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DIGESTION EXPERIMENTS.

MILCH COWS.

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DIGESTION EXPERIMENTS.

BY HARRY SNYDER.

OBJECT OF THE BULLETIN AND EXPLANATION OF TERMS.

This bulletin contains the results of experiments upon the digestibility and manurial value of pea ensilage and wheat bran when fed to milch cows. The results show what becomes of each ingredient of the food, the amounts of each recovered in the milk, returned in the dung and urine and the amount required as fuel to carry on the vital functions. These experiments are given in detail so as to serve as an outline for the remaining experiments upon the composition and digestibility of barley and shorts, barley, corn and shorts and corn, fed to grown pigs; and corn and bran, peas and bran and peas, when fed to growing pigs.

The determination of the digestibility of a fodder is simply finding the amount of it that can be utilized by the animal. A fodder, as clover, is said to be sixty per cent digestible; this means that out of every hundred pounds of the dry clover hay, sixty pounds are broken down in the digestive tract, and forty pounds are not acted upon, but leave the body undigested in the dung. Each constituent of every fodder has its own digestibility.

A digestion experiment is carried on in the following way: An animal, as a cow, sheep or pig is fed for some time upon the particular food in question, the food being carefully weighed and analyzed. This is carried on at first simply for a preliminary feeding period, the object of which is to get the animal in the same condition as it will be later on when the experiment is in progress. After this preliminary feeding all

of the dung is collected as evacuated, weighed and analyzed. This is done for a number of days. The dung and urine made for any number of days are the products of the food for an equal period. In the dung a certain portion of each of the components of the food is returned undigested; this is determined, and this amount not digested, when taken from the amount of that ingredient in the original food gives the amount digested. The results are usually expressed in percentages, and the per cent digested is called the digestion coefficient.

The names of the different fodder constituents, and the terms used in this bulletin may not be familiar to some readers, and are here briefly explained.

All food stuffs are composed of water and dry matter; the water is sensibly present in the juices, and even in field cured hay or fodder corn there is always more or less water. The larger part of the dry matter when burned is converted into smoke, while a small portion remains as ashes. The part that is burned is called the organic part.

The first general division of the constituents of fodders and food stuffs, then, is into water and dry matter; and the second, the dry matter into ash and organic matter. A farther division of the organic part is made into those compounds that contain an element or building unit known as nitrogen, and those that do not contain this element. The compounds that contain nitrogen are called nitrogenous compounds, while those that contain no nitrogen are called non-nitrogenous. All fodders contain from four to ten times more of the non-nitrogenous compounds than of the nitrogenous ones.

The most important among the nitrogenous compounds is crude protein, which includes a large class that have certain characteristics in common, one of them being that they all contain about the same per cent—16%—of the element nitrogen. The white of an egg is a typical example; lean meat is composed largely of these kinds of substances. The protein compounds of food stuffs are extremely valuable as animal food inasmuch as they contain the building materials that compose the muscles. Crude protein is usually

spoken of as muscle or flesh forming material. The protein compounds are more familiarly known as the crude albuminoids; in this work, however, both terms are used, each one having a separate meaning. Some authorities* restrict the term albuminoids to such bodies as gelatine, while others use proteids and albuminoids as synonymous terms. All albuminoids are proteids, while not all of the so called proteids, as usually determined, are albuminoids. In the analysis of plants and food stuffs the total nitrogen that is found is taken as the basis for determining the crude protein. All of the nitrogen thus determined is not in the form of albuminoids, and can not be taken as a basis for determining the albuminoids. These are determined from the albuminoid nitrogen alone. Hence the distinction is made between the total nitrogen and the nitrogen that belongs only to the albuminoids. In the columns headed "Crude Protein" the total nitrogen is taken as the basis for its determination, while in the column headed "Albuminoids" the albuminoid nitrogen is taken as the basis.

Ether Extract is the material which is extracted from fodders by ether, and is composed largely of fat, with variable quantities of foreign substances such as wax and coloring matter. In fodder analyses this is sometimes called fat or oil, but it is not pure fat.

Crude Fiber is the woody part of plants; it belongs to the same group of chemical substances as starch and sugar. In young and tender plants the fiber is more digestible than when the plant becomes tough and woody.

Nitrogen Free Extract is the name given to the remaining compounds that contain no nitrogen—free from nitrogen—and are soluble in weak acid and alkaline solutions. Such are the jellies, sugars and starches.

The ether extract, the crude fiber, and the nitrogen free extract, when digested supply the body with heat and produce fat, while the main functions of the protein compounds is to supply the materials for the muscles and waste matter. Hence the two general classes of compounds in food are the

*Johnson.

nitrogenous or flesh forming, and the non-nitrogenous or heat and fat producing bodies.

These different classes of compounds, found in food stuffs, are not equally digestible, the fibrous or woody part usually being less digestible than the starches or sugars. Each separate compound of a fodder has its own digestibility or digestion coefficient, which it is the object of a digestion experiment to determine.

Many digestion experiments have been made with nearly all the different animal foods, and the results obtained have been of material value. The importance of this work was clearly foreseen by the framers of the Hatch bill, establishing experimental stations, who in particular mentioned digestion experiments as one of the important lines of work to be conducted by them.

I. PEA ENSILAGE.

Digestibility and Value as a Cattle Food.

The few digestion experiments that have heretofore been made with peas and pea meal, show that pea meal is one of the most digestible and valuable of animal foods; but little, however, seems to have been done in the way of determining the digestibility and value of the whole plant either field cured, or ensilaged, as cattle food. The following experiment was carried out in order to obtain some data in regard to this question, particularly when the ensilage is fed to milch cows.*

The peas were cut while green and put into a separate compartment of an experimental silo, which was opened early in March, 1892. When opened, the ensilage was sweet and in good condition, and an analysis of it showed that it had the following composition:

Composition in Pounds Per Hundred of Dry Matter.						
Water.	Dry Matter	Ash.	Ether Ex-tract.	Crude Pro-tein.	Crude Fi-bre.	Nitro. Free Extract.
50.08	49.92	6.95	3.13	11.90	26.00	52.02

The points to be observed from this analysis are: That the material contains a comparatively large percentage of nitrogenous compounds, more ash and less water than ordinary ensilaged cattle foods; these are points that are all in its favor.

At the time this silo was opened the cows were receiving a corn ensilage and mixed grain ration; and some of the cows when gradually changed to pea ensilage and less grain did not seem to relish it as well as the usual corn ensilage,

*For the manner of growing peas, and their yield, the reader is referred to Bulletin No. 20, of this Station.

while others ate it equally as well. With different cows there was a difference as to the apparent palatability of the pea ensilage. Many cows that refused to eat the pure ensilage alone were induced to eat liberal quantities of it by mixing bran, timothy, or corn with it. The feeding was not carried on with a sufficient number of milch cows or for a period of sufficient length to warrant any definite conclusions as to the effects upon the yield or composition of the milk; however, the daily dairy record of the herd shows no appreciable variations either in the total yield of milk or fat while the pea ensilage was being fed. This ration of pea ensilage and bran, however, took the place of one of corn ensilage, hay, and a mixed grain ration consisting of 5 lbs. barley, 3 lbs. bran and 1 lb. oil meal per day, with a saving of the more expensive barley meal and oil meal.

The two cows selected for this experiment were Sully and Bess. Both cows were of about the same age, and had been in milk for about five months. The daily ration consisted of a mixture of thirty-four pounds of pea ensilage and twelve pounds of wheat bran. The food was restricted to these two articles so as not to introduce other factors in the experiment. The preliminary feeding lasted fourteen days. During this time the cows were gradually accustomed to the confinement and the constant presence of an attendant. Beginning at noon on March 25th and ending at noon on March 30, the solid and liquid excrements were caught as evacuated, by an attendant constantly in charge both day and night. This constant attendance prevented losses and removed many of the sources of error, such as the mixing of the dung and urine and the use of absorbents for collecting them. All of the food fed to each cow was eaten, leaving no factor for food rejected, or leavings. A daily record was kept of the weight of each cow and also the water consumed. The manure of each cow was mixed and sampled in duplicate at three different times during the experiment. The analyses of the food consumed, the manure at the different times of sampling, the milk yielded, and the urine voided, are given in tabular form on the following pages.

A sample of the pea ensilage was taken at every removal

of the ensilage from the silo, and the average of the results show the composition of the pea ensilage fed:

(Pounds per hundred of the dry matter.)							
Water.	Dry Mat- ter.	Crude Protein.	Ash.	Ether Ex- tract.	Fiber.	Nito. Free Extract.	True Al- bumin- oids.
52.88	47.12	11.90	6.50	3.00	25.00	53.60	10.50

Comparing the results of the analysis when the silo was opened, with the average results of the ensilage fed, it will be observed that the ensilage was quite uniform in composition, the water being the most variable constituent.

The wheat bran fed with the pea ensilage had the following composition, the results being expressed in pounds per hundred of the dry-matter:

Dry Mat- ter.	Ash.	Crude Protein.	Ether Ex- tract.	Crude Fiber.	NitroFree Extract.	True Al- bumin- oids.
90.00	4.20	13.20	3.1	6.00	73.50	12.00

During the five days that the dung and urine were collected, 170 pounds of ensilage and 60 pounds of wheat bran were fed to each cow; and the number of pounds of each nutrient fed in both the pea ensilage and wheat bran, and the totals, are given in the following table:

POUNDS OF FOOD COMPOUNDS CONSUMED.

Kind of Food.	Water Pounds	Dry Matter Pounds	Ash Pounds	Crude Protein Pounds	Ether Ex- tract Pounds	Crude Fiber Pounds	Nitrogen Free Extract Pounds	True Albu- minoids Pounds
In 170 lbs. Pea Ensilage	89.9	80.1	5.206	9.53	2.40	20.04	42.94	8.41
In 60 lbs. Wheat Bran...	6.0	54.0	2.27	7.18	1.67	3.22	39.69	6.48
In 230 lbs. Totals.....	95.9	134.1	7.47	16.71	4.07	23.26	82.63	14.89

The total nitrogen present in the dung is but partly in the form of undigested protein compounds; the bile contains compounds, such as glycocholic acid, which contains nitrogen and are digested products. In the crude protein column a correction is made for these small amounts of digested nitrogenous compounds. In the tables, the samples A and B are duplicate samples of the manure for the same period, and the results that are given for each sample are the averages of duplicate analyses, making in all a total of twelve analyses of the manure of each cow.

BESS.—SOLID EXCREMENTS.

Description of Samples.				Composition of Dry Manure per Hundred Pounds.											Totals
Period	Time in hours	Total pounds of Manure	Samples	Water per Cent	Dry Matter per Cent	Ash	Crude Protein	Ether Extract	Nitrogen Free Extract	Crude Fiber	Total Nitrogen	Albuminoid Nitrogen	True Albu- minoids		
First...	36	55.	A	84.50	15.50	9.03	11.40	2.06	46.10	31.41	1.82	1.37	8.56		
			B	84.30	15.70	9.21	11.52	2.04	46.01	31.22	1.84	1.34	9.00		
Second	36	61.5	A	84.85	15.12	8.90	10.44	2.54	47.00	30.52	1.67	1.36	8.50		
			B	85.41	14.59	9.00	10.37	2.70	47.17	30.76	1.66	1.31	8.18		
Third..	48	89.25	A	84.23	15.87	8.90	10.06	2.85	46.64	31.65	1.61	1.31	8.10		
			B	85.03	14.97	9.08	9.62	3.00	46.74	31.56	1.54	1.30	8.12		

POUNDS OF EACH CONSTITUENT IN THE MANURE.

First...	36	55	O Average. O	46.50	8.50	.785	.893	.175	3.951	2.68	.157	.116	.753	8.50
Second	36	61.5		52.35	9.15	.818	.952	.239	4.307	2.80	.152	.121	.762	9.12
Third..	48	89.25		75.08	14.16	1.274	1.394	.413	6.61	4.41	.224	.184	1.15	14.16
Totals	5 days	205.75		173.93	31.81	2.877	3.239	.829	14.87	9.95	.534	.422	2.666	31.78

SULLY.—SOLID EXCREMENTS.

Description of Samples.				Composition of Dry Manure per Hundred Pounds.										
Period	Time in Hours	Total Pounds Manure	Sam- ples	Water per Cent	Dry Matter per Cent	Ash	Crude Protein	Ether Ex- tract	Nitrogen Free Extract	Crude Fiber	Total Nitrogen	Albumi- nal Nitrogen	True Albu- min- oids	Total
First...	36	58.5	A	84.00	16.00	9.51	11.13	2.43	46.81	30.12	1.78	1.31	8.18	100
			B	84.12	15.88	9.33	10.85	2.66	46.96	30.20	1.72	1.37	8.56	
Second	36	59.25	A	84.81	15.19	8.40	10.31	2.90	50.26	28.13	1.63	1.29	8.06	100
			B	84.25	15.75	8.55	10.19	3.15	50.11	28.00	1.65	1.33	8.31	
Third	48	84.25	A	84.85	15.15	8.42	9.88	2.44	45.71	34.55	1.58	1.26	7.93	100
			B	85.89	14.11	8.59	10.26	2.12	45.62	33.41	1.63	1.30	8.18	

POUNDS OF EACH CONSTITUENT IN THE MANURE.

First...	36	58.5	0 Average 0	49.18	9.32	.864	.985	.237	4.39	2.82	.163	.125	.781	9.31
Second	36	59.25		50.08	9.17	.778	.940	.278	4.60	2.57	.154	.120	.752	9.17
Third..	48	84.25		71.95	12.80	1.05	1.248	.280	5.60	4.15	.197	.158	.996	12.32
Totals	5 days	202		171.25	30.79	2.692	3.173	.795	14.59	9.54	.514	.402	2.529	30.80

From these tables it will be observed that the manure from each cow was quite constant in composition and quantity, the water again being the most variable constituent. The average number of pounds of manure made by Sully per day being 40.5, by Bess 41.2. Taking the yield and the composition of the manure as an index to the condition of the digestive tract, it appears that all of the functions were carried on with uniformity, since both the yield and the composition of the manure were constant.

SUMMARY OF RESULTS.

Kind of Sample	Dry Matter	Ash	Organic Matter	Crude Protein	Ether Extract	Crude Fiber	Nitrogen Free Extract
BESS.							
Total pounds in food.....	134.1	7.47	126.6	16.71	4.07	23.26	82.63
Total pounds in manure.....	31.81	2.88	28.93	3.24	.83	9.95	14.87
Pounds digested.....	102.29	4.59	97.66	13.47	3.24	13.31	67.76
Co-efficient of digestibility...	75.5	61.4	77.	80.6	79.6	56.9	82.
SULLY.							
Total pounds in food.....	134.1	7.47	126.6	16.71	4.07	23.26	82.63
Total pounds in manure.....	30.79	2.69	28.1	3.17	.80	9.54	14.59
Pounds digested.....	103.31	4.78	98.5	13.54	3.27	13.72	68.04
Co-efficient of digestibility...	76.9	63.9	77.8	81.2	80.3	58.9	82.3

Two determinations of the digestibility of wheat bran will be found in another article in this bulletin; in one case wheat bran is found to be *more* digestible and in another *less* digestible than the mixed pea ensilage and bran. From these facts it appears that the pea ensilage alone must be at least as digestible as the bran. The effect of one food upon the digestibility of another is not well known; shorts and bran are both more digestible in one grain ration than in another. The bran fed in these experiments contained less fiber and ash than ordinary bran, and in this respect resembled more the composition of shorts. This would tend to increase the digestibility of the bran. The digestibility of the bran can not be assumed, and the pea ensilage digestibility determined by difference, inasmuch as there are two un-

known factors that tend to increase the digestibility of the pea ensilage, viz: A different composition from ordinary bran, and combination with a more digestible food.

Whatever these unknown factors may be the results show that the pea ensilage alone can not be less digestible than the results given for the peas and bran, and making due allowance for these two factors, the digestibility of the pea ensilage is, no doubt, not far from the figures assigned to the mixture.

The results farther show that when pea ensilage is introduced into the feed of milch cows, it forms the basis of a very digestible ration.

Comparing the digestion work of these two cows, it will be observed that there is a marked uniformity. About one per cent more of the total organic matter was digested by Sully than by Bess. With Sully there was a slightly greater tendency toward the more complete digestion of the nitrogenous compounds.

Milk Yield.—Complete analyses were made of the milk from each milking. In the five days Sully gave 98.5 pounds of milk, and Bess gave 108.7. The total number of pounds of fat, ash, sugar, casein, and solids, in the milk of each cow for the five days were:

	Total pounds of milk	Water	Solids	Ash	Fat	Casein	Sugar
Sully..	98.5	85.3	13.2	7.51	4.557	3.83	4.06
Bess...	108.7	97.2	11.5	.62	3.667	3.30	3.91

From the same number of pounds of food Bess gave ten pounds more milk than Sully; but the 108 pounds of milk from Bess contained less fat and solids than the 98.5 pounds given by Sully. Sully's milk, although ten pounds less, produced .89 pounds more of fat, which if made into butter would make a difference of over one pound in five days. Each cow consumed 134.1 pounds of dry matter in the food to produce 13.2 and 11.5 pounds respectively of solid matter in the milk.

In the case of Bess 8.58 per cent of the solid matter of the

food was returned in the solid matter of the milk, while with Sully 9.85 per cent was returned. The difference in the weight of the solid matters digested by the two cows, 1.02 pounds, does not entirely account for the difference in the solid matter of the milk produced, 1.7 pounds. This question will be farther discussed after considering the amount of the nitrogen of the food retained in the body of each cow, and the gain and loss in live weight.

The composition and quantity of the urine is another important factor in determining the completeness of the digestive process, inasmuch as over half of the nitrogen of the food, in these experiments, was returned in the urine.

AVERAGE COMPOSITION OF A HUNDRED POUNDS OF URINE.

	Total Lbs.	Water.	Solids.	Ash.	Total Nitro.
Bess.....	115	91.76	8.24	3.00	1.21
Sully.....	110.5	91.3	8.70	3.15	1.24

TOTAL POUNDS IN THE URINE OF EACH COW.

Bess.....	115	105.55	9.54	3.45	1.39
Sully.....	110.5	100.82	9.63	3.45	1.35

All of the data concerning the total dry matter, ash and total nitrogen of the food, and the amount of each recovered in the dung, urine and milk will be found tabulated below:

BESS.	Dry Matter.		Ash.		Nitrogen.	
	Pounds	Per Cent	Pounds	Per Cent	Pounds	Per Cent
In food.....	134.1		7.47		2.66	
In dung.....	318.1	23.7	2.88	38.5	.53	20.
In milk.....	115.	8.50	.62	8.00	.51	19.1
In urine.....	94.5	7.04	3.56	47.	1.39	52.25
Totals Returned...	52.76	39.4	6.95	93.	2.43	91.3

SULLY.	Dry Matter.		Ash.		Nitrogen.	
	Pounds	Per Cent	Pounds	Per Cent	Pounds	Per Cent
In food.....	134.1		7.47		2.66	
In dung.....	30.79	23	2.69	36.	.52	19.5
In milk.....	13.2	9.85	.77	1.	.65	24.4
In urine.....	9.63	7.18	3.45	46.	1.35	50.7
Totals Returned....	53.62	40.	6.90	92.3	2.52	94.7

Bess returned 39.4 per cent of the total dry matter of the food; Sully returned 40 per cent in the dung the milk and the urine. The question naturally arises, What becomes of the remaining 60 per cent of the total dry matter of the food, since it is not returned in the dung, urine or milk? It must be remembered that there is another means of escape of the food that has not as yet been considered, namely: the losses by respiration and through the pores of the skin. The food during digestion undergoes a series of chemical changes, the body is supplied with heat, and this heat is the result of the burning of some of the food. When food is burned either within the body or outside it is reduced to gaseous products and is no longer solid matter.

The per cent of nitrogen returned by each cow was somewhat less than the amount in the food. Sully returned nearly 95 per cent, while Bess returned a little over 91 per cent, indicating that none of the vital functions had been carried on at the expense of the muscles of the body without due compensation from the protein of the food. Nearly the same per cent of ash was returned by each cow.

Had the pea ensilage been less digestible, a larger daily quantity of food would have been required to furnish these amounts of digestible compounds, and more undigestible nitrogen would have been returned in the dung.

In this case the percentage of nitrogen returned in the dung would have been correspondingly greater. Hence the per cent of the nitrogen of the food, returned in the dung, urine and milk for one food does not, and cannot be applied to another food, since the foods may have both a different chemical composition and different co-efficients of digestibility.

The gain and loss in weight of the cows was within narrow limits, and was materially influenced by the amount of water consumed; the variations in live weights cannot be taken alone as actual indications of gain or loss in flesh, due to the pea ensilage and wheat bran, because the variations in live weight are small compared with the daily amounts of water consumed, which in turn are unequal for the two cows. The amount of water given off by the lungs and also

the amount formed by the combustion of the food are unknown factors, and no accurate estimates of these amounts can be formed. About eighty-two pounds of dry matter were burned up in the body of each cow, equivalent to a little over sixteen pounds per day.

The total weight of the two cows at the close of the experiment was seventeen pounds less than at the beginning. Bess gained ten pounds and Sully lost twenty-seven. Bess consumed twenty-eight pounds more water than Sully, and also returned sixteen pounds more in the dung, urine and milk, as the following table will show:

WATER CONSUMED.		
	BESS. Pounds.	SULLY. Pounds.
In drink.....	308	280
In food.....	96	96
Total.....	404	376

WATER RETURNED.		
	BESS. Pounds.	SULLY. Pounds.
In urine.....	105.5	100.8
In milk.....	92.7	84.3
In dung.....	174.	171.
Total.....	372.	356.
Not returned.....	32.	20.

The amount of water in the dung, urine and milk of Bess amounted to 372 pounds, thirty-two pounds less than the amount that she consumed, equivalent to six pounds per day in addition to that formed by the combustion of the food to be disposed of by the lungs and pores of the skin. With Sully twenty pounds more of water was consumed than returned. Bess returned sixteen pounds more water than Sully, or a difference of twelve pounds more than the difference between the amounts consumed and returned by Sully. Hence the loss of weight of Sully is not a loss in flesh. This is shown more conclusively in the nitrogen return of the food already referred to.

From the same number of pounds of food, Bess gained ten

pounds on live weight and retained nearly three per cent. more nitrogen in her body than Sully. Sully made no gain in live weight, digested one per cent more of solid matter of the food and returned over one per cent more solid matter in the milk, which made a return of over one pound of butter in five days. Taking these facts into consideration it is plain to be seen why Sully made a better milk return than Bess when each consumed the same number of pounds of food.

The more complete digestive work of Sully; with no tendency to gain in flesh or retain the nitrogen of the food, gave better milk returns than the less complete digestive work of Bess with a tendency to gain in weight and to retain more of the nitrogen of the food.

In feeding, any one of these factors taken alone would usually be considered too small to be of any account, and within the limits of error; but these are the factors when working together that go far towards making dairying successful or unsuccessful, since they are the results of the mechanical workings of a good dairy cow compared with a poorer one that consumed the same quantity of food, but produced one-fifth of a pound less of butter per day.

THE MANURIAL VALUE OF PEA ENSILAGE.

Another important factor in considering the value of any cattle food is the composition and value of the manure returned. The elements, the compounds of which give a manure its commercial value are nitrogen, phosphoric acid and potash, since these are usually the important materials that are found in the least abundance in the soil. In commercial fertilizers, nitrogen in its most available forms is valued at 17 cents per pound, phosphoric acid at about seven cents and potash at about four cents. Farm manures contain these same elements in forms equally as valuable, and an analysis of the dung and urine of any animal, fed on any

Care should be taken to lose as little of the urine as possible. This can be done by closing up the leaks in the stable floor, maintaining well constructed gutters, and the liberal use of straw and other absorbents.

In conclusion, the important points briefly stated in regard to ensilaged peas and wheat bran as a cattle food, are;

1. Peas furnish a food rich in nitrogenous compounds, of which the dry matter contains about twelve per cent, which is about twice the amount in ordinary ensilaged crops.

2. In every hundred pounds of the dry matter, seventy-six pounds were digested, and all of the constituents, except the ash and fiber, were nearly equally and evenly digestible.

3. The pea ensilage and bran alone took the place of corn ensilage, hay and a mixed grain ration, saving the more expensive barley and oil meal, and giving the same milk and butter yield.

4. The cow that gave the better returns in milk and butter from the same weight of food digested one per cent more of solid matter and retained three per cent less nitrogen than the one that gave a fifth of a pound less butter per day.

5. Nearly ninety-five per cent of the nitrogen of the food was returned in some form; about one-half was returned in the urine, one-fifth in the dung, and from one-fifth to one-fourth in the milk.

6. About eighty-two per cent of the original fertilizer materials in the food was returned in the dung and urine.

7. Finally, pea ensilage is a valuable cattle food, rich in nitrogen, largely digestible, and returns a valuable manure to the soil.

The storing of peas in the silo as described in this article may be unfamiliar to many and appear to be out of the reach of the ordinary farmer, but this is not so. A silo like the one in which these peas were stored can be made by any farmer at no great expense, and anyone who is desirous of securing one more valuable cattle food, should give peas, either field cured or ensilaged, a trial.

II. BARLEY AND SHORTS.

Digestibility and Manurial Value.

For this experiment a Poland-China-Duroc-Jersey barrow weighing about 250 pounds was used. The experiment was carried on in May at medium temperature. The pig was of a quiet disposition, and did not seem to be disturbed by the close confinement. The daily ration fed consisted of 9 5-7 pounds of a mixture of one-half barley and one-half shorts by weight. The percentage composition of each was.

	Water	Dry Matter	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.
Barley.....	11.78	88.22	2.32	2.70	11.57	6.00	65.63
Shorts.....	10.12	89.88	2.79	4.90	13.75	8.35	60.09

After the preliminary feeding the dung and urine were collected; the pounds of ash, fiber and protein, in the thirty-four pounds of each of the feeds consumed, and the totals, are given in the following table.

	Water	Dry Matter	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.
Barley.....	4.005	30.00	.789	.918	3.935	2.04	22.24
Shorts.....	3.443	30.55	.949	1.666	4.675	2.84	20.43
Total.....	7.448	60.55	1.738	2.584	8.610	4.88	42.67

The experiment was divided into two periods of three and four days each. During the first period nearly 25 pounds of manure was made, or an average of eight pounds per day, which contained 1.91 pounds of dry matter; during the second period 31 pounds were made or an average of about eight pounds per day, which contained about two pounds of dry matter.

AVERAGE COMPOSITION OF DRY MANURE IN POUNDS PER 100.

Period..	Water	Dry Matter	Ash	Ether Extract	Crude Protein	Nitrogen Free Ex.	Crude Fiber	True Albuminoids
First....	77.36	22.64	14.54	3.80	16.22	42.72	22.62	12.50
Second..	74.50	25.50	10.22	4.82	14.72	45.62	24.52	11.88

The variations in the composition of the manure for the two periods are greater than in the experiment with pea ensilage and wheat bran. The differences in composition of the manure for the two periods when calculated to the number of pounds of fiber, protein, etc., made per day, are partly balanced by differences in dry matter, and the total weight of the manure for each period. All of the important data of this experiment will be found in the following table:

SUMMARY OF DIGESTION RESULTS.

	Dry Matter	Ash	Organic Matter	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Extract	True Al. huminoids
Total pounds in food.....	60.55	1.738	58.812	2.584	8.61	4.88	42.67	7.65
Total pounds in manure	13.56	1.632	11.822	.596	1.92	3.22	6.01	17.45
Total pounds digested....	46.99	.106	46.984	.199	6.69	1.66	36.66	5.90
Co-efficient of digestibility of shorts and barley	77.61	.600	7.970	7.895	7.77	34.01	85.92	77.12

The co-efficient of digestibility for the crude protein, if not corrected for the biliary nitrogen would be 75.8, showing that the biliary matters, as ordinarily determined, affected the results to the extent of about two per cent.

Twenty-eight pounds of urine was made during the seven days. The average composition showed that the urine contained 5.60 per cent solids, .38 per cent ash and 2.05 per cent nitrogen. In the 28 pounds of the urine there were about 26.2 pounds of water, .11 pounds of ash, and .57 pounds of nitrogen.

The pounds of nitrogen and ash in the food and the pounds recovered in the dung and urine were:

	ASH.	NITROGEN.
In food.....	1.739	1.37
In the dung.....	1.63	.32
In the urine.....	.11	.57

The sum of the ash and nitrogen in the dung and urine, when taken from the number of pounds in the food leaves the amount retained in the body which is .48 of a pound for the nitrogen, and no appreciable amount for the ash. During the same period the pig consumed 111 pounds of water, of which 69 pounds passed in the dung and urine and 42 pounds were either in part retained in the body or given off through the pores of the skin and by respiration. At the beginning of the experiment the pig weighed 254 pounds, and at the close 273 pounds, the daily weighings showing an average gain of over 2 pounds. A large proportion of this gain was a gain in flesh, since over 65 per cent of the nitrogen of the food was retained in the body.

An average of eight pounds of manure and four pounds of urine were made per day; a fertilizer analysis of the fresh manure and the urine showed the following percentage composition:

	MANURE.	URINE
Nitrogen.....	.57%	2.05%
Phosphoric Acid.....	.72"	.06"
Potash.....	.32"	.04"

If these constituents of the dung and urine were purchased in eastern markets in the form of commercial fertilizers, based upon analysis, the dung would be valued at \$3.30 per ton and the urine \$7.31 per ton. The value of the dung made in one day would be worth \$.012 and of the urine \$.016. The mixed urine and dung together would be worth nearly three cents per day. The analysis shows that the urine is of greater money value than the dung, since over 40 per cent of the nitrogen of the food was returned in the urine, while about 25 per cent was returned in the dung.

III. BARLEY.

Digestibility and Manurial Value.

After determining the digestibility of barley and shorts, this same pig was gradually changed from barley and shorts to a ration of pure barley, and the digestibility of the barley separately determined. In this experiment the dung and urine were collected for six days; during this time, as well as during the preliminary feeding period, 6 pounds of barley was fed per day. The barley was taken from the same lot as that used in the barley and shorts mixture, but was not fed in such liberal quantities. The variations in the composition of the manure from each period were slight. A little over 24 pounds of manure was made, or an average of four pounds per day. All of the important data in connection with this experiment will be found reported in the following table:

SUMMARY OF RESULTS.

Kind of Sample	Pounds of Dry Matter	Pounds of Ash	Pounds of Organic Matter	Pounds of Ether Extract	Pounds of Crude Protein	Pounds of Fiber	Pounds of Nitrogen Free Extract	Pounds of Albuminoids
In 36 pounds barley.....	31.36	.834	30.42	.972	4.165	3.006	24.82	4.05
In manure.....	6.80	.79	6.01	.318	.779	1.531	3.38	.765
Amount digested.....	24.56	.045	24.4	.554	3.386	1.475	21.44	3.285
Digestion Co-efficient....	80.15	5.39	80.25	.654	81.42	48.74	86.56	81.

At the beginning of the experiment the pig weighed 271 pounds and at the close 274, the six pounds of barley per day being just about sufficient to maintain the live weight. The pig consumed 52 pounds of water, and voided 36 pounds in the dung and urine. The food contained 0.666 pounds of nitrogen; .123 pounds were retained in the dung, and 51

pounds in the urine, making a total recovery of 94.2 percent of the nitrogen of the food.

The average fertilizer analysis of the dung and urine showed the following percentage compositions.

DUNG.		URINE.	
Nitrogen.....	.43	Nitrogen.....	2.05
Phosphoric acid.....	.70	Phosphoric acid.....	.16
Potash.....	.62	Potash.....	.10
Value per ton.....	\$ 3.07	Value per ton.....	\$ 7.30
Value per day.....	.006	Value per day.....	.0108
Total Value per day.....		\$.017	

IV. CORN AND SHORTS.

Digestibility and Manurial Value.

The barrow selected for this experiment, a Yorkshire-Berkshire-Duroc Jersey, was of a more contrary disposition than the one used in the experiment with barley, and barley and shorts. The preliminary feeding showed that about half the food offered was refused. This necessitated the feeding of an amount of food equivalent to about half that consumed in the barley and shorts experiment. The daily ration of a little over five pounds was just sufficient to evenly maintain the weight of the animal. The food consisted of a mixture of equal parts of corn and shorts, having the following percentage composition:

	Water	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Extr't
Corn.....	11.73	1.46	3.88	11.25	2.28	69.40
Shorts.....	10.12	2.78	4.90	13.75	8.35	60.09

The experiment was carried on for seven days and during that time eighteen pounds of each were fed.

POUNDS OF EACH CONSTITUENT CONSUMED.

	Water	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.	True Al- buminoid
Corn.....	2.106	.262	.6984	2.0304	12.49	.4106	.....
Shorts.....	1.821	.501	.872	2.475	10.516	1.506	.....
Total.....	3.927	.775	1.57	4.505	23.306	1.916	4.194

The experiment was divided into two periods, but the dung from each period was uniform in composition, and the average of all the analyses showed the composition to be:

Water	Ash	Ether Extract	Crude Protein	Nitrogen Free Extract	Crude Fiber
70.92	14.79	4.00	15.62	45.59	20.00

During the experiment seventeen pounds of dung was evacuated and the seventeen pounds were composed of the following number of pounds of each constituent:

Water	Dry Matter	Ash	Ether Extract	Crude Protein	Nitrogen Free Ex.	Crude Fiber	True Albumin'ds
12.05	4.95	73.28	.198	.795	2.25	.99	.683

And when these undigested portions are taken from the amounts in the food, the amounts digested are obtained, from which the digestion co-efficients of the corn and shorts are found to be:

Dry Matter	Ash	Organic Matter	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.	True Albumin'ds
84.2	4.15	86.5	87.3	82.35	48.3	90.3	83.31

The barrow drank 51 pounds of water, and gave off in the dung and urine 30 pounds, leaving 21 pounds to be disposed of through the lungs, pores of the skin, or retained in the body. At the beginning pig weighed 236 pounds and at the close 235 pounds, daily weighing fluctuating about 2 pounds. The nitrogen in the urine amounted to .528 pounds, in the dung .135 pounds, making a total of .663 pounds, while the amount in the food was .658 pounds. The total recovery of the nitrogen was therefore a little over 100 per cent. All of the daily food consumed, 5 $\frac{1}{7}$ pounds, was used up in supporting the machinery of the animal, leaving none of the food to allow for any material gain in flesh.

A fertilizer analysis of the fresh dung and urine showed them to have the following percentage composition:

DUNG.		URINE.	
Nitrogen.....	.80	Nitrogen.....	2.65
Phosphoric acid.....	1.20	Phosphoric acid.....	.20
Potash.....	.65	Potash.....	.15
Value per ton.....	\$ 5.16	Value per ton.....	\$ 9.45
Value per day.....	.006	Value per day.....	.0120
Total value per day.....		\$.018	

V. CORN.

Digestibility and Manurial Value.

A few weeks later the barrow that had been used in the corn and shorts experiments was changed to a ration of corn. By this time the animal had recovered from his previous contrary indisposition to digestion experiments, and was willing to eat a comparatively larger amount of corn than of corn and shorts. Some of the same corn was used as in the previous experiment. Forty-five pounds of feed were consumed and 12½ pounds of dung returned in one week. As usual the experiment was divided into two periods, the composition of the manure from each period was quite uniform, and so only the average results are recorded.

COMPOSITION OF DRY MANURE.

Water	Dry Matter	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Ex.
67.88	32.12	16.36	10.05	12.81	12.83	47.95

The number of pounds of each of these compounds in the food and in the manure are given in the following table, together with the percentage of each digested:

SUMMARY OF RESULTS—CORN DIGESTIBILITY.

Kind of Samples	Pounds of Dry Matter	Pounds of Organic Mat'r	Pounds of Ash	Pounds of Ether Extract	Pounds of Crude Protein	Pounds of Crude Fiber	Pounds of Nitrogen Free Ex'act	True Al-buminoids
In forty-five pounds of Corn.....	39.72	39.07	.657	1.746	5.062	1.027	31.23	4.635
In 12½ pounds manure.....	4.02	3.37	.657	.40	.51	.52	1.927	.465
Pounds digested.....	35.07	35.70	.....	1.35	4.55	.507	29.303	4.17
Co-efficient of digestibility.....	89.7	91.3	.....	77.6	89.9	48.7	93.91	89.

The most important point of these results is that none of the ash of the corn was digested, and the amount lost in the urine was entirely at the expense of that already stored in the body.

The urine contained 2.05 per cent nitrogen and had a specific gravity of 1.0305, about the same as that of milk. The urine for the seven days contained .520 pounds of nitrogen while the dung contained .10 pound; the nitrogen in the food, .8 pound, exceeded that in the dung and urine by .18 pounds, showing that 22 per cent of the nitrogen of the food was retained in the body. At the beginning of the experiment the pig weighed 247 pounds; and at the close 255. The pig consumed in all 48 pounds of water, and voided in the dung and urine about 28 pounds.

The fertilizer analysis of the dung and urine showed the following composition:

DUNG.		URINE.	
Nitrogen.....	.82	Nitrogen.....	2.05
Phosphoric acid.....	.89	Phosphoric acid.....	.29
Potash.....	.70	Potash.....	.21
Value per ton.....	\$ 3.76	Value per ton.....	\$ 7.59
Value per day.....	.0033	Value per day.....	.0095
Total value per day,		\$.0128	

VI. DIGESTIBILITY OF SHORTS.

In the experiments reported in this bulletin, the digestibilities of barley and shorts and of barley, were separately determined upon the same animal. From the data furnished by these two experiments, the digestibility of the shorts may be obtained by the usual method of difference. The digestibilities of corn and shorts, and of corn were also separately determined upon another animal, thus furnishing entirely different data for another determination of the digestibility of shorts in the same way.

Before considering these results it is necessary to review briefly the conditions: In the experiments with barley and shorts, the pig was fed a very liberal ration of nearly ten pounds per day, and made rapid gains in weight; when barley alone was fed the ration was cut down to six pounds per day, and the pig made no appreciable gain. In the experiments with corn and shorts, a ration of $5\frac{1}{2}$ pounds per day made no gain, while with six pounds of corn per day a noticeable gain resulted. With each set of experiments it will be observed that the conditions were intentionally varied; furthermore the pigs used for these experiments were of different breeds, of different dispositions, and of slightly different weights. Breed, live weight, individual characteristics, combinations of the shorts with other grains, and the quantity of the food fed are all factors so entirely different throughout, that the results obtained, for the digestibility of shorts, when compared, are under the most severe tests to which they could be subjected.

The results are as follows:

SHORTS—DIGESTIBILITY BY DIFFERENCE BETWEEN.

	Dry Matter	Ash	Crude Protein	Crude Fiber	Nitrogen Free Extract
Barley and Shorts and Barley.....	74	6.6	71	25	85.5
Corn and Shorts and Corn.....	79	4.1	76	48	88.

Except the fiber, the most extreme difference is five per cent for the dry matter and the protein, showing that the digestibility of the shorts was increased, when fed in combination with a more digestible grain, and under more favorable conditions.

Outline.—In the previous experiments with pigs the animals weighed on the average about 250 pounds. In the following experiments, growing pigs of about 150 pounds were used. The digestion work as here reported can be divided at this point. The object of this division will appear when the disposition of the food is discussed. In the following work the digestibilities of corn and bran, peas and bran, and peas, are given; this furnishes data for two determinations of bran. All of the experiments were divided into two and three periods each, and the results given are the averages of all of the analyses made, which in no case was less than six.

VII. CORN AND BRAN.—Digestibility.

SUMMARY OF RESULTS.

	Dry Matter	Ash	Organic Matter	Ether Extract	Protein	Crude Fiber	Crude Nitrogen Free Extract	True Al- buminoids
Total pounds in 29 pounds food.....	25.59	1.15	24.44	1.34	3.84	1.97	17.29	3.53
Total pounds in dung...	7.28	.864	6.36	.40	.83	1.36	3.76	.77
Total pounds digested...	18.36	.28	18.08	.95	3.00	.60	13.52	2.76
Digestion Co-efficients...	71.7	24.6	73.9	70.1	78.3	30.6	78.2	78.1

The food consumed consisted of a mixture of one half corn (ground) and one half bran; 29 pounds of this mixture was fed for one week, and 24 pounds of dung was returned in the same time. The pig consumed 56 pounds of water and voided 29 pounds in the dung and urine. The total nitrogen in the urine amounted to .22 pounds, in the dung .14 pounds. There was .61 pounds of total nitrogen in the food. The pig weighed 141 pounds at the beginning of the experiment, and 150 at the close. The mixed bran and corn and the manure returned had the following compositions; the results for the manure are calculated to dry substance; the results on the bran and corn are for the mixture as fed:

	Water	Ash.	Ether Ext.	Protein	Fiber	N. Free Ex.
Bran and Corn	11.76	3.97	4.60	13.25	6.80	59.62
Manure.....	69.87	12.00	5.40	11.56	18.9	52.14

The average fertilizer analysis for the dung and urine gave the following results in percentages:

COMPOSITION AS VOIDED.

DUNG.		URINE.	
Nitrogen.....	.57	Nitrogen.....	1.57
Phosphoric acid.....	1.70	Phosphoric acid.....	.52
Potash.....	.70	Potash.....	.20
Value per day.....	\$.008	Value per day.....	\$.006
Value per ton.....	4.06	Value per ton.....	6.22
Value, Mixed.....		\$5.10	

VIII. PEAS AND BRAN.—Digestibility.

SUMMARY OF RESULTS.

	Dry Matter	Ash	Organic Matter	Ether Extract	Protein	Crude Fiber	Crude Extract	Nitrogen Free	True Al- buminoids
Total pounds in 31 lbs. of bran and peas...	37.70	1.38	26.22	.913	5.71	2.65	16.92	5.49	
Pounds in manure.....	5.80	.92	4.87	.232	.98	1.12	2.53	.77	
Pounds digested.....	21.90	.46	21.33	.681	4.73	1.53	14.39	4.72	
Digestion Co-efficients...	79.	33.5	81.3	74.5	82.7	57.6	85.	85.	

The food consumed consisted of a mixture of ground peas and bran, half and half by weight; 31 pounds of this mixture was consumed in seven days; 26 pounds of urine and 37.45 pounds of dung were returned in the same time; 69 pounds of water was consumed and 55 pounds voided in the dung and urine. The food contained .91 pounds of nitrogen, the dung .15 pounds, urine .40 pounds. The pig weighed 135 pounds at the beginning and 138 at the close.

The composition of the peas and bran as fed, and of the dry dung are as follows:

	Water	Ash	Ether Ex.	Fiber	Protein	N. Free	Album'ds
Peas.....	11.90	3.06	.85	7.46	21.69	55.04	20.62
Bran.....	9.40	5.95	5.05	10.25	15.18	54.17	14.81
Dung.....	84.50	15.90	4.00	19.40	17.00	43.7	14.07

The fertilizer compounds were present in the fresh dung and urine in the following percentages:

DUNG.		URINE.	
Nitrogen.....	.44	Nitrogen.....	1.54
Phosphoric acid.....	.94	Phosphoric acid.....	.35
Potash.....	.50	Potash.....	.10
Value per day.....	\$.0075	Value per day.....	\$.10
Value per ton.....	3.20	Value per ton.....	5.80

IX. PEAS.—Digestibility.

SUMMARY OF RESULTS.

	Dry Matter	Ash	Organic Matter	Ether Extract	Protein	Crude Fiber	Crude Nitrogen Free Extract	True Al- buminoids
In 24 pounds of peas.....	21.15	.734	20.42	.204	5.20	1.79	13.209	4.95
In dung, pounds.....	2.16	.438	1.72	.104	4.59	3.96	.628	4.4
Digestible, pounds.....	18.99	.296	18.69	.100	4.61	1.39	12.56	4.46
Digestion Co-efficients...	89.8	40.3	91.5	(50)	88.6	77.9	95.08	90.

In this experiment the dung and urine were collected for only four and a half days. At the beginning of the experiment the pig weighed 152 pounds and at the close 151½. The confinement to a pea diet finally resulted in producing a diarrhœa. At this point the experiment was stopped.

X. BRAN.—Digestibility.

From the experiments on the digestibility of corn and bran, peas and bran, and peas, all of the data that are necessary are given for two determinations of the bran, one in combination with corn and the other with peas. When fed with corn the dry matter of the bran was only 53 per cent digestible, with peas 77 per cent.

This difference is too great to be overlooked, and would indicate, as in the case with shorts, that the per cent digested is materially influenced by two factors, viz: Combination in which it is fed, and peculiarities of the animal to which it is fed.

In reviewing the factors given by different investigators on the digestibility of bran, results will be found that vary as much as the ones here given. One factor that always tends to make a disagreement for bran co-efficients, is the variations in the composition of the samples of bran, due to the differences in the completeness of the milling process, and the character of the wheat.

The digestion results that are obtained from a bran from which everything is removed that possibly can be, are not applicable to a bran in which variable quantities of the interior of the grain are left. A chemical analysis of these two kinds of bran, alone, cannot be taken as a safe guide in determining this point, and to apply digestion co-efficients to such brans would be even more impossible. In the following table are given the results of analyses of samples of bran and shorts, from different grades of wheat in which the milling process was not as complete as for the bran and shorts used in these experiments. The low per cent of the protein in some of these samples is due entirely to the incomplete removal of the starch in the flour. These samples are usually considered of more value as feed, on account of the flour that

has not been removed, and if digestion co-efficients were applied to such samples the results would be far from the true value.

WHEAT BRAN—COMPOSITION OF ONE HUNDRED POUNDS.

Kind of Sample.	Water	Ash	Extract	Ether	Protein	Crude	Fiber	Crude	Nitrogen Free Extract	Albuminoids	Al-	Weight per Bushel
Scotch Fife.....	10.59	6.37	4.30	13.43	11.20	54.11	13.12	63½				
Blue Stem.....	10.82	6.01	4.60	15.00	12.60	50.97	14.37	59				
Ladoga.....	10.97	6.78	4.40	12.81	12.61	50.53	12.50	57				
Scotch Fife.....	10.32	6.13	5.02	14.43	10.57	53.53	14.06	61½				
Scotch Fife bleached.....	10.65	6.53	5.31	13.75	11.00	52.76	13.43	60				
Scotch Fife badly bleac'd	10.24	6.12	5.60	16.12	10.32	51.60	15.56	57½				
Scotch Fife frosted.....	10.40	5.48	4.12	13.89	10.50	55.61	13.50	58½				
Scotch Fife badly frosted	10.33	5.82	4.03	15.62	15.00	55.12	15.00	58				

SHORTS—COMPOSITION OF ONE HUNDRED POUNDS.

Scotch Fife.....	10.12	4.30	4.00	11.62	11.43	63½
Blue Stem.....	10.40	3.80	3.75	14.25	13.75	59
Ladoga.....	9.21	4.40	3.30	11.25	10.60	57
Scotch Fife.....	10.24	2.25	2.75	12.12	11.37	61½
Scotch Fife bleached.....	10.42	2.40	2.92	10.87	10.31	60
Sc'ch Fife badly bleached	10.89	2.18	2.65	11.62	11.25	57½
Scotch Fife frosted.....	10.62	2.40	2.50	10.06	9.62	58½
Scotch Fife badly frosted	10.34	3.25	2.95	12.08	11.87	58

SUMMARY OF DIGESTION CO-EFFICIENTS.

Kind of Grain.	Dry Matter	Ash	Ether Extract	Crude Protein	Crude Fiber	Nitrogen Free Extract	Albuminoids
Corn and Shorts.	84.2	4.15	87.3	82.4	48.3	90.3	81.3
Corn.....	89.7		77.6	89.9	48.7	93.9	89
Shorts.....	79	4.15		76	48	88	
Barley and Shorts	77.6	6.09	78.9	77.7	34	85.9	77.1
Barley.....	80.1	5.39	67.3	81.4	48.7	86.6	81
Shorts.....	74	6.63		71	25	85.5	
Corn and Bran...	71.7	24.6	70.1	78.3	30.6	78.2	78.1
Bran.....	53.7		65.4	75.8	26.9	56	
Peas and Bran....	79	33.5	74.5	82.7	57.6	85	85
Peas.....	89.8	40		88.6	77.9	95	90
Bran.....	77.8	30.1	78.1	74.4	39.1	75	75.8

In order to form some idea of the comparative value of these grains it is necessary to take into consideration the chemical composition as well as the digestibility. The chemical analyses show how many pounds of ash, fiber and protein there are in a hundred pounds of the grain or fodder. The digestibility is simply the amount that is digestible. The corn, for example, was found to be composed of 11.25 per cent of protein or 11.25 pounds of protein in every hundred pounds of the corn. This protein was found to be 89.9 per cent digestible, and in 11.25 pounds of protein there are 11.25 times .899 or 10.11 pounds of digestible protein in every hundred pounds of the corn. In like manner the pounds of digestible organic matter, fiber and other compounds are calculated.

In the following table the percentage composition of each grain is given, and then the number of pounds of digestible organic matter, fiber and protein in every hundred pounds of the grain as fed:

Kind of Grain.	Dry Matter		Organic Matter		Ether Extract		Crude Protein		Crude Fiber		N. Free Extract		Nutritive Ratio
	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	Pounds per Hundred	Pounds Digestible	
Corn.....	88.28	79.18	86.82	79.26	3.88	3.01	11.25	10.11	2.28	1.11	69.40	65.16	7.2
Corn & Shorts.	89.08	75.00	86.89	75.14	4.39	3.83	12.00	10.29	5.31	2.56	64.73	58.22	6.8
Barley	88.22	70.71	85.90	69.01	2.70	1.86	11.57	9.42	6.00	2.92	65.63	56.82	6.6
Barley & Shorts	89.00	69.08	86.45	68.90	3.80	3.06	12.66	10.00	7.18	2.44	63.86	54.45	6.4
Shorts, average	89.88	68.76	87.09	.....	4.90	.....	13.75	10.11	8.35	3.09	60.09	52.20	6.5
Corn and Bran	88.24	63.27	84.27	62.17	4.60	3.22	13.25	10.37	6.8	2.08	59.62	46.62	5.5
Peas and Bran	89.35	70.58	84.84	68.97	2.95	2.21	18.54	15.38	8.86	4.66	54.50	56.32	3.6
Peas	87.10	79.11	84.04	76.85	.85	.42	21.69	19.22	7.46	4.30	55.04	46.78	3.2

COMPARISON OF THE MANURIAL VALUES.

In the following table the fertilizer value of the food consumed by each animal per day, and the corresponding values of the dung and urine are given, together with other important data, for a comparison of the manurial values:

Kind of Food	Pounds of food per day	Per cent of nitrogen retained in body	Fertilizer Value of the food consumed	Value of the urine per day (Cents)	Value of the dung per day	Total Value per day	Initial weight of pigs
Barley and Shorts.....	9 5-7	35	.043	.016	.012	.028	254
Barley.....	6	6	.02	.010	.006	.016	275
Corn and shorts.....	5 1-7	0	.021	.012	.006	.018	235
Corn.....	6½	22	.016	.010	.003	.013	258
Peas and Bran.....	4 3-7	28	.....	.01	.007	.017	135
Corn and Bran.....	4 1-7	25	.....	.008	.006	.014	141

The value of the manure returned in one day, it will be seen, depends upon the quantity and kind of food and the per cent of nitrogen retained in the body. The dung returned from a hundred pounds of the barley is more valuable than that returned from a hundred pounds of the corn. The addition of shorts to either barley or corn very noticeably increased the value of the dung.

The money values assigned to the mixed dung and urine are much greater than the actual returns would be to the farmer; and the results in order to conform to his conditions should be divided at least by three and possibly four, since ordinarily all the urine is lost, which in these experiments amounts to over half the value of the dung. A farther and additional loss occurs from drainage before the dung is spread in the fields.

THE NITROGEN IN THE FOOD SUPPLY.

COMPARISON OF RESULTS.

In the following table the important data in connection with the nitrogen of the food supply, and the amounts returned in the dung and urine, will be found, together with the amounts retained in the body.

Kind of Food.	Pounds of food per day	Initial weight of pigs	Total lbs of nitrogen per week in				Pounds per day of digestible protein in food	Pounds of gain per week
			Food	Dung	Urine	Retain'd in body		
Barley and Shorts	9 5-7	254	1.37	.32	.57	.48	.95	19
Barley.....	6	271	.76	.14	.58	.04	.56	3
Corn and Shorts..	5 1-7	236	.66	.14	.53	.00	.52	loss 1½
Corn.....	6½	247	.80	.10	.52	.18	.75	8

It will be seen that when no nitrogen was retained in the body there was a slight loss of weight, and when only a small quantity of nitrogen was retained a slight gain resulted. An increase in weight will be found to be accompanied by an increase of the nitrogen stored up in the body. With about half a pound of digestible protein per day in the food, the pigs fed on barley, and corn and shorts made no appreciable gains, but when the digestible protein was increased to three quarters of a pound per day, and the other compounds increased in the same ratio, the pig made a fair gain, and when the amount was still farther increased to nearly a pound per day the pig gained nineteen pounds in a week. From the table it will be seen that a little over half a pound of nitrogen per week was passed in the urine of each animal, and this occurred whether the animal was gaining or losing in weight. The amount of nitrogen carried off in the dung varied according to the amount of undigestible nitrogen to be disposed of in the food. The nitrogen in the urine repre-

sents nearly all of the digestible nitrogen of the food that was used in the body for mechanical purposes, while the nitrogen in the dung represents mainly the indigestible nitrogen of the food.

When the digestible nitrogen in the food was increased above the amount required to maintain the animal, nearly all of this increase was stored up in the body.

To the farmer these results mean that for every six and one-half pounds of barley or corn fed to a pig weighing 250 pounds, about six pounds are used up mechanically, in the body, and only about half a pound goes to make flesh. The chief benefits that are derived from the food, comes from the small amount that is in excess of that required for maintenance. These figures show how unprofitable it is to deal out small or unbalanced rations for fattening mature animals since a certain amount must go for supplying fuel and doing work, and nearly all above this amount is made into flesh. It is economical to feed a liberal ration.