28	377.72	1360.28	40.32	12591.9
Total percent digested.....		95.59	95.32	97.67	59.43	95.73
Available energy total food.....						90.47

Digestibility of Total Food. Summary of Experiments Nos. 1, 2 and 3.

Foods	Protein	Fat	Carbo- hydrates	Available Energy
Man 1.....	95.66 94.65 95.59	96.26 94.74 95.32	97.94 97.02 97.67	91.08 89.52 90.47
Man 2.....				
Man 3.....				
Average.....	95.30	95.44	97.54	90.36

The average of the three experiments in which cottage cheese formed an essential part of the ration show the cheese to be highly digestible. Over 95 per cent of both the proteids and fats and 97 per cent of the carbohydrates of the ration were digested and utilized by the body. In similar experiments, in which the ration consisted of bread and milk alone, it was found that from 91 to 95 per cent of the protein, 93 to 97 per cent of the fat and 97 to 98 per cent of the carbohydrates were digested, depending upon the individual experimented with. In these experiments, where cottage cheese was combined with bread and milk, the total digestibility of the ration remained practically unaltered. Ninety-five per cent of the fat and proteid of cottage cheese and 97 per cent of the carbohydrates were digested and 90 per cent of the energy was available to the body. These results show that cottage cheese has the same digestibility as milk and other dairy products.

A pound of cottage cheese prepared in the way described contains about .17 of a pound of protein, .08 of a pound of fat and .07 of a pound of carbohydrates. This is as much total nutritive material as is found in the edible portion of many cuts of meat, but not as much as is found in meats containing large amounts of fat. Pound for pound, cottage cheese prepared with cream compares favorably in composition and digestibility with beef and other meats. One hundred pounds of skim

milk and four pounds of cream, containing 20 per cent fat, will make from 15 to 16 pounds or more of moist cottage cheese. At 2 cents per quart for skim milk and thirty-five cents per quart for cream, cottage cheese would cost about 11 cents per pound, and compares very favorably in nutritive value with meats at the same price per pound. Where skim milk can be procured at a low cost, cottage cheese is one of the most economical foods that can be used. The addition of cream to cottage cheese favorably influences both its nutritive value and its palatability without increasing the cost above that of average meats. Upon the farm, where milk is produced, cottage cheese is one of the cheapest foods that can be used. Under such a condition it is more economical to use cottage cheese made with cream than it is to make the cream into butter and purchase meat. Cottage cheese supplies a large amount of protein and fat in a very digestible and palatable form.

#### DIGESTION EXPERIMENTS WITH RICE. NOS. 4, 5 AND 6. SERIES 2.

In the second series of experiments, Nos. 4, 5 and 6, rice was substituted for the bread of the first series. The ration consisted of cottage cheese, rice, milk and sugar. The same men were employed as were experimented upon in the first series of digestion trials, and the conditions were alike in every respect, except that rice was substituted for bread. The uncooked rice contained 8.55 per cent of proteids, which is somewhat higher than is found in many samples. The flour from which the bread was made contained 11.80 per cent of proteids. The rice contained about  $3\frac{1}{2}$  per cent more starch than the flour. The men consumed about 0.8 of a pound per day of rice, and in the first series of experiments about 0.7 of a pound per day of flour in the form of bread. The substitution of the rice for the bread made a slight decrease in the total amount of protein and an increase in the carbohydrates content of the ration.

Each day a weighed quantity of rice was cooked separately for each subject, as it was found that the uncooked rice could be more accurately sampled for analysis than the cooked rice. The cottage cheese prepared for this series of experiments was quite similar in composition to that used in the first series, indicating that when prepared under uniform conditions cottage cheese is fairly constant in composition. In all the experiments, the heats of combustion or calories were determined by combustion of the materials in an Atwater-Bertholet bomb calorimeter.

The total amounts of rice and other foods consumed during the experiments, the amounts of nutrients in the various foods, the indigestible nutrients recovered from the feces, and the per cent of nutrients digested, are given in the following tables, Nos. 18, 19 and 20.

Table XVIII. Results of Digestion Experiment No. 4. Man 1.

Food Consumed	Weight of Material Grams	Protein (x6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Combustion Calories
Rice.....	875	74.81	2.71	681.50	2.88	3372.0
Cheese.....	906	154.10	65.70	59.00	8.89	1843.0
Sugar.....	90			90.00		359.5
Milk.....	4550	145.60	217.50	221.60	39.13	3533.
Total.....		374.51	285.91	1052.10	50.90	9107.5
Feces (water free).....		29.02	10.32	20.22	16.45	407.1
Total amount digested.....		345.49	275.59	1031.88	34.45	8700.4
Total percent digested.....		92.25	96.39	98.07	67.68	95.53
Available energy total food.....						90.39

Table XIX. Results of Digestion Experiment No. 5. Man 2.

Food Consumed	Weight of Material Grams	Protein (x6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Combustion Calories
Rice.....	1300	111.20	4.03	1013.00	4.29	5010.0
Cheese.....	1350	229.60	97.90	87.91	13.25	2746.0
Sugar.....	90			90.00		359.5
Milk.....	4820	154.30	230.60	234.70	41.45	3743.0
Total.....		495.10	332.53	1425.61	58.99	11858.5
Feces (water free).....		47.62	16.98	33.20	27.05	669.5
Total amount digested.....		447.48	315.55	1392.41	31.94	11189.0
Total percent digested.....		90.38	94.89	97.67	54.15	94.36
Available energy total food.....						89.14

Table XX. Results of Digestion Experiment No. 6. Man 3.

Food Consumed	Weight of Material Grams	Protein (x6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Combustion Calories
Cheese.....	1380	234.70	100.10	89.86	13.54	2807.0
Milk.....	6750	216.00	322.70	328.70	58.05	5741.0
Sugar.....	90			90.00		359.5
Rice.....	1125	96.19	3.48	876.86	3.71	4336.0
Total.....		546.89	426.28	1384.86	75.30	12743.5
Feces (water free).....		45.15	12.70	33.61	30.53	604.6
Total amount digested.....		501.74	413.58	1351.25	44.77	12138.9
Total percent digested.....		91.74	97.02	97.57	59.46	95.25
Available energy total food.....						89.89



**TABLE XXI.** Composition of Foods used in Digestion Experiments.

	Used in Experiment Series	Dry Matter	Pro- teids	Fat	Carbo- hydrates	Ash	Calories
Flour.....	1	87.71	11.80	1.06	74.43	.42	3.888
Bread.....	1	67.5	13.12	1.06	85.25	.57	4.389
Cheese.....	1	.....	56.25	20.	21.62	2.13	6.220
Milk.....	1	13.75	3.17	4.87	4.84	.87	.855
Rice.....	2	87.08	8.55	.31	77.89	.33	3.854
Milk.....	2	13.71	3.20	4.78	4.87	.86	.776
Cheese.....	2	31.75	53.56	22.84	20.51	3.09	6.407
Bread.....	3	87.82	8.27	.38	78.85	.32	3.833
Pea Soup.....	3	19.35	24.97	1.24	67.06	6.73	4.928
Bacon.....	3	14.03	3.27	4.85	5.11	.80	.859
Bread.....	4	65.82	13.68	1.40	83.90	1.02	4.457
Pea Soup.....	4	17.60	24.59	.81	91.98	2.62	4.210
Bacon.....	4	90.48	35.68	49.22	.....	5.58	6.580
Cheese.....	5	41.44	52.91	25.77	17.10	4.22	6.527
Bread.....	5	66.6	13.65	1.40	84.29	.66	4.575
Bacon.....	5	95.18	25.25	64.03	.....	5.90	7.478

(Figures for composition of bread and peas and cheese on dry matter basis)

**TABLE XXII.** Nitrogen Balance.

Experi- ment No.	Total Nitrogen in			Gain Grams
	Food	Feces	Urine	
1	82.16	3.48	75.83	.95
2	89.34	4.77	66.03	6.18
3	88.36	3.90	77.63	2.27
4	59.86	4.64	55.16	.02
5	79.12	8.46	65.74	1.64
6	87.39	7.32	70.60	3.19
7	51.90	6.69	38.70	2.17
8	67.78	8.19	54.16	.14
9	69.86	8.94	53.03	2.76
10	76.35	12.77	46.61	5.65
11	79.26	28.36	48.90	.68
12	87.40	14.09	58.69	4.87
13	118.14	7.40	71.26	13.16
14	148.26	7.94	88.05	17.42
15	159.08	8.26	99.34	17.16

**Digestibility of Total Food. Summary of Digestion Experiments  
Nos. 4, 5 and 6.**

	Foods	Protein Per cent	Fat Per cent	Carbo- hydrates Per cent	Available energy Per cent
Man 1.....	Rice, Cheese, Sugar, Milk	92.25	96.39	98.07	90.39
Man 2.....		90.38	94.89	97.67	89.14
Man 3.....		91.74	97.02	97.57	89.89
	Average.....	91.46	96.10	97.77	89.81

The substitution of the rice for the bread resulted in lowering the digestibility of the protein of the ration to the extent of about 4 per cent. In a former investigation<sup>7</sup> the addition of 20 per cent of wheat starch to bread resulted in lowering the digestibility of the protein to the extent of about 3 per cent. It has also been observed that breads made from white flour of high protein content were more completely digested than breads made from flour of low protein content<sup>8</sup>. In this respect rice resembles wheat flours of low protein content, inasmuch as the protein is less completely absorbed than in the case of flours of high gluten content.

Rice is commonly called a digestible food. It is a food that, when well cooked, is easily digested, but it is not as completely digested as wheat bread. It has, nevertheless, a high food value, but at the same price per pound as wheat flour it furnishes less nutritive material than bread. The digestibility of bread has been determined in a number of digestion experiments, and it has been found that, when bread is made from straight grade flour, about 88.6 per cent of the proteids and 97.7 per cent of the carbohydrates are digested.<sup>9</sup>

In these experiments, in which rice formed an essential part of the ration, if corrections be made for the digestibility of the other foods with which the rice was combined, it will be found that about 83 per cent of the rice proteids were digested and 98 per cent of the carbohydrates, and that about 90 per cent of the total energy was available to the body.

Rice is a food which supplies to the body a large amount of digestible carbohydrates. A pound of rice like the sample used contains .07 of a pound of digestible protein and .76 of a pound of digestible carbohydrates, which is about .04 of a pound less of protein and more of carbohydrates than is present in wheat flour. When extensively used in the dietary, rice should be combined with foods of high protein content, as meat, cheese and the legumes. Rice is a food that is easily digested, but some of the nutrients, as protein, are not as completely digested as in case of cereals of higher protein content. The rice samples used in these digestion trials were selected types of American grown rice, and the analyses show that they contained a larger amount of nutritive material than is present in average imported rice,—being equal in food value to flours of low gluten content. In these experiments, where the rice was combined with the cottage cheese, milk and sugar, the

<sup>7</sup>U. S. Dept. of Agr., Office of Experiment Stations, Bul. 101.

<sup>8</sup>U. S. Dept. of Agr., Office of Experiment Stations, Bul. 167.

<sup>9</sup>U. S. Dept. of Agr., Year Book 1903, pp. 347-362.

ration gave entire satisfaction and the rice supplied over 36 per cent of the total energy of the ration.

DIGESTION EXPERIMENTS WITH RICE AND PEAS,  
NOS. 7, 8 AND 9. SERIES 3.

In the third series of experiments, peas were substituted for cottage cheese; in all other respects, however, the ration was the same as for the second series. The peas were thoroughly cooked for twelve hours; at first rapidly over a burner and then in an oven for several hours, until they were thoroughly disintegrated, forming a porridge or thick soup. The ration consisted of pea porridge, rice, sugar and milk. The men consumed per day about six ounces of the dry peas made into a porridge containing about 82 per cent of water. Both the dry peas and the pea porridge were analyzed, and the dry matter showed the presence of nearly 25 per cent of proteids and 70 per cent of carbohydrates. Nearly one-third of the total protein was supplied by the peas and over one-half of the carbohydrates by the rice. This ration contained two extreme types of food, peas a nitrogenous and rice a starchy food. About one ounce per day of sugar was used, as in all the preceding experiments. This ration, in which rice and peas formed an essential part, gave entire satisfaction and caused no digestion disorders.

The total amounts of pea porridge, rice and other foods and the nutrients which they contained, together with the amounts of indigestible nutrients in the feces and the percentage of nutrients digested, are given in the following tables, Nos. 23, 24 and 25.

Table XXIII. Results of Digestion Experiment No 7. Man 1.

Food Consumed	Weight of Material Grams	Protein (nx 6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Com- bustion Calories
Pea Soup.....	2355	113.80	5.64	305.63	30.67	1904.0
Rice.....	900	74.43	3.42	709.70	2.88	3391.0
Sugar.....	90			90.00		359.5
Milk.....	4200	137.30	203.70	214.60	33.60	3480.0
Total.....		325.53	212.76	1319.93	67.15	9134.5
Feces (water free).....		41.75	9.70	37.63	18.92	490.1
Total amount digested.....		283.78	203.06	1282.30	48.23	8644.4
Total percent digested.....		87.18	95.44	97.15	71.82	94.64
Available energy total food.....						90.18

Table XXIV. Results of Digestion Experiment No. 8. Man 2.

Food Consumed	Weight of Material Grams	Protein (n x 6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Comb- uration Calories
Pea Soup.....	2880	139.10	6.89	373.74	37.51	2329.0
Rice.....	1200	99.24	4.56	946.20	3.84	4521.0
Sugar.....	90	.....	.....	90.00	.....	359.5
Milk.....	4750	155.30	230.40	242.70	38.00	3935.0
Total.....		393.64	241.85	1652.64	79.35	11144.5
Feces (water free).....		51.22	9.05	46.67	23.06	616.9
Total amount digested.....		342.42	232.80	1605.97	56.29	10527.6
Total percent digested.....		86.99	96.26	97.18	70.94	94.46
Available energy total food.....		.....	.....	.....	.....	90.05

Table XXV. Results of Digestion Experiment No. 9. Man 3.

Food Consumed	Weight of Material Grams	Protein (n x 6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Comb- uration Calories
Pea Soup.....	2450	118.40	5.87	317.88	31.91	1981.0
Rice.....	1200	99.24	4.56	946.20	3.84	4521.0
Sugar.....	90	.....	.....	90.00	.....	359.5
Milk.....	6750	220.70	327.40	344.90	54.00	5592.0
Total.....		438.34	337.83	1698.98	89.75	12453.5
Feces (water free).....		55.89	18.53	46.64	25.95	721.2
Total amount digested.....		382.45	319.30	1652.34	63.80	11732.3
Total percent digested.....		87.25	91.56	97.25	71.09	94.21
Available energy total food.....		.....	.....	.....	.....	89.81

Digestibility of Total Food. Summary of Digestion Experiments Nos. 7, 8 and 9.

	Foods	Protein	Fat	Carbohy- drates	Available Energy
Man 1.....	} Rice, Peas, Milk, Sugar }	87.18	95.44	97.15	90.18
Man 2.....		86.99	96.26	97.18	90.05
Man 3.....		87.25	91.56	97.25	89.81
	Average.....	87.14	94.42	97.19	90.01

TABLE XXVI. Composition of Feces.

Experiment No.	Man	Protein	Fat	Ash	Carbo- hydrates	Calories
1	1	26.19	15.66	26.13	32.02	5.221
2	2	24.07	16.91	25.03	33.99	5.612
3	3	23.71	17.99	26.73	31.57	5.443
4	1	38.18	13.58	21.64	26.60	5.356
5	2	42.31	11.89	21.38	24.42	5.321
6	3	37.01	10.41	25.02	27.56	4.956
7	1	38.66	8.98	17.52	34.84	4.578
8	2	39.40	6.96	17.74	35.90	4.480
9	3	38.02	12.60	17.65	31.73	4.747
10	1	55.09	10.32	7.71	26.88	6.235
11	2	64.01	12.11	7.78	16.10	5.564
12	3	50.31	7.90	8.49	33.30	5.184
13	1	47.66	21.64	10.89	19.81	5.884
14	2	47.67	26.81	11.12	14.40	5.930
15	3	47.37	26.36	12.38	13.89	5.820

TABLE XXVII. Composition of Urine Samples.

Experiment No.	Man	Total Nitrogen Per cent.	Specific Gravity
1	1	2.24	1.021
2	2	2.16	1.03
3	3	2.33	1.03
4	1	1.22	1.022
5	2	1.25	1.024
6	3	1.41	1.026
7	1	.90	1.023
8	2	1.11	1.022
9	3	1.20	1.026
10	1	1.16	1.022
11	2	1.33	1.029
12	3	1.26	1.023
13	1	1.67	1.024
14	2	2.13	1.03
15	3	1.61	1.025

In these experiments, in which peas and rice formed a large part of the ration, 87.1 per cent of the protein, 94.4 per cent of the fat and 97 per cent of the carbohydrates were digested, and 90 per cent of the energy, measured in calories, was available to the body. The substitution of the peas for the cottage cheese of the second ration lowered the digestibility of the protein of the ration 4 per cent. When corrections are made for the digestibility of the other foods with which the peas were combined, the peas alone were found to have the following average digestibility:

Protein .....	80.04
Carbohydrates .....	96.20

The proteids of peas are not as completely digestible as the proteids of the cereals, particularly of wheat flour. Although the proteids in peas are less digestible than in cereals, the large total amount makes nearly twice as much total available protein in peas as in cereals. Peas contain a large amount of protein. A pound of peas costing 8 cents contains .17 of a pound of digestible protein, which is as much as is found in the edible portion of any of the meats.

In former digestion trials, where beans<sup>10</sup> were used, it was found that about 80 per cent of the protein and fat and 96.2 per cent of the carbohydrates were digested by working men. The same results were obtained in these digestion trials with peas. The beans were combined in a ration with bread, milk and butter, while the peas in these trials were combined with rice, milk and sugar. Peas and beans, when combined under similar conditions, have the same digestibility and supply the body with practically the same amounts of nutritive substances. The statements made in the former work in regard to the digestibility, nutritive value and cost of beans also apply in general to peas. As a cheap source, of protein, peas are valuable in the dietary, particularly for combination with starchy foods, making a more balanced ration.

#### DIGESTION EXPERIMENTS WITH BACON AND PEAS. NOS. 10, 11 AND 12. SERIES 4.

In this series of experiments, the ration consisted of peas, bacon and bread. The object of this and of the next series was to determine the digestibility and nutritive value of bacon, and incidentally to make a further study of the influence of peas and cottage cheese when combined with other foods.

The bacon used in these experiments was cured at the meat house of the Minnesota Experiment Station by the Division of Animal Husbandry. It was lean bacon of good quality, such as could be prepared and cured on any farm<sup>11</sup>. The bacon was cut into thin slices and baked until crisp and brown. All of the bacon fat was used in the ration. A composite sample of the bacon used in each of the series of experiments was made and analyzed. The bacon contained less water, more protein or lean meat, and less fat than is present in many samples. The average of the two samples showed about 7½ per cent

<sup>10</sup>Minn. Agr. Expt. Station, Bul. No. 74.

<sup>11</sup>U. S. Dept. of Agriculture, Farmer's Bulletin No. 133.

water, 30 per cent protein and 57 per cent fat. As the analysis indicates, it was distinctly a type of lean bacon.

The bacon supplied over 95 per cent of the total fat of the ration. Peas and rice contain but little fat. It was the intention to have the protein supplied mainly by the peas and bread, but on account of the lean character of the bacon, over half of the total protein was supplied by this material. No sugar or milk was used in this series of experiments.

The men consumed on an average about nine ounces per day of bacon, due largely to the ration being confined to only three food articles. The ration produced no digestion disorders. In the case of Man No. 2, the charcoal marker failed to work satisfactorily, and as a result a sharp separation of the feces for the experimental period was not secured. For this reason the digestion coefficients of the ration of Man No. 2 are not included in the averages.

In Tables 28, 29 and 30 the usual data in connection with the digestion experiments is given.

**Table XXVIII. Results of Digestion Experiment No. 10. Man 1.**

Food Consumed	Weight of Material Grams	Protein (nx 6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Com- bustion Calories
Pea Soup.....	2700	116.85	3.83	342.05	12.45	2000.6
Bread.....	1383	124.53	9.65	766.83	9.28	4057.2
Bacon.....	660	235.30	324.89	.....	36.83	4342.8
Total.....		476.68	338.28	1108.88	58.56	10400.6
Feces (water free).....		77.13	14.45	37.63	10.80	872.9
Total amount digested.....		399.55	323.83	1071.25	47.76	9527.7
Total percent digested.....		83.81	95.73	96.61	81.56	91.61
Available energy in total food.....						85.88

**Table XXIX. Results of Digestion Experiment No. 11. Man 2.**

Food Consumed	Weight of Material Grams	Protein (nx 6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Com- bustion Calories
Pea Soup.....	2300	99.54	3.27	291.40	10.61	1704.2
Bread.....	1175	105.80	8.20	651.50	7.89	3447.0
Bacon.....	813	290.10	400.20	.....	45.30	5350.0
Total.....		495.44	411.67	942.90	63.80	10501.2
Feces (water free).....		177.31	33.54	44.60	21.55	1541.2
Total amount digested.....		318.13	378.13	898.30	42.25	8960.0
Total percent digested.....		64.21	91.85	95.27	66.22	85.33
Available energy in total food.....						79.45

Table XXX. Results of Digestion Experiment No. 12. Man 3.

Food Consumed	Weight of Material Grams	Protein (nx 6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Com- bustion Calories
Pea Soup.....	3200	138.50	4.55	405.40	14.75	2371.07
Bread.....	1375	124.80	9.50	762.40	9.20	4033.59
Bacon.....	795	283.70	391.30	.....	44.30	5231.00
Total.....	.....	547.00	405.35	1167.80	68.25	11635.66
Feces (water free).....	.....	87.54	13.75	57.94	14.67	902.02
Total amount digested.....	.....	459.46	391.60	1109.86	53.58	10733.64
Total percent digested.....	.....	84.00	96.61	95.04	78.51	92.25
Available energy in total food.....	.....	.....	.....	.....	.....	88.29

Digestibility of Total Food. Summary of Digestion Experiments Nos. 10, 11 and 12.

	Foods	Protein	Fat	Carbo- hydrates	Available Energy
Man 1.....	Bacon, Peas and Bread	83.81	95.73	96.61	85.88
Man 3.....		84.00	96.61	95.04	88.29
	Average.....	83.90	96.17	95.82	87.08

In this series of experiments, where the ration consisted of bacon, peas and bread, 83.9 per cent of the protein, 96.17 per cent of the fat and 95.82 per cent of carbohydrates were digested. Since over 95 per cent of the fat of the ration was supplied by the bacon, the average for the digestibility of the total fat (96.17%) can be taken with a fair degree of accuracy as representing the digestibility of the bacon fat. This is a high coefficient of digestibility. The digestibility of the protein can be discussed more advantageously in conjunction with the next series of experiments in which bacon forms an essential part.

#### DIGESTION EXPERIMENTS WITH COTTAGE CHEESE AND BACON, NOS. 13, 14 AND 15. SERIES 5.

In this series of experiments, the ration consisted of cottage cheese, bacon, sugar and bread; the cottage cheese was substituted for the peas of ration No. 4, and the bacon for the milk of ration No. 1. The average of the three digestion experiments shows a high degree of digestibility of the ration as 94.42 per cent of the protein, 96.79 per cent of the fat and 97.57 per cent of the carbohydrates were digested, and 89.57 per cent of the energy was available to the body. In ration No. 4,



where the fat was supplied largely by the bacon, 96.17 per cent was digested, which is practically the same digestibility as was found in ration No. 5, in which the fat was in part derived from the cream used in the preparation of the cottage cheese, and in ration No. 4, where the fat was supplied entirely by the milk and the cheese.

Compared with other foods, bacon fat has a high coefficient of digestibility. The proteids of bacon were also found to have a high digestion coefficient. In ration No. 4, in which the bacon was combined with peas, it was found that 83.9 per cent of the protein of the entire ration was digested, while 94.4 per cent was digested when the peas were replaced with cottage cheese. Making the necessary corrections for the digestibility of the foods with which the bacon was combined, it was found that the bacon proteids have a digestion coefficient of about 92 when combined with cottage cheese and bread, and a much lower digestibility when combined with peas. While the bacon proteids have a high digestibility, they are not as completely digested as the fats.

**Table XXXI. Results of Digestion Experiment No. 13. Man 1.**

Food Consumed	Weight of Material Grams	Protein (x6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Cheese.....	1910	418.80	203.90	135.3	33.40	5166.0
Bacon.....	770	194.42	493.03		45.43	5758.0
Sugar.....	90			90.00		359.5
Bread.....	1420	129.10	10.03	800.30	6.29	4327.0
Total.....		742.32	706.96	1025.60	85.12	15610.5
Feces (water free).....		46.23	20.99	19.22	10.56	570.8
Total amount digested.....		696.09	685.97	1006.38	74.56	15039.7
Total percent digested.....		93.77	97.03	98.13	87.59	96.34
Available energy in total food.....						90.40

**Table XXXII Results of Digestion Experiment No. 14. Man 2.**

Food Consumed	Weight of Material Grams	Protein (x6.25) Grams	Fat Grams	Carbohydrates Grams	Ash Grams	Heat of Combustion Calories
Cheese.....	2838	622.20	303.10	201.10	49.63	7676.0
Bacon.....	770	194.42	493.03		45.43	5758.0
Sugar.....	90			90.00		359.5
Bread.....	1251	113.70	9.00	705.10	5.50	3812.0
Total.....		930.32	805.13	996.20	100.56	17605.5
Feces (water free).....		49.58	27.88	14.48	11.56	616.72
Total amount digested.....		880.74	777.25	981.72	89.00	16988.78
Total percent digested.....		94.67	96.54	98.55	88.56	96.50
Available energy in total food.....						88.89

Table XXXIII. Results of Digestion Experiment No. 15. Man 3.

Food Consumed	Weight of Material Grams	Protein (x6.25) Grams	Fat Grams	Carbohy- drates Grams	Ash Grams	Heat of Comb- uration Calories
Cheese .....	2980	653.40	318.20	211.2	52.10	8060.0
Bacon .....	885	223.46	566.66	90.0	52.21	6618.0
Sugar .....	90					359.5
Bread .....	1345	122.30	9.45	758.1	5.96	4098.0
Total .....		999.16	894.31	1059.3	110.27	19135.5
Feces (water free) .....		51.63	28.73	15.0	13.49	634.4
Total amount digested .....		947.53	865.58	1044.3	96.78	18501.1
Total per cent digested .....		94.83	96.79	98.59	87.77	96.69
Available energy in total food .....						89.42

These digestion experiments with bacon show that it yields a large amount of available energy to the body. When burned in the bomb calorimeter, the bacon yielded from 6.5 to 7.4 calories per gram, due to the presence of the large amount of fat. Starch and the carbohydrates yield 4.2 calories per gram, the fats about 9.2. Allowing 5 per cent for waste, a pound of bacon will contain from .1 to .3 of a pound of digestible protein, and from .4 to .6 of a pound of digestible fat, which is about two-thirds as much as is found in butter.

Lean bacon has a unique value in the dietary. It furnishes as much digestible protein as other meats and nearly twice as much fat, making the total nutrients and available energy derived from bacon much larger than from other meats. Bacon fat is easily digested and when combined with other foods it appears to exert a favorable mechanical action upon digestion.

In each of the digestion experiments, the income and outgo of nitrogen was determined and a nitrogen balance made. In nearly all of the experiments there was a gain of from .2 to 17. grams of nitrogen per day, showing that all of the rations supplied the requisite amount of protein. The experimental period, however, was too short to warrant definite conclusions being drawn in regard to the income and outgo of nitrogen in the food. The gains and losses in the weights of the subjects were within narrow limits.

The Experiments taken as a group show:

That cottage cheese prepared from skim milk and enriched with cream is a cheap, digestible and nutritious food, and when the materials for its preparation are produced on the farm it is one of the most economical foods that can be used. At two cents per quart for skim milk and 35 cents per quart for cream cottage cheese compares favorably with meats at 11 cents per pound.

That rice is easily digested when well cooked, but is no more completely digested than other cereal foods. In these experiments the carbohydrates (starch) of rice were more completely digested than the proteids, but the proteids of rice were not as completely digested as the proteids of wheat bread. The samples of American grown rice used in these experiments supplied nearly as much protein as bread made from low gluten content flours, but at a greater cost. Rice is a food which supplies a large amount of carbohydrates and can be used to best advantage when combined with such foods as peas, cottage cheese and meats, which are rich in protein.

That when peas are used in the ration, they supply a large amount of protein. This is because of the high percentage which they contain, although the proteids of peas are not as completely digestible as the proteids of rice and other cereals. Peas supply the body with about the same amount of available nutrients as beans. When judiciously combined with other foods, peas form one of the cheapest sources for obtaining proteids to make better balanced rations.

The actual digestibility of rations in which milk is used is higher than the calculated digestibility of the individual foods, showing that, when combined with other foods, milk exerts a favorable influence upon digestibility.

That lean bacon in a ration supplies a large amount of digestible nutrients and available energy. Over 96 per cent of the bacon fat was digested and absorbed by the body. Lean bacon contains as much protein and about twice as much digestible fat as other meats, making it at the same and even at a higher price per pound a cheaper food than other meats.