375-1213-20m

TEXAS AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 163 DECEMBER, 1913

DIVISION OF CHEMISTRY

Digestion Experiments on Men with Cottonseed Meal

POSTOFFICE
College Station, Brazos County, Texas

VON BOECKMANN-JONES CO., PRINTERS, AUSTIN, TEXAS
1913

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

CHARLES PURYEAR, *President Pro Tem.*

TEXAS AGRICULTURAL EXPERIMENT STATION

BOARD OF DIRECTORS

E. B. CUSHING, *President*, Houston ..... Term expires 1915
JOHN I. GUION, *Vice-President*, Ballinger ..... Term expires 1919
E. H. ASTIN, Bryan ..... Term expires 1919
L. J. HART, San Antonio ..... Term expires 1919
R. L. BENNETT, Paris ..... Term expires 1917
T. E. BATTLE, Marlin ..... Term expires 1917
J. S. WILLIAMS, Paris ..... Term expires 1917
J. ALLEN KYLE, Houston ..... Term expires 1915
WALTON PETEET, Fort Worth ..... Term expires 1915

GOVERNING BOARD, STATE SUBSTATIONS

WILL H. MAYES, *President*, Brownwood ..... Term expires 1915
P. L. DOWNS, *Vice-President*, Temple ..... Term expires 1919
CHARLES ROGAN, Austin ..... Term expires 1917
..... Term expires 1915

STATION STAFF

ADMINISTRATION

B. YOUNGBLOOD, M. S., *Director*
A. B. CONNER, B. S., *Assistant Director*
CHAS. A. FELKER, *Chief Clerk*
A. S. WARE, *Secretary*

DIVISION OF VETERINARY SCIENCE

M. FRANCIS, D. V. S., *Veterinarian in Charge*
H. SCHMIDT, D. V. M., *Assistant Veterinarian*

DIVISION OF CHEMISTRY

G. S. FRAPS, Ph. D., *Chemist in Charge*
J. B. RATHER, M. S., *Assistant Chemist*
WILLIAM LEVIN, A. B., *Assistant Chemist*
J. W. CHEWNING, B. S., *Assistant Chemis*

DIVISION OF HORTICULTURE

H. NESS, M. S., *Horticulturist in Charge*
W. S. HOTCHKISS, *Horticulturist*

DIVISION OF ANIMAL HUSBANDRY

J. C. BURNS, B. S., *Animal Husbandman in Charge*
————, *Animal Husbandman*

DIVISION OF ENTOMOLOGY

WILMON NEWELL, M. S., *Entomologist in Charge*
F. B. PADDOCK, B. S. E., *Entomologist*

DIVISION OF AGRONOMY

A. B. CONNER, B. S., *Agronomist in Charge*
A. H. LEIDIGH, B. S., *Agronomist in Charge of Soil Improvement*
H. H. JOBSON, B. S., *Assistant Agronomist*
R. E. DICKSON, B. S., *Assistant Agronomist*

DIVISION OF PLANT PATHOLOGY AND PHYSIOLOGY

F. H. BLODGETT, Ph. D., *Plant Pathologist and Physiologist in Charge*

***DIVISION OF FARM MANAGEMENT**

REX E. WILLARD, M. S., *Farm Management Expert in Charge*

DIVISION OF FEED CONTROL

W. L. BOYETT, *State Feed Inspector*
J. H. ROGERS, *Deputy Feed Inspector*
W. H. WOOD, *Deputy Feed Inspector*
T. H. WOLTERS, *Deputy Feed Inspector*
R. B. EHLINGER, *Deputy Feed Inspector*

SUBSTATION NO. 1: Beeville, Bee County

E. E. BINFORD, B. S., *Superintendent*

SUBSTATION NO. 2: Troup, Smith County

W. S. HOTCHKISS, *Superintendent*
R. W. COX, B. S., *Scientific Assistant*

SUBSTATION NO. 3: Angleton, Brazoria County

N. E. WINTERS, B. S., *Superintendent*
J. W. JACKSON, B. S., *Scientific Assistant*

***SUBSTATION NO. 4: Beaumont, Jefferson County**

E. M. JOHNSTON, B. S., *Superintendent*

SUBSTATION NO. 5: Temple, Bell County

A. K. SHORT, B. S., *Superintendent*
W. Z. MILLER, B. S., *Scientific Assistant*

SUBSTATION NO. 6: Krum, Denton County

T. W. BUELL, B. S., *Superintendent*

SUBSTATION NO. 7: Spur, Dickens County

I. S. YORK, *Superintendent*
E. W. HARRISON, B. S., *Scientific Assistant*

SUBSTATION NO. 8: Lubbock, Lubbock County

V. L. CORY, B. S., *Superintendent*

SUBSTATION NO. 9: Pecos, Reeves County

H. C. STEWART, B. S., *Superintendent*
J. M. THOMSON, B. S., *Scientific Assistant*

SUBSTATION NO. 10: Feeding and Breeding Substation, College Station, Brazos County

C. S. SCHARFF, *Acting Superintendent*

SUBSTATION NO. 11: Nacogdoches, Nacogdoches County

G. T. MCNESS, *Superintendent*

CLERICAL ASSISTANTS

STATION

J. M. SCHAEDEL, *Stenographer*
C. A. CASE, *Stenographer*
C. L. DURST, *Mailing Clerk*

FEED CONTROL

DAISY LEE, *Registration Clerk*
MATTIE THOMAS, *Stenographer*
P. K. BROWNLEE, *Shipping Clerk*

*In cooperation with Bureau of Plant Industry, United States Department of Agriculture.

CONTENTS

BLANK PAGE IN ORIGINAL

PREFACE.

Cotton seed, formerly merely a waste by-product, is now an important source of wealth to the South. Cottonseed oil once was regarded with little favor as a human food, but now is recognized as a wholesome, nutritious, edible oil. Formerly its presence in compound lard was disguised, but now lard substitutes are boldly proclaimed as being made from cottonseed oil. This change is partly due to the overcoming of prejudice against cottonseed oil as a human food, but it is mainly due to improvements in the manufacture and refining of the oil, and improved methods of utilizing it.

Cottonseed meal is used almost exclusively as a cattle feed and as a fertilizer. Various people have, however, used it as a food. During the Civil War, cotton seed were roasted and used, to some extent, at least, as a substitute for coffee. At present, cottonseed meal is being used to a limited extent as a human food in Texas and other parts of the South. Mr. G. A. Baumgarten, of Schulenburg, for example, has been using wheat flour mixed with cottonseed flour in his home for the past eight years, and the writer has in his possession the names of a number of others who are using it. Mr. J. W. Allison, of Ennis, Texas, has advertised cottonseed flour quite extensively.

The present high prices of meat, and the prospect of still higher prices in the future, is stimulating the search for a substitute for the protein of meat. Cottonseed meal is exceedingly rich in protein, and is a very cheap substitute for meat. It therefore offers a possibility for securing a new human food at a low price, which is a substitute for the most expensive food that we have.

Many years may pass before cottonseed meal will be generally recognized as a human food, but it is now being used as such, and it is very probable that its use will continue to increase. The data presented by Mr. Rather in the following pages will be of interest both to those who are now using cottonseed meal as a human food, and to those who are looking forward to a new source of food supply for the human family. There are some who say that the increase in the population of the world is in a greater proportion than the increase in human food. To such as these, the possibility of the use of cottonseed meal as a human food should have a peculiar interest.

G. S. FRAPS,
Chemist, Experiment Station.

BLANK PAGE IN ORIGINAL

DIGESTION EXPERIMENTS ON MEN WITH COTTONSEED MEAL.

J. B. Rather, Assistant Chemist.*

In a former bulletin of the Texas Experiment Station (Fraps, Bull. 128, Cottonseed Meal as Human Food) analyses of cotton seed bakery products were reported, and the use of cottonseed meal as a food for man was discussed. The work presented below is a continuation of this study and deals with the digestibility of cottonseed meal as a human food.

So far as we can find, no digestion experiments with cottonseed meal have ever been made on human beings. Mendel and Fine (*J. Biol. Chem.* II, I) fed cottonseed flour to dogs and found that 71.6 per cent of the proteins were digested, on an average, and when meat was fed to the same animals that 91.0 per cent protein was digested. Since the digestive system of the dog is very similar to that of man, a like relative result would be expected in digestive experiments with the latter.

It has been pointed out by Fraps (*loc. cit.*) that cottonseed meal is a substitute for meat and that its use as a substitute for bread is neither desirable nor safe.

EXPLANATION OF TERMS USED IN THIS BULLETIN.

Protein is the nitrogenous portion of the food, and is used by the body for the production of flesh, or to replace waste of flesh or tissue. No other nutrient can take the place of protein for this purpose. Protein may also be burned in the body for the production of energy, and if an excess of protein is consumed, it will be disposed of in this way. The white of an egg and lean meat are examples of almost pure protein. Protein is exceedingly important because it is the substance of the animal muscles.

Meat is rich in protein, and its peculiar value is due to this fact. Cottonseed meal, however, contains more than twice as much protein as average meat. The chief function of meats is to supply the body with protein.

Protein can be used in the body for the production of fat, but it is not an economical food for this purpose. Proteins from different foods are not equally digested. While protein is indispensable to the body, an excessive amount is as undesirable as a scant amount.

Fat, or Ether Extract, is the term applied to that class of compounds which is soluble in ether. In the case of concentrated human foods, like meats and cereals, the ether extract consists principally of fats and oils. The ether extract of hays and fodders contains large amounts of waxes, chlorophyls, and other non-fats, and has less value as a nutrient than the true fats. Fat is used by the body to furnish energy, to do work, or for other uses of the body.

---

*Under the general direction of G. S. Fraps, chemist.

Fat may also be stored up as such. It is a concentrated form of nourishment. A pound of fat has the value of 2.2 pounds of sugar, starch, or other carbohydrates. Fat cannot be used to make lean flesh, or to repair loss of lean flesh. Cottonseed meal contains about half as much fat as average fresh meats.

Nitrogen-free extract of human foods is composed mostly of sugars and starches, and other bodies known to chemists as carbohydrates. These nutrients furnish the body with energy, or may be converted into fats and stored up, but they cannot produce flesh or repair tissue. The nitrogen-free extract of cottonseed meal is composed most largely of a sugar known as raffinose. It also contains some pentosans. Cottonseed meal contains no starch. It could thus be used for a diet in cases of sickness where starch is not desired.

Crude fiber is the woody fiber, not very well digested by human beings, and not present in any appreciable quantity in ordinary human foods, though it may be present in larger quantities in greens, such as turnips, and any coarse vegetable food. The chief objection to the use of alfalfa as a human food is the quantity of crude fiber which it contains. If cut young, alfalfa is not so fibrous.

Nitrogen-free extract and crude fiber are often grouped together under the name carbohydrates, but this term is not correctly used, since other bodies are present in addition to true carbohydrates. In human foods the crude fiber is usually small in amount, and the compounds are mainly carbohydrates, but in animal foods the term includes a large number of compounds less similar in character and food value.

Water is present in all foods, and while its presence is a necessity for the consumption and digestion of the food, yet it can only be regarded as a diluent of a food when the food is being purchased. The food is not purchased for the water which it contains, but for other substances than water.

Ash is the residue left on burning the material. It contains substances which are necessary to the growth and maintenance of the body. Cottonseed flour is much richer in ash than wheat flour, rice, corn meal, eggs, or meat.

Fuel Value.—The most conspicuous nutritive requirement of the body is energy which is used for the work of the body. All organic nutrients serve as fuel to yield this energy. Then one of the best bases for the comparison of foods is that of fuel value. The fuel value of carbohydrates is about the same as that of protein (4.1 and 4.35 calories per gram, respectively), while the fuel value of fats is about twice as great (9.45 calories per gram).

TOXIC SUBSTANCES.

When cottonseed meal is fed to pigs in large amounts and for a long time, it often causes death. Many efforts have been made to find what this toxic substance is, but no theory of the toxicity has as yet been successfully advanced. Pigs have been fed on cottonseed meal and corn successfully for 156 days. Withers, Brewster et al. (*J. Biol. Chem.* 15, 161), have recently found that sulphate of iron (copperas) will render cottonseed meal harmless to rabbits and pigs.

COMPLETENESS VERSUS EASE OF DIGESTION.

With the average person the idea of digestibility is synonymous with ease of digestion, and especially that ease and rapidity of stomachic or gastric digestion. There is slight direct relation between the ease which a food is digested in the stomach and the extent to which it is digested before the residue leaves the body. The amount of food eaten does not appear to affect the digestibility of it. The doubling of a small diet of milk and crackers reduced the coefficient of digestibility by less than 1 per cent (Sherman).

According to popular belief, the enjoyment of food is a very important factor in securing its proper digestion. The work of Pawlow appears to support this belief, but experiments on healthy men seem to indicate that the palatability of a food or the monotony of a uniform diet do not affect the digestibility of the food. So long as the food is actually eaten and retained, the mastication being normal, the digestibility is not affected.

The term "digestibility" may therefore mean the ultimate extent of the digestion of the food, or the comfort, ease, and rapidity with which it is digested. We are concerned in this work with the extent of the digestion of the foods studied, that is, the per cent which disappears during its passage through the alimentary canal. This per cent is called the *coefficient of digestibility.*

Another popular belief is that when foods are "bolted" or eaten hastily and insufficiently masticated, that they are digested to a less extent than when properly chewed. This idea is correct in regard to vegetable foods which have a protective coat, such as beans and field peas. A field pea swallowed whole, even if thoroughly cooked, may pass through the body entirely unaffected, and emerge with the skin unbroken. The work of Foster and Hawk (*Orig. Comm. 8th Int. Cong. Appl. Chem.* 1912, Vol. 19, p. 131) indicates, however, that whether meat is masticated normally or swallowed in lumps ("bolted"), the difference in the digestibility of the protein is very slight, and the difference when the food is masticated normally and excessively, is nothing.

COMPOSITION OF BREADS MADE FROM COTTONSEED FLOUR.

Table 1 shows the composition of the bread from cottonseed flour used in these experiments, together with that of a number of other food products for comparison. The bread used was made by a mixture of cottonseed meal, or flour, and bolted pearl corn meal. The use of pure cottonseed meal for bread making does not appear to be desirable. It would be difficult, or impossible, to secure a palatable food without dilution of some sort, and there would be danger of overeating. In our work we found that a bread made from two parts corn meal and one part cottonseed meal was much less palatable than one from four parts corn meal and one part cottonseed meal.

TABLE NO. 1.

Percentage Composition of Cottonseed Meal Breads, Etc.

Laboratory No.		Protein.	Fat.	Crude fiber.	Nitrogen free extract.	Water.	Ash.
	Cottonseed meal bread (Fraps)	14.13	4.85	1.95	51.98	24.98	2.11
7737	Cottonseed meal corn bread No. 1, 33% cotton-seed meal	10.25	2.13	1.84	31 29	51.53	2.97
7759	Cottonseed meal corn bread No. 2, 20% cotton-seed meal	8.57	2.24	1.60	34.55	50.14	2.91
7774	Cottonseed meal corn bread No. 3, 20% cotton-seed meal	8.60	2.34	1.12	34.14	50.41	2.98
	Wheat bread (average)	9.2	1.3	1.51	52.10	35.3	1.10
7749	Corn bread No. 2	4.31	1.33	0.70	37.83	55.59	1.90
	Beef loin	16.40	16.90	.....	.....	61.30	0.90
	Eggs	13.20	12.00	.....	.....	73.30	0.60
	Cheese	25.90	33.70	.....	2.40	34.20	3.80
	Cottonseed meal-corn meal mixture (calc.)*	17.17	4.41	1.76	65.32	9.39	1.95
	Corn meal	8.93	2.77	1.22	75.91	10.17	1.00
	Cottonseed meal-wheat flour mixture (calc.)*	19.15	2.99	1.02	64.66	10.85	1.63
	Wheat flour	11.40	1.00	0.30	75.10	12.00	0.60
7775	Cottonseed flour	50.16	10.96	3.92	22.95	6.25	5.76

*20% Cottonseed meal or flour.

The cottonseed bread analysis reported by Fraps (*Texas Bulletin,* 128) shows that the product contained almost as much protein as beef loin (14.13 per cent and 16.40 per cent for the two, respectively). This bread was a cottonseed flour-wheat flour product. Our cottonseed meal-corn bread, made up in the proportion which we recommend, contained 8.6 per cent protein, as compared with 4.3 per cent in a corn bread of about the same water content. It contained nearly twice as much fat and almost as much carbohydrates as the corn bread.

On account of the difference in water content of foods made by different methods, and the difference in the added ingredients, the analyses are not directly comparable. We can, however, compare the analyses of the uncooked products. An examination of the table will show that the cottonseed-corn meal mixture contains approximately twice as much protein, twice as much fat, and nine-tenths as much carbohydrates as corn meal. Likewise the cottonseed-wheat flour mixture contains nearly twice as much protein, three times as much fat, and nine-tenths as much carbohydrates as wheat flour.

The cottonseed meal mixtures are therefore about twice as rich in the most expensive nutrients (protein and fat) and almost as rich in the cheapest of nutrients (carbohydrates) as wheat flour and corn meal. The protein content of the products is higher than that of beef loin and eggs, and about three-fourths as high as that of cheese. The fat content, however, is much lower. The water content of cottonseed bakery products ranges from 6.5 per cent (ginger snaps) to 50.4 per cent (cottonseed meal-corn bread). The protein in the cooked breads would therefore range from *one-third less to one-third more than the protein content of eggs.* Straight cottonseed flour contains nearly five times the amount of protein, and nearly as much fat as eggs, but it is not desirable to use cottonseed flour without dilution.

THE DIGESTIBILITY OF COTTONSEED FLOUR AND MEAL COMPARED WITH MEAT.

Three digestion experiments were made with men with ordinary cottonseed meal, and two with a specially prepared cottonseed flour. In order to compare the digestibility of the meal with that of meat, two experiments were made on a canned meat product known as chicken loaf. Analysis showed that the meat contained a considerable amount of some cereal, but this apparently did not affect the digestibility of the protein and fat.

The cottonseed meal used in this work was fresh meal from fresh seed. It was slightly below the average quality and was not very finely ground. It was sifted through a 20-mesh sieve. The residue (30 per cent), consisting of hulls and unground cake, was rejected.

The cottonseed flour used was made from prime meal and was an almost impalpable powder. The meal had been put through a roller mill, according to the manufacturer's statement. It was practically free from hulls.

METHOD OF CONDUCTING DIGESTION EXPERIMENTS.

Each experiment was two days (six meals) in length. A simple mixed diet was fed. It consisted of milk, corn bread, and meat, in the meat experiments, and of milk, butter, and cottonseed meal-corn bread in the cottonseed meal and flour experiments. The food was eaten *ad libitum* with the exception of the meat, 300 grams of which was fed daily. The food offered each subject was weighed before and after each meal and the amount eaten determined. Samples were taken from each loaf of bread and each box of chicken loaf. After the determination of loss of water in preparation, the samples were combined into one composite sample of meat and one of bread for analysis. Each sample of milk was mixed, sampled and analyzed as soon as possible. A single gelatin capsule (No. 00) filled with lampblack was given with the breakfast of the first day, and a similar capsule with the breakfast of the day following the experiments. The first lot of colored feces was included in those reserved for analysis and the last lot rejected. The urine was collected for the entire period, beginning with the time of the first meal, and ending at the same time on the morning of the day following the last meal of the experiment. The urine was measured and analyzed for total nitrogen for each day separately. Each subject was weighed without clothes just before the first meal of the experiment, and at the same time on the morning of the day after the close of the experiment.

The health of all the subjects continued good through the experiments. One experiment, however, on man No. 3 had to be thrown out on account of constipation.

FORMULAS FOR THE BREAD USED IN THIS WORK.

The breads were made according to the following formulas:

Corn bread used in Experiment No. 1, Period 1.

Corn meal	400 gm.
Salt	25 gm.
Water	a sufficient quantity.

Cottonseed meal-corn bread, Experiment No. 1, Period 2.

Corn meal	160 gm.
Cottonseed meal	80 gm.
Salt	10 gm.
Water	a sufficient quantity.

Corn bread used in Experiment No. 2, Period 1.

Corn meal	485 gm.
Salt	15 gm.
Water	a sufficient quantity.

Cottonseed meal-corn bread used in Experiment No. 2, Period 2, and in Experiment No. 3.

Corn meal	190 gm.
Cottonseed meal or flour	50 gm.
Salt	10 gm.
Water	a sufficient quantity.

The ingredients were accurately weighed out and well mixed. Sufficient boiling water was added to moisten the mass and was thoroughly worked in with a spoon. The mixture was spread out in a cake in a hot skillet which had been greased slightly with a cloth dipped in melted lard, and baked on both sides. Great care was taken to cook the bread thoroughly. In the first experiment sufficient bread was cooked to last through the entire period, but in all others bread was cooked and served hot with each meal.

The analyses of the products and the calculations were conducted in the usual manner, but the following points should be mentioned. All fats in the breads were calculated from the fat content of the ingredients. This was done because it is known that fat is rendered to some extent insoluble in ether by cooking. (This fact was recognized as early as 1892. Cf. M. Weibull, *Svensk Kemisk Tidskrift,* 1892, No. 5.)

The per cent of corn meal in the water-free cottonseed-corn meal mixture was taken as the per cent of corn meal in the water-free bread. The number of grams of the nutrients in the corn meal portion of the water-free bread fed, was subtracted from the total nutrients, calculated from analyses of the bread, and the remainder taken as nutrients fed as cottonseed meal.

The following coefficients of digestibility were assumed in making these calculations: for milk, protein, 97 per cent; fat, 95 per cent;

carbohydrates, 98 per cent; for butter, fat, 95 per cent; and for corn meal, protein, 85 per cent; fat, 90 per cent; and carbohydrates, 98 per cent. These results are the averages by Atwater (quoted by Sherman, *Chemistry of Food and Nutrition*, p. 76) of the results of a large number of digestion experiments. While these figures may not be exactly correct in the foods used by us, the results with cottonseed meal and with meat are directly comparable, since the above factors were assumed for both calculations. The results are shown in Table 2.

TABLE NO. 2.

Percentage of Nutrients Digested, Cottonseed Meal and Meat.

Man No.		Protein.	Fat.	Carbohydrates	Carbohydrates and Fats.	Carbohydrates, when fats are assumed 95% digested.
1	Canned chicken loaf	99.3	100.0	.....	.....	.....
2	Canned chicken loaf	93.9	99.3	.....	.....	.....
1	Cottonseed meal	80.2	100.0	56.7	79.0	78.4
2	Cottonseed meal	74.7	100.0	25.5	58.8	48.0
3	Cottonseed meal	77.9	100.0	51.2	72.3	65.4
1	Cottonseed flour	79.7	100.0	49.0	70.1	61.2
2	Cottonseed flour	79.2	100.0	68.7	85.8	79.4
	Average for meat	96.6	99.7	.....	.....	.....
	Average for cottonseed meal	77.6	100.0	44.5	70.1	65.9
	Average for cottonseed flour	79.5	100.0	58.9	78.0	70.3
	Average digestibility of cereals	85.	90.	98.	.....	.....
	Average digestibility of legumes	78.	90.	97.	.....	.....
	Cottonseed meal digested by dogs (Mendel and Fine)	71.6	.....	.....	.....	.....
	Cottonseed meal digested by animals (ruminants)	88.4	93.3	60.6	.....	.....
	Total food of average mixed diet (Atwater)	92.	95.	98.	.....	.....

The average digestibility of the fat and protein of the meat was 96.6 and 99.7 per cent respectively. Of the cottonseed meal, 77.6 per cent protein, 100 per cent fat, and 44.5 per cent carbohydrates were digested on an average. Of the cottonseed flour, 79.5 per cent protein, 100 per cent fat, and 58.9 per cent carbohydrates were digested. The difference in the digestibility of the cottonseed meal and the cottonseed flour was practically nothing in the case of the protein and fat, and not a great deal in the case of the carbohydrates. The *protein of cottonseed meal, by far its most valuable constituent, is as equally as digestible as that of peas and beans, eight-tenths as digestible as that of meat, and nine-tenths as digestible as that of cereals.*

The digestibility of the fats appears to be very high in cottonseed meal, and that of the carbohydrates very low. The figures in Table 8 show that the digestibility of fats is apparently much higher than 100 per cent. This, of course, is impossible. The high results are due, most likely, to incomplete extraction of the fat in the feces, in the determination of fat in those samples. The results were far from concordant, and would have to be about twice as great as they were found to be, if the digestibility of fat were reduced to 95 per cent. This difficulty in the determination of fats in feces seems to be related to the feeding of cottonseed meal, as the coefficients of digestibility of the

fats in the meat averages only a little higher than the average of published determinations. The coefficients of digestibility of carbohydrates in cottonseed meal are affected by the errors in the fat analyses, since the carbohydrates are determined by difference. The carbohydrates of the feces would appear too high, and this makes their digestibility appear too low.

The calculation of the digestibility of the combined fats and carbohydrates is not affected by errors in the fat determinations. The digestibility of the combined fats and carbohydrates averaged 70.1 per cent for the cottonseed meal and 78.0 per cent for the cottonseed flour. This is from 25 to 35 per cent lower than the digestibility of the combined fats and carbohydrates of cereals. The low results are probably due to the low digestibility of the carbohydrates of cottonseed meal and not to the fat, which seems to be very highly digested.

By assuming a factor for the digestibility of the fats, we can calculate the digestibility of the carbohydrates from the data of the experiments. Assuming that the coefficient of digestibility of the fat of cottonseed meal is approximately the same as that of animals, half way between its apparent digestibility and that of cereals (95 per cent), we find that the digestibility of the carbohydrates average 65.9 per cent for cottonseed meal, and 70.3 per cent for cottonseed flour. This may be compared with 60.6 per cent digested by ruminants. Man digests 98 per cent of the carbohydrates of cereals. The digestibility of the carbohydrates of cottonseed meal is about two-thirds of that of cereals. Cottonseed meal is a meat substitute, and since the percentage of carbohydrates is low and since cottonseed meal *contains no starch*, their low digestibility is not of much importance.

It will be noted that the calculated digestibility of the carbohydrates of cottonseed meal is 5 per cent less than that of cottonseed flour. While there may be an actual difference in the digestibility, the individual variations in the digestion of these nutrients by different men make such a conclusion unwarranted.

DIGESTIBLE NUTRIENTS IN COTTONSEED FLOUR AND MEAL.

In Table 3 we have calculated, based on the values given above, the digestible nutrients in cottonseed meal and flour and a number of other foods for comparison.

In order to make an exact comparison between vegetable foods, we have calculated the digestibility of carbohydrates in terms of fat by dividing the carbohydrates by 2.2. We have assumed that the digestibility of the fat of cottonseed flour is 95 per cent and that of the carbohydrates 68 per cent. The reasons for these assumptions have been explained above.

TABLE NO. 3.

Parts D gested by Man From One Hundred Parts Eaten.

	Protein digested.	Fat digested (including carbo-hydrates divided by 2.2).	Approximate relative fuel value.
Cottonseed meal (Texas)	36.94	18.51	37
Cottonseed flour	39.33	18.72	38
Eggs	12.80	11.40	18
Beef flank	19.01	20.04	30
Beef loin	15.91	16.05	24
Mutton (leg)	18.14	16.62	26
Cottonseed meal corn bread	7.91	18.42	22
Wheat bread (average)	7.82	25.50	30
Corn bread (corn meal, water and salt)	3.66	18.37	20
Cottonseed meal-corn meal (20% cottonseed meal)	13.95	32.22	39
Corn meal	7.59	36.85	41
Cottonseed meal-wheat flour (20% cottonseed meal)	15.63	30.14	38
Wheat flour	9.69	34.50	40
Cottonseed meal and wheat bakery products—			
50% water (minimum)	8.80	16.99	21
6% water (maximum)	16.52	31.93	40

Cottonseed meal and flour contain twice as much digestible protein as beef flank, three times as much as eggs and twice as much as mutton. Since cottonseed meal should be eaten mixed with wheat flour or corn meal, the above comparison might be misleading. The comparison can be made on the foods as eaten. The water content of the cottonseed bakery products varies from 6 per cent (ginger snaps) to 50 per cent (cottonseed meal-corn bread). The digestible protein of cottonseed meal-wheat bread has a minimum of 8.80 per cent and a maximum of 16.52 per cent. Then the digestible protein of cottonseed meal-wheat bread varies from one-third less to one-third more than that of eggs, and from half as much to as much as beef loin, according to the amount of water in the bread. So far as digestible protein is concerned, cottonseed meal bread averages equally as valuable as eggs, pound for pound. We have no information as to the relative values of the digestible protein to the body. They may or may not be of equal value. The digestible protein of *peas* and *beans* seems to be equally as valuable as that of meat. Cottonseed meal and flour are as rich in fat and fat-forming nutrients as beef loin, and mutton, much richer than eggs, and nearly as rich as beef flank. Cottonseed meal breads vary from an equal amount of these substances to twice as much as those in beef loin, depending on the water content of the bread. Since cottonseed meal contains no starch, the value of the digested carbohydrates could quite possibly be less than that of an equal amount of cereal carbohydrates. However, the major portion of the carbohydrates of cottonseed meal bread is derived from wheat or corn.

Fats have approximately twice as much fuel value as protein. Cottonseed meal flour has twice the fuel value of eggs, one-half more than that of beef loin and mutton. Cottonseed breads vary from a little more than the same fuel value, to more than twice the fuel value of eggs. It will be noted that the fuel value of wheat bread and that of mutton is nearly the same, but the fact should be emphasized that foods are richest in two different nutrients, and that the carbohydrates and

fats are not substitutes for protein in the body. It should always be borne in mind that *cottonseed meal is a meat substitute and not a flour substitute.*

THE NITROGEN BALANCE.

We can ascertain whether the food eaten in these digestion experiments was sufficient to supply the body with protein by estimating of the nitrogen balance. A certain amount of protein, or flesh, is daily decomposed in the body and eliminated in the urine. The amount eliminated depends upon the amounts of nutrients fed, the weight of the subject, and several other factors. The amount of protein required daily by men varies from about 75 grams to 125 grams. By subtracting the amount of nitrogen (or protein) eliminated in the urine from the amount digested, we can find out whether the food is furnishing sufficient protein. This has been done, and the results are shown in Table 4.

TABLE NO. 4.

Nitrogen Digested and Voided in Urine, in Grams.

Laboratory No.		Day.	Nitrogen Digested.	Nitrogen Voided.	Balance.
7727	Man 1, experiment 1, period 1	1	.....	11.7	
7730	Man 1, experiment 1, period 2	2	.....	14.0	
	Total	.....	34.3	25.7	+8.6
7734	Man 1, experiment 2, period 2	1	.....	9.7	
7735	Man 1, experiment 2, period 2	2	.....	12.0	
	Total	.....	25.2	21.7	+3.5
7742	Man 2, experiment 2, period 1	1	.....	13.8	
7746	Man 2, experiment 2, period 1	2	.....	14.3	
	Total	.....	32.3	28.1	+4.2
7755	Man 2, experiment 2, period 2	1	.....	14.5	
7757	Man 2, experiment 2, period 2	2	.....	9.3	
	Total	.....	31.8	23.8	+8.0
7756	Man 3, experiment 2, period 2	1	.....	15.0	
7758	Man 3, experiment 2, period 2	2	.....	13.7	
	Total	.....	29.7	28.7	+1.0
7769	Man 1, experiment 3	1	.....	10.0	
7771	Man 1, experiment 3	2	.....	11.5	
	Total	.....	27.4	21.5	+5.9
7770	Man 2, experiment 3	1	.....	9.2	
7772	Man 2, experiment 3	2	.....	9.5	
	Total	.....	32.2	18.7	+13.5

An examination of the table shows that, in every case, there was a slight gain in nitrogen by the body. The removal of meat from the diet and the substitution of cottonseed meal did not cause any loss of flesh. In four out of five of the cottonseed meal tests about fifty grams of cottonseed meal were fed daily. More than half of the protein came from the milk fed. With one-half gallon of milk, the body needs for protein were met with a little less than two ounces of cottonseed meal, and about seven ounces of corn meal daily.

TESTED RECIPES FOR COTTONSEED MEAL FOOD PRODUCTS.

In order to test the effect of continued eating of cottonseed meal upon the health of the human body, and to test in a practical way the palatability of food products containing cottonseed meal, cottonseed meal was used in the writer's home for a period of about ten days to the complete exclusion of meat.

It was hoped that sufficient cottonseed meal would be eaten for the observer to be able to judge whether there were any toxic effects. The subjects of the study, however, habitually eat more bread at breakfast in the form of buttered toast than they do the rest of the day. The removal of meat from the diet did not cause a corresponding increase in the consumption of breads. Less than one ounce of cottonseed meal per person per day was eaten, and the experiment throws no light on the possible toxicity of the meal. It *does* indicate that unless people using cottonseed meal in the diet are very hearty bread eaters, there would be little danger of overeating cottonseed meal, if the proportions of cottonseed meal and corn meal or wheat flour, found satisfactory in our cooking tests, were observed.

In this experiment a number of different cottonseed meal food products were prepared and eaten. It was desired to study at first hand the palatability of cottonseed meal prepared in different ways, and to determine to what extent, if any, the common recipes for corn meal and wheat flour products had to be modified in the use of cottonseed meal.

Hot Cakes.

Cottonseed meal or flour, sifted	⅓ cup
Wheat flour	1⅓ cups
Baking powder	1 teaspoonful
Sugar	1 teaspoonful
Lard	1 melted teaspoonful
Sweet milk	2 cups
Eggs	1

Mix the cottonseed meal with flour, mix the lard and sugar and beat the eggs into the mixture. Mix with the flour and make into a batter with the milk. Beat in the baking powder and cook as for ordinary wheat cakes.

These cakes tasted quite like ordinary wheat cakes. A little experience in cooking them is necessary, as with wheat cakes, to prevent the cakes from being soggy.

Cottonseed-Corn Bread.

Cottonseed meal or flour	⅓ cup
Corn meal	1⅓ cups
Sweet milk	2 cups
Baking powder	¾ teaspoonful
Salt	⅓ teaspoonful

Mix the corn meal and cottonseed meal with the salt and pour on

the water. Work the water in thoroughly, but use no more than is necessary for this purpose. Form the mass into loaves with the hands and bake in an oven, or on a slightly greased skillet on top of a stove.

This bread tasted well hot, but, like corn pone, it was not good when cold.

Cottonseed-Corn Cakes.

Cottonseed meal or flour	⅓ cup
Corn meal	1⅓ cups
Eggs	2
Lard	1½ teaspoonfuls

Make into a batter with water and cook as with ordinary corn or wheat cakes.

This product was eaten with butter and syrup, and was as agreeable in taste as ordinary corn cakes. The flavor of the cottonseed meal was not apparent, but that of the corn meal appeared to be altered. These cakes were readily eaten by a three-year-old child.

Cottonseed Meal-Sour Milk Biscuit.

Cottonseed meal or flour	½ cup
Wheat flour	2 cups
Sour milk	1½ cups
Butter or lard	1 teaspoonful
Baking powder	1 level teaspoonful
Soda	½ teaspoonful
Salt	1 teaspoonful

Sift salt with flour, chop in butter and milk, add baking powder and soda, and mix to a soft dough. Handle as little as possible. Roll out into a sheet ½ inch thick. Cut into rounds and bake in floured pans.

These biscuits were brown in color, were light, and had an agreeable taste.

Cottonseed Meal-Muffins.

Cottonseed meal or flour	½ cup
Wheat flour	2 cups
Butter	2 teaspoonfuls
Sugar	1 tablespoonful
Eggs	4
Milk (or water)	1 cup
Salt	¾ teaspoonful

Rub butter and sugar to a cream, beat into this the eggs, and then the milk or water. Sift baking powder and salt into the cottonseed meal and wheat flour, and add the butter-egg-milk mixture. Turn into a heated and greased muffin tin and bake in a very hot oven.

Cottonseed Meal Cake.

Cottonseed meal or flour	½ cup
Wheat flour	2 cups
Butter	1 tablespoonful
Eggs	2
Water	¾ cup
Sugar	1½ cups
Baking powder	1 teaspoonful
Vanilla	to suit

Mix the cottonseed meal, flour and baking powder. Cream the butter with the sugar, beat in the eggs and the water and vanilla. Mix with the flour mixture and bake. The cake may be stacked, with two layers spiced and one plain.

This cake was good. The flavor of cottonseed meal could not be detected, either in the spiced or unspiced layers.

The above recipes were similar to those which are recommended for wheat flour and corn meal, the only difference being that one-fifth of the flour or meal is substituted by cottonseed meal or flour. No modifications were found necessary. It seems safe to propose the following rule: *In preparing cottonseed meal bread and cakes, use one part cottonseed meal or flour to four parts corn meal or wheat flour, and use the same recipes commonly used for corn and wheat breads and cakes.* The reason we advise a proportion of one to four for the mixed meal or flour is that this proportion will produce a palatable food free from any objectionable taste or odor, and that there will be very little danger of overeating cottonseed meal so diluted. In our first experiment on the digestibility of cottonseed meal, we found that a bread made from one part cottonseed meal and two parts corn meal was extremely unpalatable and it was eaten with the greatest difficulty, amounting to a positive repugnance. Then it should be remembered that one of the most valuable properties of wheat flour is its ability to form light and porous cooked products. The greater the dilution of wheat flour with cottonseed meal, the heavier and therefore the more unpalatable the bread will become.

RELATIVE FOOD VALUE AND COST OF COTTONSEED MEAL.

Prime cottonseed meal costs about $32 per ton, which would be 1.6 cents per pound. Assuming that one-third was lost in sifting the meal before cooking (with sufficiently fine grinding much less would be lost), the cost per pound for digestible protein would be 5 cents. The cost per pound of digestible protein in eggs at 20 cents per dozen, and in round steak at 15 cents per pound, would be $1.06 and $.73, respectively. *A pound of digestible protein is 21 times as expensive in eggs and 15 times as expensive as meat as it is in cottonseed meal.* There are, of course, other factors than digestibility to be considered. Few persons will give up meat entirely in favor of cottonseed meal, except those who are driven by necessity to do so. That class is small at present, but in view of the rapidly decreasing supply of cattle in this country, and the accompanying rise in the cost

of meat, it is not impossible that a large number of people will be driven by economic reasons to search for meat substitutes. In such an emergency, cottonseed meal would deserve serious consideration. The available supply is enormous and is increasing yearly. It is cheaper than all but a very few of the staple foodstuffs, and is enormously cheaper than meats. In proportion to its food value, it is the cheapest foodstuff known to the writer. We are not advising the use of cottonseed meal as a complete substitute for meat; our knowledge of the toxic effect of cottonseed meal on pigs should make us cautious in using large amounts in the diet. About five ounces of cottonseed meal would have to be fed daily to take the place of meat completely. Whether this amount can be safely used, experience alone can tell. We have already shown, however, that the needs for protein of the subjects used in our experiments were met with a little less than two ounces of cottonseed meal daily, when about one-half gallon of milk was fed, together with an amount of corn meal necessary to make palatable bread.

SUGGESTIONS CONCERNING THE USE OF COTTONSEED MEAL.

The following suggestions (*Texas Bulletin,* 128) are made to those who desire to use cottonseed meal as a food:

The flour should be a bright yellow in color, free from any trace of rancidity, and of a sweet odor. Cottonseed meal is equally as valuable as cottonseed flour, if it is finely ground and sifted free from hulls and lint. Old meal, damaged meal, or dark meal should not be used.

A proportion of four parts corn meal or wheat flour to one part cottonseed meal has been found to give satisfactory results. A larger proportion of cottonseed meal should be avoided. The meal should be eaten as a *substitute for meat* and not in addition to it, unless it is known that the regular diet is deficient in protein. A diet too rich in any nutrient may easily cause trouble. We do not recommend the continued use of cottonseed meal in large amounts and as a complete substitute for meat, because we have at present no knowledge on that subject.

In the use of cottonseed meal *diluted with wheat flour or corn meal as recommended by us,* there will be little danger of an adult male eating more than two ounces of cottonseed meal daily. This, we believe, is a safe amount, and is equivalent to four ounces of meat. The average cooks should be able to prepare palatable foods from the recommended mixture, using the ordinary recipes for wheat and corn bread and cakes, with which she is familiar.

As regards the agreement of cottonseed meal with individuals, we quote here from Dr. Atwater's remarks concerning food in general:

"Different persons are differently constituted with respect to the chemical changes which their food undergoes in digestion and the effect produced, so that it may literally be true that one man's meat is another man's poison. Milk is for most people a very wholesome, digestible, and nutritious food, but there are persons who are made ill by drinking it, and they should avoid milk. The writer knows a boy who

is made seriously ill by eating eggs. A small piece of sweet cake in which eggs have been used will cause him serious trouble.

"The sickness is nature's evidence that eggs are for him an unfit article of food. Some persons have to avoid strawberries. . Indeed, cases in which the most wholesome kinds of foods are hurtful to individual persons are, unfortunately, numerous. Every man must learn from his own experience what food agrees with him and what does not."

ACKNOWLEDGMENT.

Most of the analytical work in connection with this bulletin was done by Messrs. Spaulding, Merry and Hudgins under the direction of Dr. Fraps.

TABLE NO. 5.

Percentage Water Lost in Preparation.

Laboratory No.	Portion.						Average.
	1.	2.	3.	4.	5.	6.	
7721	38.1	38.7	36.2	43.9	30.5	.....	35.5
7722	65.5	61.9	65.9	.....	.....	.....	64.4
7737	48.6	.....	.....	.....	.....	.....	48.6
7749	49.9	43.4	57.2	43.1	57.7	56.7	51.3
7750	65.2	65.1	66.7	66.9	66.5	67.2	66.3
7759	43.1	53.8	48.4	47.1	51.5	46.9	47.5
7774	49.3	50.4	50.0	47.6	48.0	48.4	49.0

TABLE NO. 6.

Urine Voided Daily.

Laboratory No.		Day.	Volume in c. c.
7727	Experiment 1, period 1, man 1	1	937
7730	Experiment 1, period 1, man 1	2	1240
7734	Experiment 1, period 2, man 1	1	860
7735	Experiment 1, period 2, man 1	2	700
7742	Experiment 2, period 1, man 2	1	1930
7746	Experiment 2, period 1, man 2	2	2300
7755	Experiment 2, period 2, man 2	1	1830
7756	Experiment 2, period 2, man 3	1	1820
7757	Experiment 2, period 2, man 2	2	2530
7758	Experiment 2, period 2, man 3	2	1730
7769	Experiment 3, man 1	1	1200
7770	Experiment 3, man 2	1	1809
7771	Experiment 3, man 1	2	970
7772	Experiment 3, man 2	2	2140

TABLE NO. 7.

Percentage Composition of Foods and Excrements.

Laboratory No.	Description.	Protein.	Grams nitrogen in 100 c. c.	Fat.	Crude Fiber.	Nitrogen-free extract.	Carbohydrates.	Water.	Ash.
7718	Bolted corn meal, all experiments	8.93	.....	2.77	1.22	75.91	.....	10.17	1.00
7719	Cottonseed meal (sifted)	46.33	.....	9.84	7.32	24.04	.....	6.69	5.78
7720	Milk, experiment 1, period 1, sample 1	3.55	.....	3.67	.....	.....	3.58	88.46	0.74
7721	Corn bread, experiment 1, period 1 (air dry)	8.24	.....	3.14	1.42	72.53	73.95	7.12	7.55
7722	Meat (chicken loaf), experiment 1, period 1	16.92	.....	9.76	1.39	3.72	.....	66.15	2.09
7723	Butter, experiments 1 and 2	.....	.....	84.59	.....	.....	.....	12.14	3.27
7727	Urine, experiment 1, period 1, man 1, 1st day	.....	1.244	.....	.....	.....	.....	.....	.....
7729	Milk, experiment 1, period 1, sample 2	3.66	.....	3.86	.....	.....	3.54	88.26	0.68
7730	Urine, experiment 1, period 1, man 1, 2nd day	.....	1.130	.....	.....	.....	.....	.....	.....
7732	Milk, experiment 1, period 2, sample 1	3.49	.....	3.50	.....	.....	3.85	88.46	0.70
7733	Milk, experiment 1, period 2, sample 2	3.38	.....	4.08	.....	.....	3.37	88.50	0.67
7734	Urine, experiment 2, period 2, man 1, 1st day	.....	1.127	.....	.....	.....	.....	.....	.....
7735	Urine, experiment 2, period 2, man 1, 2nd day	.....	1.717	.....	.....	.....	.....	.....	.....
7736	Excrement, experiment 1, period 1, man 1 (dry)	28.59	.....	21.44	9.34	11.40	20.73	10.12	19.12
7737	Bread (cottonseed meal), dried	19.93	.....	4.14	3.57	60.87	64.44	5.71	5.78
7739	Milk, experiment 2, period 1, sample 1	3.43	.....	3.50	.....	.....	3.29	89.02	0.76
7741	Milk, experiment 2, period 1, sample 2	2.96	.....	3.22	.....	.....	4.25	88.85	0.72
7742	Urine, man 2, experiment 2, period 1, 1st day	.....	0.714	.....	.....	.....	.....	.....	.....
7745	Excrement, experiment 1, period 2, man 1 (dry)	25.99	.....	8.08	8.87	28.14	37.01	5.40	23.52
7746	Urine, man 2, experiment 2, period 1, 2nd day	.....	0.623	.....	.....	.....	.....	.....	.....
7748	Milk, experiment 2, period 2, sample 1	3.55	.....	4.06	.....	.....	3.46	88.24	.69
7749	Corn bread, experiment 2, dried	8.84	.....	2.72	1.44	77.67	79.11	8.80	3.89
7750	Meat, experiment 2, period 1	15.83	.....	9.17	1.02	4.01	.....	67.77	2.22
7752	Milk, experiment 2, period 2, sample 2	3.46	.....	5.03	.....	.....	2.24	88.54	.73
7753	Butter, experiment 2, period 2, man 2, 1st day	.....	.....	91.64	.....	.....	.....	7.15	1.21
7755	Urine, man 2, experiment 2, period 2, 1st day	.....	.793	.....	.....	.....	.....	.....	.....
7756	Urine, man 3, experiment 2, period 2, 1st day	.....	.823	.....	.....	.....	.....	.....	.....
7757	Urine, man 2, experiment 2, period 2, 2nd day	.....	.397	.....	.....	.....	.....	.....	.....
7758	Urine, man 3, experiment 2, period 2, 2nd day	.....	.794	.....	.....	.....	.....	.....	.....
7759	Cottonseed meal bread, experiment 2, period 2 (air dry)	16.32	.....	4.26	3.05	65.80	68.85	5.03	5.54
7760	Excrement, man 2, experiment 2, period 1	30.36	.....	22.05	10.42	11.17	21.59	6.00	20.00
7765	Milk, experiment 3, sample 1	3.55	.....	5.30	.....	.....	4.00	86.48	0.67
7766	Butter, experiment 3	.....	.....	93.48	.....	.....	.....	5.38	1.14
7767	Excrement, man 2, experiment 2, period 2	25.45	.....	7.35	12.27	28.42	40.69	8.29	18.22
7768	Milk, experiment 3, sample 2	3.14	.....	3.46	.....	.....	4.47	88.26	0.67
7769	Urine, man 1, experiment 3, 1st day	.....	.829	.....	.....	.....	.....	.....	.....
7770	Urine, man 2, experiment 3, 1st day	.....	.486	.....	.....	.....	.....	.....	.....
7771	Urine, man 1, experiment 3, 2nd day	.....	1.184	.....	.....	.....	.....	.....	.....
7772	Urine, man 2, experiment 3, 2nd day	.....	.443	.....	.....	.....	.....	.....	.....
7773	Excrement, man 3, experiment 2, period 2	29.25	.....	11.30	10.04	24.58	34.62	7.32	17.51
7774	Cottonseed meal bread, experiment 3, dried	17.67	.....	4.59	2.20	66.92	69.12	2.77	5.85
7775	Cottonseed flour, experiment 3	50.16	.....	10.96	3.92	22.95	26.87	6.25	5.76
7776	Excrement, man 1, experiment 3	30.06	.....	14.18	4.86	32.45	.....	9.51	18.93
7777	Excrement, man 2, experiment 3	30.00	.....	10.61	6.31	23.32	29.63	10.79	18.97

TABLE NO. 8.

Nutrients Fed, Excreted and Digested. Experiment 1, Period 1, Man No. 1.

Laboratory No.		Gm., Protein.	Gm., Fat.	Gm., Carbohydrates.
	Weight at beginning, 51.7 kilo.			
	Weight at end, 52.1 kilo.			
	Fed—			
7720	Milk, 929 gms.	33.0	34.1	33.3
7729	Milk, 1730 gms.	63.3	66.8	61.3
7722	Meat, 600 gms.	101.5	58.6	30.9
7723	Butter, 58 gms.	.....	49.1	.....
	Bread, 57 gm. = 35.3 gm., air dry.			
	Bread, 148 gm. = 90.7 gm., air dry.			
	Bread, 80 gm. = 51.0 gm., air dry.			
	Bread, 32 gm. = 17.9 gm., air dry.			
	Bread, 130 gm. = 90.3 gm., air dry.			
7721	Bread, total. . . . . 285.2 gm., air dry.	23.5	9.0	210.9
	Eaten	221.3	217.6	336.2
7736	Excreted, 24.8 gm.	7.1	5.3	5.1
	Digested	214.2	212.3	331.1
	Digested from milk, butter and corn	113.4	150.6	290.9
	Digested from meat	100.8	61.7	40.2
	Percentage digested meat	99.3	100.0	100.0

TABLE NO. 8—Continued.

Nutrients Fed, Excreted and Digested. Experiment 1, Period 2, Man No. 1.

Laboratory No.		Gm. Protein.	Gm., Fat.	Gm. Carbohydrates.	Gm. Combined fat and carbohydrates.	Gm. Carbohydrates (fats assumed 95% digested).
	Weight at beginning 51.4 kilo.					
	Weight at end 50.5 kilo.					
	Fed—					
7732	Milk 1488 gm	51.9	52.1	57.3	.....	.....
7733	Milk 2382 gm	80.5	97.2	80.3	.....	.....
7737	Bread 350 gm. = 180 gm. air dry { corn meal	10.6	3.3	91.0	.....	.....
	{ cottonseed meal	25.3	4.1	24.0	.....	.....
	Eaten	168.3	156.7	253.5	.....	.....
7745	Excreted 40.3 gm	10.5	3.2	14.9	.....	.....
	Digested	157.8	153.5	238.6	.....	.....
	Digested from milk and corn meal	137.5	144.7	225.0	.....	.....
	Digested from cottonseed meal	20.3	8.8	13.6	.....	.....
	Percentage digested from cottonseed meal	80.2	100.0	56.7	79.7	78.3

TABLE NO. 8—Continued.

Nutrients Fed, Excreted and Digested. Experiment 2, Period 1, Man No. 2.

Laboratory No.		Gm., Protein.	Gm., Fat.	Gm., Carbohydrates.
	Weight at beginning, 54.3 kilo.			
	Weight at end, 53.6 kilo.			
	Fed—			
7739	Milk, 880 gm	30.2	30.8	29.0
7741	Milk, 1850 gm	54.8	59.6	78.6
7750	Meat, 600 gm	95.0	55.0	30.2
7723	Butter, 93 gm	.....	78.7	.....
	Bread, 132 gm. = 66.1 gm., air dry.			
	Bread, 97 gm. = 54.9 gm., air dry.			
	Bread, 215 gm. = 92.0 gm., air dry.			
	Bread, 36 gm. = 20.5 gm., air dry.			
	Bread, 200 gm. = 84.6 gm., air dry.			
	Bread, 200 gm. = 86.6 gm., air dry.			
7749	Bread, total.....404.7 gm., air dry	35.8	11.0	320.2
	Eaten	215.8	235.1	458.0
7760	Excreted, 45.0 gm	13.7	9.9	9.7
	Digested	202.1	225.2	448.3
	Digested from milk, butter and corn	112.9	170.6	419.4
	Digested from meat	89.2	54.6	28.9
	Percentage digested, meat	93.9	99.3	95.7

TABLE NO. 8—Continued.

Nutrients Fed, Excreted and Digested. Experiment 2, Period 2, Man No. 2.

Laboratory No.		Gm., Protein.	Gm., Fat.	Gm. Carbohydrates.	Gm. Combined fat and carbohydrates.	Gm. Carbohydrates (fats assumed 95% digested).
	Weight at beginning 53.0 kilo.					
	Weight at end 53.9 kilo.					
	Fed—					
7748	Milk 1024 gm.	36.4	41.6	35.4	.....	.....
7752	Milk 2782 gm.	96.2	139.9	62.3	.....	.....
7753	Butter 120 gm.	.....	110.0	.....	.....	.....
	Bread 150 gm.= 85.4 gm. air dry.					
	Bread 200 gm.= 92.4 gm. air dry.					
	Bread 180 gm.= 92.9 gm. air dry					
	Bread 160 gm.= 84.6 gm. air dry					
	Bread 200 gm.= 97.0 gm. air dry					
	Bread 175 gm.= 92.9 gm. air dry					
7759	Bread, total....545.2 gm. air dry { corn meal	38.6	12.0	333.5	.....	.....
	{ cottonseed meal	50.3	11.2	41.9	.....	.....
	Eaten	221.5	314.7	473.1	.....	.....
7767	Excreted 88.2 gm.	22.5	6.5	35.9	.....	.....
	Digested	199.0	308.2	437.2	.....	.....
	Digested from corn, milk and butter	161.4	287.7	426.5	.....	.....
	Digested from cottonseed meal	37.6	20.5	10.7	.....	.....
	Percentage digested from cottonseed meal	74.7	100.0	25.5	58.8	48.

TABLE NO. 8—Continued.

Nutrients Fed, Excreted and Digested. Experiment 2, Period 2, Man No. 3.

Laboratory No.		Gm., Protein.	Gm., Fat.	Gm. Carbohydrates.	Gm. Combined fat and carbohydrates.	Gm. Carbohydrates (fats assumed 95% digested).
	Weight at beginning 58.8 kilo.					
	Weight at end 58.6 kilo.					
	Fed—					
7748	Milk 1241 gm.	44.1	50.4	42.9	.....	.....
7752	Milk 2297 gm.	79.5	115.6	51.5	.....	.....
7753	Butter 113 gm.	.....	103.6	.....	.....	.....
	Bread 150 gm.= 85.3 gm. air dry					
	Bread 168 gm.= 77.6 gm. air dry					
	Bread 180 gm.= 92.9 gm. air dry					
	Bread 160 gm.= 84.6 gm. air dry					
	Bread 184 gm.= 89.2 gm. air dry					
	Bread 175 gm.= 92.9 gm. air dry					
7759	Bread, total....522.5 gm. air dry { corn meal	37.0	11.5	319.6	.....	.....
	{ cottonseed meal	48.3	10.8	40.2	.....	.....
	Eaten	208.9	291.9	454.2	.....	.....
7773	Excreted 80.3 gm.	23.5	9.1	27.8	.....	.....
	Digested	185.4	282.8	426.4	.....	.....
	Digested from milk, butter and corn	151.3	266.5	405.8	.....	.....
	Digested from cottonseed meal	34.1	16.3	20.6	.....	.....
	Percentage digested from cottonseed meal	77.9	100.0	51.2	72.3	65.4

TABLE NO. 8—Continued.

Nutrients Fed, Excreted and Digested. Experiment 3, Man No. 1.

Laboratory No.		Gm., Protein.	Gm., Fat.	Gm. Carbohydrates.	Gm. Combined fat and carbohydrates.	Gm. Carbohydrates (fats assumed 95% digested).
	Weight at beginning 52.1 kilo.					
	Weight at end 51.5 kilo.					
	Fed—					
7765	Milk 1204 gm	42.8	42.1	48.2	.....	.....
7768	Milk 2090 gm	65.6	72.3	93.4	.....	.....
7766	Butter 120 gm	.....	112.2	.....	.....	.....
	Bread 124 gm.= 62.9 gm. air dry					
	Bread 180 gm.= 89.3 gm. air dry					
	Bread 180 gm.= 90.0 gm. air dry					
	Bread 180 gm.= 94.3 gm. air dry					
	Bread 190 gm.= 98.8 gm. air dry					
	Bread 180 gm.= 92.9 gm. air dry					
	—— { corn meal	35.5	10.5	293.3	.....	.....
7774	Bread, total.....468.2 gm. air dry { cottonseed flour	47.2	11.0	30.4	.....	.....
	Eaten	191.1	248.1	465.3	.....	.....
7776	Excreted 64.7 gm	19.5	9.2	24.1	.....	.....
	Digested	171.6	238.9	441.2	.....	.....
	Digested from corn meal, milk and butter	134.0	224.8	426.3	.....	.....
	Digested from cottonseed flour	37.6	14.1	14.9	.....	.....
	Percentage digested from cottonseed flour	79.7	100.0	49.0	70.1	61.2

TABLE NO. 8—Continued.

Nutrients Fed, Excreted and Digested. Experiment 3, Man No. 2.

Laboratory No.		Gm., Protein.	Gm., Fat.	Gm. Carbohydrates.	Gm. Combined fat and carbohydrates.	Gm. Carbohydrates (fats assumed 95% digested).
	Weight at beginning 53.9 kilo.					
	Weight at end 53.4 kilo.					
	Fed—					
7765	Milk 1269 gm	45.1	67.3	50.8	.....	.....
7768	Milk 2463 gm	77.3	85.2	110.1	.....	.....
	Bread 180 gm.= 91.3 gm. dried					
	Bread 200 gm.= 99.2 gm. dried					
	Bread 180 gm.= 90.0 gm. dried					
	Bread 180 gm.= 94.3 gm. dried					
	Bread 200 gm.=104.0 gm. dried					
	Bread 180 gm.= 92.9 gm. dried					
	—— { corn meal	41.4	12.8	358.2	.....	.....
7774	Bread, total.....571.7 gm. dried { cottonseed meal	59.6	13.4	37.0	.....	.....
	Butter 120 gm	.....	112.2	.....	.....	.....
	Eaten	223.4	290.9	556.1	.....	.....
7777	Excreted 74.2 gm	22.3	7.9	22.0	.....	.....
	Digested	201.1	283.0	534.1	.....	.....
	Digested from corn, milk and butter	153.9	263.3	508.7	.....	.....
	Digested from cottonseed flour	47.2	19.7	25.4	.....	.....
	Percentage digested from cottonseed flour	79.2	100.0	68.7	85.8	79.4

SUMMARY AND CONCLUSIONS.

(1) Cottonseed meal or flour contains about four times as much protein as eggs and three times as much as beef loin. Cottonseed meal food products made from one part cottonseed meal and four parts wheat flour contain from one-third less to one-third more protein than eggs, depending on the amount of water in the bread. Cottonseed meal is, therefore, a meat substitute and not a flour substitute.

(2) Seven digestion experiments were made with men; three being with cottonseed meal, two with cottonseed flour, and two with meat.

(3) The digestibility of the protein of cottonseed meal averaged 77.6 per cent and that of cottonseed meal-flour 78.4 per cent, as compared with 96.6 per cent for the protein of meat. The protein of cottonseed meal and that of cottonseed flour is equally digested. It is eight-tenths as digestible as that of meat and nine-tenths as digestible as that of cereals, and equally as digestible as that of peas and beans.

(4) The digestibility of the fat of cottonseed meal and flour appears to be very high. The fats are probably digested about 95 per cent and the carbohydrates about 68 per cent. The fat of meat was digested 99 per cent. The fat of cottonseed meal seems to be more completely digested than that of cereals, and practically the same as that of meat. The carbohydrates of cottonseed meal are about seven-tenths as digestible as that of cereals.

(5) Cottonseed meal and flour contain twice as much digestible protein as beef flank, three times as much as eggs, and twice as much as mutton. Cottonseed food products made from one part cottonseed meal and four parts wheat flour, contain from one-third to less than one-half more digestible protein than eggs. The digestible fat and carbohydrates of cottonseed meal, calculated as fat, are nearly equal in amount to that of beef flank, and more than equal to that of beef loin and mutton leg.

(6) In these experiments the needs of the body for protein were met with a daily ration of approximately two ounces cottonseed meal or flour, one-half gallon milk, and eight ounces corn meal. If the milk were removed from this ration, about twice as much cottonseed meal and corn meal would have to be fed to maintain the protein in the bodies of the subjects.

(7) A number of recipes for cottonseed food products are given. These foods were equally as palatable as similar ones made from corn meal or wheat flour.

In preparing cottonseed cakes or bread, use one part cottonseed meal or flour to four parts corn meal or wheat flour, and use the same recipes commonly used for wheat and corn bread and cakes.

(8) A pound of digestible protein is 21 times as expensive in eggs, and 15 times as expensive in meat, as it is in cottonseed meal.

(9) One part of fresh, sweet meal, sifted free from hulls and lint, should be used mixed with at least four parts of corn meal or wheat flour. Diluted in this way, few people will be able to eat more than two ounces of cottonseed meal daily. Cottonseed meal should not be eaten *in addition* to meat, unless it is known that too little meat is being eaten.