A STUDY OF THE FACTORS INFLUENCING THE ABILITY OF THE ANIMAL TO DIGEST ITS FOOD

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Part I. Historical

The coefficient of digestion, as usually determined, is not the true coefficient of digestion, but is the apparent coefficient of digestibility. There are two sources of error which make the coefficient of digestion, as usually determined, an apparent coefficient only. The feces contain, in addition to undigested food particles, substances which are generally spoken of as metabolic products. The metabolic products consist mainly of epithelial cells, dead bacteria, and the digestive juices, which are to a large extent not reabsorbed. Bacteria also act on the crude fiber of the feed, forming gaseous products, such as methane, which are lost to the animal.

While these two sources of error may amount to considerable they are somewhat constant, and when results of digestion trials are to be compared with each other they should not make any great difference. The metabolic products cause the digestion coefficients, especially of protein and fat, to appear to be lower than they actually are, since the metabolic products are rich in nitrogenous and ether-soluble material. But this material represents a loss to the body due to digestion; therefore the coefficient of digestibility (especially of protein and fat) represents a net gain to the body of these two constituents. The difference due to metabolic products is much greater in carnivora than in herbivora. Atwater (working with men) has proposed the term "available" for the apparently digestible food. The apparent coefficient of digestibility of farm animals is generally spoken of as simply the coefficient of digestibility.

It is now generally agreed that in digestion trial work the feces should be collected at least ten days. The variations in the amounts of dung voided from day to day make this necessary. These variation in weights of dung per day are considerable in some cases. The following data is from digestion trials conducted at the Missouri Station[1].

Grams of Dung Voided during 24 Hours.

Day of Trial	Steer 48	Steer 18	Steer 501	Steer 507	Cow 27
1	12,932	3,694	10,636	6,963	30,245
2	11,938	2,298	3,619	2,299	28,011
3	20,546	2,676	3,422	2,454	30,110
4	17,158	2,934	3,631	2,467	35,608
5	17,226	3,251	9,628	3,207	32,728
6	14,547	2,926	4,374	3,309	29,935
7	16,319	2,801	5,319	4,420	31,502
8	20,526	2,811	9,531	2,788	28,801
9	14,808	3,378	4,436	3,131	26,638
10	18,883	3,007	3,686	2,910	28,237
11	------	-----	13,422	2,826	------

It is easily seen from the foregoing data that two or three day trials would not mean much. Even five day trials would probably be subject to serious errors. Ten days seems to be a safe period of time for collecting feces.

The American investigations on digestibility have been concerned mainly with the determination of the coefficients of digestion of specific feed stuffs. When the German or Wolff feeding standards were introduced into this country some years ago they were very favorably received, both by Experiment Station workers, and by the practical feeder. The American feeder, however, was using very different feeds from those used in Europe. The knowledge concerning the digestibility of American feeding stuffs, at that time, was very limited. It was therefore necessary for the Experiment Stations to determine the digestibility of a large number of the American feeding stuffs. This work was so urgent that generally attention was given to no other problems concerning digestion. We do, however, find a few American experiments concerning the factors influencing the ability of the animals to digest food, and of late the work of the Experiment Stations on digestion as a whole seems to tend more in this direction than formerly. Most of the experimental work concerning the factors influencing the ability of the animal to digest its food has been done by German investigators, and more especially by the earlier ones. Wolff seems to have studied this phase of the subject more than other investigators.

That an animal is not able to digest roughages as well as concentrates is a well recognized fact. The digestibility of several representative American feeding stuffs taken from the tables in the appendix of Henry and Morrison's "Feeds and Feeding" is given below.

Digestibility of Nutrients

	Per Cent Dry Matter	Per Cent Crude Protein	Per Cent Crude Fiber	Per Cent Nitrogen Free Extract	Per Cent Fat
Corn Meal	90	74	57	94	93
Wheat Bran	65	78	31	72	68
Oats	70	78	35	81	87
Cotton Seed Meal (Choice and Prime)	77	84	37	75	95
Linseed meal(old process)	79	89	57	78	89
Corn Stover	57	37	66	59	62
Timothy	55	48	50	62	50
Alfalfa	60	71	43	72	38
Clover (Red)	59	59	54	66	57
Corn Silage	66	51	65	71	82

From these figures it appears that the digestibility of the nutrients of roughages is less than that of concentrates, with the exception of crude fiber, which seems to be more digestible in roughage than in concentrates.

The lesser digestibility of the nutrients in roughages is probably due partly to their physical condition. Roughages contain a large percentage of the difficultly digestible crude fiber which surrounds the other nutrients and prevents the digestive juices from acting upon them. The chemical composition of the different constituents also varies. The difference in digestibility of protein may be due partly to this cause. The difference in amount of metabolic products would also affect the coefficient of digestibility of protein. The fat varies considerably in digestibility. This may be due partly, of course, to the physical condition and to the quantity of metabolic products, but is probably due also, in part, to the difference in composition of the fat or ether-soluble material. Fraps and Rather[2] find that the ether extract of hays and fodders contains from 36 to 72 per cent of unsaponifiable matter, with an average of 58 per cent. The digestibility of the unsaponifiable varies from 0 to 86.6, with an average of 29.1. The digestibility of the saponifiable varies from 8.6 to 92.3, with an average of 66.4. Fraps and Rather conclude that the low digestibility of the ether extract of hays and fodders is due to the presence of wax alcohols, waxes, chlorophyll, and other substances not as easily digestible as the free fatty acids or fats.

The variation in the digestibility of the nitrogen-free extract may also be due to a difference in composition. McDowell[3] of Pennsylvania studied the digestibility of the pentosans of the nitrogen-free extract in connection with steer feeding experiments--The average digestibility of various feeds was as follows:

Clover hay	60.75
Timothy hay	57.18
Corn meal (fed with clover hay)	94.73
Bran (fed with timothy hay)	66.39

The author states that the corn meal apparently increased the digestibility of the hay. McDowell states "that while pentosans seem to be as digestible as other plant substances it must be borne in mind that apparent digestibility does not mean food value."

Fraps[4] studied the distribution of pentosans and their digestibility. He finds that legumes contain a much lower per cent of pentosans than non-legumes, and that the pentosans of the legumes were generally better digested.

Since both the amount and digestibility of pentosans vary in various feeds, we should expect that the nitrogen-free extract coefficient would be different in different feeds. Since the major portion of the nitrogen-free extract of corn consists of the easily digestible hexosan (starch) we should expect a high coefficient of digestibility such as we find.

The crude fiber of roughages, on the whole, is recognized as being more digestible than that of concentrates. The crude fiber of roughages consists largely of cellulose which is more easily digestible than some of the other crude fiber constituents. We should expect, too, that the stems of roughage would be more easily digestible than the hard seed coatings of the concentrates. That these seed coatings are very indigestible is shown by the well-known fact that whole corn, when not masticated by cattle, passes thru the animal's alimentary tract without being digested.

The quantity of one constituent present in a given feed or ration may affect the digestibility of one or more other constituents. Kellner[5] cites the following experiment from Kühn, showing the effect of the one-sided addition of an easily digestible carbohydrate to a ration of meadow hay. The animals used were oxen. To a ration consisting of 9 kilograms meadow hay, 1.662 and 2.866 kilograms, respectively, of dry starch were added. The starch was assumed to be entirely digestible.

Per Cent Nutrients of Meadow Hay Digested.

	Organic Substance	Crude Protein	Crude Fat	N. F. E.	Crude Fiber
Meadow hay alone	62.5	57.0	29.7	61.8	67.5
Meadow hay + 1.662 Kg. starch	58.4	49.1	26.6	58.7	61.5
Meadow hay + 2.866 Kg. starch	56.0	41.9	27.4	55.5	60.5

With the exception of crude fat, the digestibility of all nutrients seems to be depressed.

More recently, Ewing and Wells[6] have found that starch, when added to a ration in excessive amounts, appeared to have a depressing effect on the digestibility of nitrogen and crude fiber. When 47.3 per cent of the total energy of the ration was supplied by starch the digestibility of the total ash was also lowered. These depressions were accompanied by a rise in the digestion coefficient for fat.

Kellner[5] states that the addition of a nitrogenous concentrate will diminish the effect due to adding an excessive amount of an easily digestible carbohydrate. Ewing and Wells' work shows this to be true. They find that the addition of a nitrogenous concentrate (cottonseed meal) will largely overcome the depression due to starch. The one-sided addition of protein does not seem to have a depressing effect, but, as stated before, will diminish the depression due to the addition of starch.

The one-sided addition of fat or oil, according to Kellner[6], does not alter the digestibility, provided it is added in a finely divided form and in moderate quantity (one pound per 1000 pounds live weight). If large quantities are added, or if oil is poured over the feed, a depression will occur.

The addition of lactic acid has no effect on the digestibility of a feed so far as studied. This is important, since lactic acid is formed during the fermentation of silage.

The effect of adding common salt to a ration has been studied by H. Grouven, E. Wolff, V. Hofmeister, H. Weiske, and others. All find that salt has no effect. Two experiments by Wolff[7], one with sheep and one with horses, are quoted below.

In the following experiment sheep were fed a ration of meadow hay to which salt was added.

Per Cent Nutrients Digested.

Salt per day per head	Organic Substance	Crude Protein	Crude Fat	N. F. E.	Crude Fiber
0 gr.	67	58	50	70	66
4 gr.	66	59	49	70	62
8 gr.	67	58	48	71	63

In the second experiment horses were fed a ration of meadow hay, oats, and spelt straw to which salt (20 grams) was added in one case.

Per Cent of Nutrients Digested

	Organic Substance	Crude Protein	Crude Fat	N. F. E.	Crude Fiber
Without salt	59	67	42	71	29
With salt	59	66	41	70	31

In neither of these experiments does the addition of salt seem to have any effect upon the digestibility of the feed.

The addition of calcium carbonate ($CaCO_3$) has been studied by J. Volhard[8]. Fifty grams of calcium carbonate was added daily, in one case, to a basal ration of cotton seed meal and hay.

Per Cent of Nutrients Digested

	Organic Substance	Crude Protein	Crude Fat	N. F. E.	Crude Fiber
Basal ration	71.2	76.6	71.8	79.5	63.0
Basal ration + lime	70.0	74.9	70.6	82.1	61.3
Difference	-1.2	-1.7	-1.2	+2.6	-1.7

The digestibility does not seem to be appreciably affected by the addition of calcium carbonate.

G. Fingerling[9] found that the addition of fennel or anise to a ration did not affect its digestibility.

Michael and Kennedy[10] studied the effect of various commercial condimental stock foods on the digestibility of feed. The results in brief are given below.

	Per Cent Organic Dry Matter Digested
Corn alone	89.84
Corn + International stock food	89.25
Corn + Iowa stock food	89.60
Corn + Standard stock food	89.70

These figures show that these stock foods did not materially influence the digestibility either way, and at least did not benefit it.

The difference in digestive power of different animals has actually been studied in some cases, while in other cases the amount of difference can be judged by comparing the average coefficients obtained for different feeds with different types of animals.

The following data comparing the digestive power of the sheep and horse is cited from Kellner[5] from an experiment by Wolff.

Per Cent of Nutrients Digested

Feed	Organic Substance	Crude Protein	Crude Fat	N. F. E.	Crude Fiber
Meadow Hay (good)					
Sheep	64	57	51	62	56
Horse	57	57	24	55	36
Meadow Hay (inferior)					
Sheep	48	--	49	37	59
Horse	23	19	--	18	27
Clover Hay					
Sheep	56	56	56	61	50
Horse	57	56	29	64	37
Lucerne Hay					
Sheep	59	71	41	66	45
Horse	58	73	14	70	40
Maize Kernel					
Sheep	89	79	85	91	62
Horse	89	77	61	94	70

The horse seems to be able to digest the crude protein in all feeds as well as does the sheep, but does not seem to be able to digest the other constituents as well in a roughage. The horse can digest concentrates just as well as the sheep; with roughages, the better the quality, the nearer the horse approaches the sheep.

Kellner[5] compares the average coefficients of digestion for swine and ruminants for different feeds. The comparison of a few representative feeds is given below.

Per Cent of Nutrients Digested

Feed	Organic Substance	Crude Protein	Crude Fat	N. F. E.	Crude Fiber
Clover (young)					
Ruminant	74	74	65	83	60
Swine	51	49	24	71	24
Clover (mature)					
Ruminant	68	76	67	75	53
Swine	40	33	12	57	16
Maize Kernels					
Ruminant	90	72	89	95	58
Swine	90	79	74	94	44
Barley Corn					
Ruminant	86	70	89	92	50
Swine	82	74	19	88	6

Swine seem to be able to digest concentrates as well as do ruminants, but they cannot digest roughages as well. They are especially poor in digesting crude fiber in both roughages and grain.

From the foregoing comparisons it is evident that the digestive ability of the non-ruminant is not as good as that of the ruminant. There appears to be little difference, however, in the digestive powers of the different ruminants except in the handling of coarse feeds. Kellner[11] compares the digestibility of meadow hay and oat straw by sheep and steers.

	Digestion Coefficients Steers	Sheep
Meadow Hay		
Dry Matter	64.9	62.4
Organic Matter	67.1	64.6
Crude Protein	60.6	57.0
N. F. E.	70.3	68.5
Crude Fat	61.0	56.7
Crude Fiber	63.8	60.5
Oat Straw		
Dry Matter	57.2	47.1
Organic Matter	58.1	47.7
Crude Protein	31.7	18.5
N. F. E.	57.7	49.4
Crude Fat	42.9	50.4
Crude Fiber	62.6	48.7

The sheep digested the hay slightly less and the oat straw considerably less than did the steers. There seems to be a distinct advantage in favor of the steers.

Armsby, Frear, and Caldwell[12] found that sheep digested as much of the dry matter of young dent fodder corn as did steers, but they digested less of the protein and fiber and more of the starchy matter. They also determined the digestibility of fine cut silage by steers and sheep. The corn from which the silage was made was a large coarse variety.

Digestibility of Silage by Steers and Sheep
Per Cent of Nutrients Digested.

	Dry Matter	Ash	Protein	Fiber	N. F. E.	Fat	Nutritive Ratio
Steers	68.1	35.9	44.0	77.6	69.7	76.6	1:25.4
Sheep	53.8	13.3	21.5	63.6	54.9	68.3	1:40.7

The sheep rejected the coarser portions of the silage and ate only the finer, leafier, and probably more digestible portion. But in spite of this, the sheep did not digest any of the ingredients as well as did the steers.

J. M. Bartlett[13] compared the digestive powers of sheep and cattle. He found that steers had a greater capacity for digesting coarse fodders low in protein like timothy hay and corn fodders than the sheep. Sheep were able to digest the more nitrogenous rations as well as the steers. The author also states that there seems to be as great a difference between sheep individually as between sheep and steers.

Since little difference is to be found in the relative digestive ability of sheep and steers, except in the utilization of coarse roughage, we should expect still less between the different breeds of animals. E. Wolff[14] fed five different rations to three different breeds of sheep. The average coefficients of digestibility for all of these experiments is given. Two animals (wethers) of each breed were used.

Per Cent of Nutrients Digested

Breed of Sheep	Organic Substance	Crude Protein	Crude Fat	N. F. E.	Crude Fiber
Electoral	71	68	75	79	50
Bastard	71	68	74	79	49
Southdown	68	64	74	77	48

There seems to be, as we should expect, no appreciable difference in the digestive powers of the different breeds of sheep. This is no doubt true of the other farm animals also.

Armsby and Fries[15] have compared the digestive power of a pure bred and a scrub steer. The experiment extended over a period of three years and the ability of each animal to digest timothy hay and grain was studied.

Comparative Digestibility of Timothy Hay

	Pure bred	Scrub
1905		
Total Dry Matter	52.8	54.9
Energy	49.5	50.8
Protein	14.4	3.0
1906		
Total Dry Matter	53.7	55.3
Energy	50.7	52.6
Protein	34.1	33.8
1907		
Total Dry Matter	62.0	61.4
Energy	58.6	57.9
Protein	43.8	43.6

Comparative Digestibility of Grain (by computation)

	Pure bred	Scrub
1905		
Bran		
Total Dry Matter	66.1	66.5
Energy	67.5	69.1
Protein	72.7	81.4
1906		
Mixed Grain		
Total Dry Matter	81.4	80.4
Energy	82.3	81.9
Protein	72.6	76.0
1907		
Mixed Grain		
Total Dry Matter	77.8	78.8
Energy	78.9	79.7
Protein	73.4	80.3

Armsby and Fries state that these figures give no support to the idea that pure bred animals digest their food better than do scrubs. That there is no difference in digestibility does not indicate, however, that there is no difference in the utilization of the digested food. So far as the digestibility alone is concerned, however, there appears to be no difference between the pure bred animal and the scrub.

The age of the animal does not seem to directly affect its powers of digestion, provided its digestive organs have become fully developed and its teeth are in good condition. In the experiments cited here the animals were given a ration fully sufficient for bodily needs.

E. Wolff[16] compared the digestive ability of Bastard and Southdown wethers at various ages.

Effect of Age on Digestion

Per Cent of Nutrients Digested

Age in Months	Organic Substance	Crude Protein	Crude Fat	N. F. E.	Crude Fiber
6	67	82	83	72	67
8	67	80	84	71	67
9	69	76	81	74	69
11 1/2	69	75	77	77	69
14	69	78	77	75	69

So far as this experiment is concerned there seems to be no effect due to age.

More recently Christensen and Simpson[17] have conducted digestion trials on range steers of different ages, feeding alfalfa hay. In 1911 yearlings and two-year-olds were compared, and in 1912 calves and three-year-olds were used. The results are as follows:

Experiments in 1911

Per Cent of Nutrients Digested

	Dry Matter	Ash	Organic Matter	Protein	Non-Protein	Crude Fiber	N. F. E.	Ether Extract	Total Nitrogen
Trial I									
Ave. of two-year-olds	59.63	39.60	62.63	66.32	100.00	25.63	76.53	30.60	71.31
Ave. of yearlings	53.35	18.82	57.24	60.39	100.00	31.37	71.57	20.17	66.53
Trial II									
Ave. of two-year-olds	57.38	40.08	58.87	58.20	100.00	41.79	71.71	27.88	68.05
Ave. of yearlings	58.45	43.39	59.77	58.64	100.00	42.31	72.62	38.30	68.53
Trial III									
Ave. of two-year-olds	54.36	42.74	55.65	56.21	100.00	33.39	70.56	37.67	65.70
Ave. of yearlings	53.69	45.95	54.60	55.41	100.00	32.27	69.12	38.14	64.95
Experiments in 1912									
Trial I									
Three-year-olds	56.97	51.56	57.66	63.71	100.00	28.88	73.41	32.72	72.59
Calves	53.80	58.20	53.24	62.61	100.00	20.85	70.68	34.54	71.58
Trial II									
Three-year-olds	56.29	43.28	57.61	58.53	100.00	36.06	73.70	43.87	68.05
Calves	57.20	45.75	58.28	58.54	100.00	37.85	73.27	38.11	68.83
Trial III									
Three-year-olds	58.09	45.64	59.36	61.02	100.00	31.08	74.83	40.84	68.53
Calves	58.78	54.22	59.23	64.88	100.00	28.47	74.64	55.13	71.59

As seen by this data, the differences in digestibility for the different ages are not uniformly in one direction. Christensen and Simpson conclude that this data gives no positive evidence that the age of the animal influences its ability to digest feed.

The results of this Station (to be discussed later) do not show any positive evidence of a direct effect due to age, but an indirect effect has been noticed, due probably to the condition of the animal.

The effect of the quantity of food fed upon the ability of the animal to digest it has been studied by several investigators. Kellner[5] distinguishes between the effect of feeding different quantities of roughage and different quantities of a mixed ration.

E. Wolff, et.al.[18] experimented on a horse doing ordinary farm work. He was fed different rations and twice the digestion coefficient for timothy hay alone was determined. The horse received different quantities of feed each time.

		Per Cent of Nutrients Digested					
Period	Wt. Dry Substance Eaten	Dry Substance	Organic Substance	Crude Protein	Crude Fat	Crude Fiber	N.F.E.
I	8,812.00	55.78	56.84	63.69	42.17	47.21	63.16
III	10.898.75	53.42	53.95	61.75	42.60	44.19	59.77

These results indicate that the coefficient of digestion decreases as the quantity of food increases.

Since in the above case the timothy hay was not the same in both cases it was determined to investigate this matter further. For this purpose Wolff[19] repeated the experiment, using pure lucerne hay. The results are given below.

		Per Cent of Nutrients Digested					
Period	Wt. Dry Substance fed	Dry Substance	Organic Substance	Crude Protein	Crude Fat	Crude Fiber	N.F.E.
I	6,695.2	55.20	55.94	73.51	---	32.97	69.94
II	8,431.0	57.47	57.97	73.25	---	37.05	70.91
III	9,936.0	60.64	61.07	77.03	---	42.88	71.83

In this experiment the result seems to be exactly opposite to that of the previous experiment: the coefficient of digestion increases as the food increases.

Wolff[19] tried a similar experiment with sheep. Two, two-year-old wethers were fed different amounts of lucerne hay. In the first and second periods animal No. 2 had a slight sickness and could not be used, and it was only in the third period that he was sufficiently normal to be used.

Per Cent of Nutrients Digested

Animal and Period	Wt. Dry Substance Fed	Dry Substance	Organic Substance	Crude Protein	Crude Fat	Crude Fiber	N.F.E
1 I	679.28	58.84	60.80	72.12	26.34	43.58	70.61
1 II	850.00	60.34	61.87	74.76	30.84	48.46	68.28
1 III	1033.56	60.96	62.43	73.94	31.72	47.46	70.53
2 III	953.50	61.31	63.28	73.83	33.96	49.09	70.64

There are no marked differences to be noted here; at least, there is not a decrease in digestibility with an increase in quantity.

Henneberg and Stohman[20] fed clover hay in different quantities to oxen. The results follow:

Per Cent of Nutrients Digested

Animal No.	Wt. of Feed Fed	Protein	Crude Fiber	N. F. E.
1	20.4	51	38	68
1	25.0	50	40	66
2	24.1	53	38	67
2	29.0	51	39	66

From these figures, there seems to be no appreciable difference due to the quantity of feed fed.

Armsby and Fries in comparing the digestibility of timothy hay on maintenance and submaintenance rations state that their results seem to indicate clearly a real, tho slight, effect of the increasing quantity diminishing the digestibility.

The quantity of roughage fed appears to have little influence upon its digestibility. With mixed rations (in which the ratio of grain to hay is kept constant) the result is somewhat different.

Kellner[5] fed a ration consisting of meadow hay, molasses cake, rye meal, and cotton seed meal to oxen, in different quantities.

Per Cent of Nutrients Digested

Daily Ration	Organic Substance	Crude Protein	N. F. E.	Crude Fat	Crude Fiber
10.84 K.	76.1	71.0	82.0	63.5	62.8
13.01 K.	74.7	68.3	80.8	64.4	61.2
15.18 K.	72.8	65.8	79.0	64.2	59.2
10.84 K.	75.8	71.2	81.2	67.6	62.6

The difference in quantity seems to have a marked effect on the digestibility. There is generally a decrease in the coefficient of digestion with an increase in quantity.

Jordan and Jentner[21] ran digestion trials with four sheep on two different kinds of rations. Sheep Nos. 1 and 2 were on full feed during both experiment, while sheep Nos. 3 and 4 were on half feed. Full ration No. 1 consisted of

100 grams timothy hay, 800 grams corn silage, 100 grams ground oats, and 120 grams ground peas; half ration No. 1 consisted of one-half these amounts. Full ration No. 2 consisted of 300 grams of timothy, 500 grams of corn silage, 40 grams malt sprouts, 60 grams brewers grains, and 60 grams of Buffalo gluten feed; half ration No. 2 consisted of one-half these amounts.

The summary of both trials follows.

	Per Cent of Nutrients Digested						
	Dry Matter	Ash	Organic Matter	Protein	Fiber	N. F. E.	Fat
Ration I							
Full	69.4	13.4	71.7	70.8	59.0	75.4	80.5
Half	74.4	30.7	76.4	75.6	67.2	79.0	82.1
Ration II							
Full	61.6	7.9	64.2	65.3	60.0	65.0	73.8
Half	66.0	21.5	68.0	70.7	62.3	69.2	76.1

The authors state that the results show that the half ration was uniformly better digested.

H. Weiske[23] in experiments with rabbits, to determine the influence of salts, fed oats in differing amounts.

	Per Cent of Nutrients Digested			
Quantity Fed	Protein	Fat	Cellulose	N. F. E.
93.5	66.8	93.6	19.6	67.9
84.5	81.3	94.7	10.4	84.2
52.0	92.6	93.1	34.7	86.5

The digestibility of the protein and nitrogen-free extract increases with a decrease in quantity. The fat and fiber variations are not uniform.

T. Katayama[24] fed two swine a ration of potato chips, molasses cake, wheat bran, and rye meal. Two digestion trials were run and in one the animals received twice as much feed as in the other.

Per Cent of Nutrients Digested

Animal	Wt. of Food	Dry Substance	Organic Substance	Crude Protein	N. F. E.	Crude Fat	Crude Fiber
5	1450	86.4	88.0	68.1	94.0	---	55.2
6	1450	86.0	87.6	66.9	94.0	---	54.3
Average for full ration		86.2	87.8	67.5	94.0	---	54.8
5	725	86.4	88.2	73.4	93.7	---	54.4
6	725	86.1	87.8	72.3	93.6	---	54.4
Average for half ration		86.3	88.0	72.8	93.7	---	54.4

There seems to be little difference here except in the digestibility of protein. More fat was excreted than ingested by these swine in every case--due to metabolic products. T. Katayama determined the amount of nitrogen in the feces which was soluble in alcohol and ether (metabolic) and subtracted this from the total feces nitrogen. The coefficient of digestibility of the protein was then recalculated. These figures are compared with the coefficients as usually obtained below.

	5(1)	6(1)	Ave.	5(2)	6(2)	Ave.
Digestion Coefficient for Protein	66.1	66.9	67.5	73.4	72.3	72.8
(Taking out metabolic nitrogen in feces)	72.6	71.6	72.1	75.8	75.2	75.5

In this way he obtains a much closer agreement for the coefficient of digestion of protein, but the coefficient for the small ration is still larger.

Eckles[25] ran digestion trials on two Jersey cows on full ration and on maintenance. These cows were fed a ration consisting of alfalfa hay, silage, corn, bran, and oil meal in different quantities.

Per Cent of Nutrients Digested

Animal	Ration	Organic Dry Matter	Protein	Fat	Crude Fiber	N. F. E.
27	Full Feed	66.27	58.75	66.95	53.82	72.62
62	Full Feed	66.95	60.58	59.82	53.89	73.62
27	Maintenance	73.79	67.32	73.17	55.33	82.12
62	Maintenance	72.19	65.54	73.92	52.06	80.99

The organic dry matter, protein, fat, and nitrogen-free extract seem to be better digested by the cows on a maintenance ration than when full fed.

Phelps and Woods[26] fed sheep a ration of soy bean meal and timothy rowen in different quantities. In the first period each sheep received one-half pound soy bean meal and one pound of timothy, and in the second period each received three-fourths pound soy bean meal and one and one-half pounds of timothy.

Per Cent of Nutrients Digested

Animal No.	Wt. of Food	Organic	Protein	Fat	Fiber	N. F. E.
A	3405	68.5	75.8	71.1	61.2	66.7
A	5100	67.0	77.0	74.1	59.7	62.2
B	3405	70.5	77.0	76.7	61.2	69.0
B	5100	69.5	77.4	73.3	63.1	66.5
C	3405	71.5	80.0	77.4	63.1	68.4
C	5100	66.9	78.5	72.0	55.8	63.5
E	3405	65.4	76.0	71.4	56.7	60.9
E	5100	73.7	80.0	73.1	69.5	71.8
Average for small ration		69.0	77.2	74.2	60.6	66.3
Average for large ration		69.3	78.2	73.1	62.0	66.0

Sheep A pulled some wool, which was probably eaten, from its side, in the first trial. The difference in quantity here does not seem to make any appreciable difference in the average coefficients. A, B, and C show an increase in digestibility with a decrease in quantity, but E shows an increase. There seems to be some error here, due to individuality.

Mumford, Grindley, Hall, and Emmett[27] find that in feeding a ration of clover hay and ground corn to steers (ratio 1:1) the coefficients will vary inversely as the quantity fed when the feed consumed varies from maintenance to full feed. The average results are given below.

Per Cent of Nutrients Digested

Plane of Nutrition	Dry Matter	Crude Protein	Carbohydrates	(Ether Extract) Fat
Maintenance	69.99	45.48	74.85	73.58
One-third Feed	65.85	44.54	71.72	74.20
Two-thirds Feed	65.62	42.52	70.24	72.24
Full Feed	63.03	40.45	67.48	72.23

They also state "That the coefficients of digestibility of dry substance and carbohydrates of a ration of clover hay and ground corn in the ratio of 1:3 or 1:5 may be greater in the maintenance ration than in the one-third feed ration, the two-thirds feed ration, or the full feed ration. Between the coefficients of dry substance of rations heavier than maintenance or one-third feed there is little, if any, difference.

The coefficients of digestibility of protein and fat of rations composed of clover hay and ground corn in the ratio of 1:1, 1:3, and 1:5, apparently do not vary with the amounts fed."

In determining the digestibility of a ration of clover hay, ground corn and oil meal (ratio 1:4:1) Mumford, Grindley, et.al., find no difference due to the amounts of feed fed.

Per Cent of Nutrients Digested

Plane of Nutrition	Dry Matter	Crude Protein	Carbohydrates	Fat
Maintenance	79.99	70.33	83.03	84.38
One-third Feed	77.14	67.73	80.39	82.88
Two-thirds Feed	75.10	66.66	77.83	83.33
Full Feed	76.12	68.22	79.09	80.60

The previously mentioned authors conclude ''that the cause of differences in digestibility induced by differences in the amounts of feed consumed seems to be the proportion of hay in the ration. Apparently, the essential point of difference caused by the larger proportion of hay is in the content of crude fiber. Hence it may be said that differences in the amounts of feed consumed influence the digestibility only when the quantity of crude fiber in the ration is relatively large."

The evidence regarding the influence of the amount of roughage fed seems to indicate that the amount fed does not affect the digestibility. When grain and roughage are fed in constant ratio in differing quantities the experimental evidence seems to be conflicting. In some cases we find that there is a decrease of digestibility with an increase in quantity and in others no difference is noted.

Kellner seems to think that there is a difference, due to the amount of food fed (mixed ration). He mentions two factors which might cause this to be true. The consumption of a large amount of food probably makes the passage of the food thru the alimentary canal more rapid, and when large quantities of easily digestible food are consumed, it is possible that the intestines are not able to absorb all of the digested material.

An experiment by H. Weiske[28] seems to throw some light on this point. He studied the effect of feeding a like quantity of feed in one and several portions. The following results are from an experiment with a sheep fed hay and oats in one and in four portions.

	Protein	Fat	Cullulose	N. F. E.
Feed in one portion	58.12	78.26	36.06	77.97
Feed in four portions	62.20	82.40	33.80	76.34
	+4.08	+4.14	-2.26	-1.63

The protein and fat seem to be better digested when fed in four portions. Feeding the ration in four portions does not seem to benefit the digestibility of cellulose or nitrogen-free extract. This experiment seems to indicate that the bulk does not influence the coefficient as much as the ability of the intestine to absorb the digested nutrients.

Mumford, Grindley, et.al, seem to have an entirely different idea as to the cause of the influence of quantity as seen from their conclusion, previously quoted.

The coefficient of digestibility does not seem to be influenced by the condition under which the animal is placed. The temperature, lighting, or other conditions of the stable have no appreciable effect, so far as studied. The removal of the wool in sheep does not appear to affect digestion. Whether an animal is working or resting does not appear to materially influence the coefficient of digestion. Excessive work has been shown to depress it slightly while moderate work has increased the digestibility. Kellner states, without citing experiments, that alterations of the conditions under which the animals are placed are without influence upon the digestibility of food, provided violent excitement and disturbance of health are avoided.

The writer has not been able to find any experimental data concerning the influence of the treatment and condition of the animal.

Part II. Experimental

The purpose of the digestion trials, to be discussed in this paper, was to determine the effect of various factors on the ability of the animal to digest it's food. The object of these experiments is somewhat different from the great majority of digestion trial experiments. It was not the purpose of these digestion trials to determine the coefficient of digestibility of any particular feed or ration. The purpose of these digestion trials was to determine the coefficient of digestibility of the animal rather than that of the feed. The principal factors studied are the effect of age, the plane of nutrition, the condition of the animal, and the effect of gestation. Other minor factors will be taken into consideration and discussed.

The animals used for the digestion trials were also being used in other experiments. The digestion trials were conducted partly to help answer the question of the specific experiment, and partly to answer questions regarding the digestive power of the animal under different conditions. The animals selected for use in digestion trials represented a variety of conditions and treatment.

Two kinds of animals were used for these experiments--steers and swine (gilts). The principal factors studied with steers were the effect of the kind of ration, the effect of age, the effect of the plane of nutrition and condition of the animal. The principal factors studied in the experiment with gilts were the effect of gestation, lactation, and the condition of the animal. The ration fed the gilts was quite different from that fed to the steers, and taking everything into consideration it will be best to discuss each kind of animal separately, and then compare where necessary. By far the major portion, and the most important data, is from steers, and they, therefore, will be discussed first.

A. Digestion Trials with Steers

Method of Conducting Trial--

The first of the digestion trials on steers was conducted in 1907. The last reported here were conducted in June, 1915. The methods of conducting the trials have changed somewhat, particularly in the manner of collecting the feces. This will be discussed later.

The ration fed-- Three different rations were fed to the different steers on these trials. Ration I consisted of alfalfa hay, three parts; oat straw, two parts. Ration II consisted of alfalfa hay, four parts; grain mixture, ten parts. The grain mixture consisted of corn chop, eight parts; linseed meal (old process) one part. Ration III consisted of alfalfa hay, five parts; grain mixture ten parts. The grain mixture in this ration consisted of corn chops, six parts; oats, three parts; linseed meal (old process), one part. Water and salt was given ad libitum. to all steers.

Preliminary feeding period-- The animals used were kept continuously on the same ration thruout the experiment (except when very young), the only variable being the quantity fed. The animals were in practically all cases fed the same amount of the same ration for at least two weeks before the digestion trial. In some cases, animals which were on a high plane of nutrition were continually refusing feed, and therefore refused feed during the trial. This refused feed was weighed and analyzed separately, and the amounts of nutrients contained in same were subtracted from the amounts offered. The amount of feed refused during a period of ten days would be practically the same as for the preceding ten days, and therefore this should cause no appreciable error in the results.

Feeding and sampling of feeds-- The animals were fed twice daily. When a grain mixture was fed the different grains were mixed in the proportion desired, before weighing out the feed. The hay was chopped before feeding. The amounts of feed for each animal were carefully weighed out. Whenever possible, during a digestion trial, the feeds for the entire period were weighed out at the same time--to prevent any error due to a change of moisture content. A representative sample of each feed was taken for analysis. The different grains in the grain mixtures were analyzed separately and not composited.

Method of analysis for feeds-- In general, the methods of the A. O. A. C. were followed in analyzing the feeding stuffs used. Moisture, nitrogen, ash, fat, and crude fiber were determined. The nitrogen-free extract was obtained by difference.

The moisture was determined, generally, by drying in a vacuum over sulphuric acid.

Collecting of feces-- Metabolism stalls were used for the earlier digestion trials. The animals were fitted with a rubber feces duct and urine funnel, as described in Pennsylvania Station Bulletin No. 42, page 74. For the later trials this method was discarded. Attendants were kept with the animals to catch the dung. The urine was not collected from these animals. The attendants were provided with large dippers, with long handles, with which to catch the feces. They rarely failed to catch the dung, but in case any fell on the floor, which was kept clean, it was picked up, put in a separate container, and the weight taken. This dung was not used in making up the composite dung sample.

There are several advantages from our point of view in using the attendant, with a dipper, rather than the feces duct. The feces duct previously used seemed to irritate the animal. The animals were kept ordinarily in an open shed with southern exposure. When conducting the trials in metabolism stalls it was therefore necessary to move the animals into strange surroundings, which very probably had an effect on the experiment.

With the method now in use the animal is kept in the stall to which he has become accustomed. He is held either by a stanchion or tied with a rope. The animal can get up or lie down at will.

It might be well to mention here that the metabolism stalls perviously spoken of were lined with matting. Steer

592, a submaintenance animal, ate part of the matting of his stall. The matting was discarded after this experience. The stalls now used have a plank floor.

The feces are collected at least ten days. In some of the earlier trials they were collected eleven days. The attendant catches the dung in the dipper (previously mentioned) and immediately transfers it to a tight covered can. The dung is weighed up once every twenty four hours during the trial. If the attendant has allowed any dung to drop on the floor it is also weighed up separately and the total weight of dung voided obtained. The clean dung is then thoroly mixed and an aliquot of the total dung voided (1/10 to 1/20) accurately weighed out, and placed in an air-tight container. A little chloroform or some alcoholic solution of thymol is used as a preservative. When the trial is being conducted in warm weather the aliquots are always kept in a cool place. At the conclusion of the trial, the different aliquots are mixed thoroly and a composite dung sample thus is obtained. This composite dung sample is used for analysis.

Methods of analysis-- In general the proceedure and methods are the same as for the feeding stuffs, but some differences are to be noted.

Nitrogen--Nitrogen was always determined on the fresh dung sample. This was handled as follows: a well mixed portion of dung was placed in a weighing bottle and a small spatula was also weighed with the weighing bottle. The samples for nitrogen were weighed by difference, in triplicate, onto filter paper. The filter paper was folded and introduced into a Kjeldahl flask, and nitrogen determined as usual. A blank determination to correct for the filter paper and reagents was run as usual. This method gave excellent results so far as checks and ease of handling are concerned.

Moisture--Samples were weighed in triplicate for moisture and the weight of moisture obtained by drying in a vacuum over sulphuric acid.

Air dried sample--A large sample (300 to 500 grams) was air dried for the remaining analyses. This sample, when air dry, was ground so as to pass thru a 1 mm. sieve, and moisture, fat, crude fiber, and ash were determined on this sample.

Description of the Steers Used--

The steers used in digestion trials were drawn from the ''General Use of Food Experiment''. The animals in this experiment may well be divided into four separate experiments, the Retarded Growth Experiment, the Special Maintenance Experiment, the Regular Maintenance Experiment, and the Use of Food Experiment proper. The last may well be divided into three groups, I, II, and III.

Two animals from the Retarded Growth Experiment have been used, Nos. 582 and 586. These animals have been fed a scant ration from birth, and have received no grain. Their ration consisted of alfalfa hay and oat straw, previously designated as Ration I. Steer 582 was a Hereford-Shorthorn born April 18, 1914. Steer 586 was a Shorthorn born April 21, 1914.

Steers 592, 595, and 599 from the Special Maintenance Experiment were used for digestion trials. Steer 592 was a Hereford-Shorthorn born April 15, 1907. Steer 595 was a pure bred Hereford born May 15, 1907. Steer 599 was a Hereford-Shorthorn born March 1, 1907. All were well fed until February 25, 1908. At that date steer 592 was put on Submaintenance (made to lose one-half pound per day), steer 595 on Maintenance (held at body weight), and steer 599 on Supermaintenance (allowed to gain one-half pound per day). These animals weighed 664, 609, and 730 pounds respectively, February 25, 1908. All three received the ration previously designated as Ration II, consisting of alfalfa, corn chops, and linseed.

Steers 18, 48, 164, 197, and 588 were taken from the Regular Maintenance Experiment. These animals received Ration II. They were subjected to a variety of treatments and therefore each animal must be described separately.

Steer 18 was a grade Shorthorn, born in April, 1905. He was in the cooperative feeding experiment until February, 1907. At that date he was placed on maintenance and kept on maintenance until after the digestion trial.

Steer 48 was a grade Shorthorn born in April, 1904. Until February, 1907, 48 was in the cooperative feeding experiment. He was placed on maintenance in February, 1907, and kept on maintenance until June 30, 1907. From June 30, 1907, he was on full feed.

Steer 164 was a grade Hereford, born April 1, 1906. He was used in the cooperative feeding experiment until May, 1907. From May, 1907, he was on maintenance.

Steer 197 was a registered Shorthorn born October 26,

1906. From the spring of 1907 to December, 1907, steer 197 was a very fat show steer (Rudolph). From December, 1907, he was on maintenance.

Steer 588 was a registered Angus born December 10, 1904. From June, 1906, to February, 1907, he was used as a show steer (Edwin Ruthven). From February, 1907, he was on maintenance. He was used twice for digestion trials.

The Use of Food Experiment proper furnished steers 501, 502, 507, 509, 522, 527, 529, 549, 551, and 559. These animals, as previously stated, were divided into Groups I, II, and III. Group I was full fed, Group II was fed for maximum growth without the laying on of fat, and Group III was fed a scant ration (allowed to gain one-half pound per day). These animals were all fed the ration previously designated as III except steer 529 in his first trial. His ration in his first trial consisted of milk and alfalfa hay.

Steer 501 was a grade Hereford born March 28, 1907. He was used as a Group I animal and was full-fed from birth.

Steer 502 was a Hereford-Shorthorn born March 23, 1907. He was liberally fed until weaning time (about five months of age) and then placed in Group II and allowed the limited ration of that group.

Steer 507 was a Hereford-Shorthorn born March 18, 1907. He was treated the same as steer 502.

Steer 509 was a grade Hereford born March 20, 1907. He was liberally fed until weaned and then put on a scant ration (in Group III).

Steer 522 was a Jersey steer and showed considerable of the dairy type. He was born January 1, 1907, and fed liberally until weaned. He was fed as a Group II animal until February, 1908. At that time he was put on full feed, and was on full feed during the digestion trial.

Steer 527 was a Hereford-Shorthorn born October 8, 1907. He was placed in Group I and therefore was full-fed from birth.

Steer 529 was a Hereford-Shorthorn born November 2, 1907. He was scantily fed until six months of age when the first digestion trial was run. He was then held at body weight from the first digestion trial to the second. He was fed a ration of milk and alfalfa hay during the first trial and the regular Ration III during the second trial. He had been on maintenance six months when the second trial was conducted.

Steers 549, 551, and 559 were fed according to the group they were placed in from birth. Steers 549 and 551 were placed in Group III and steer 559 in Group II. Three digestion trials have been conducted on each of these animals. Steer 549 was a Shorthorn born April 23, 1912. Steer 551 was a Shorthorn born March 30, 1912; steer 559 was a Shorthorn born April 17, 1912.

Results of the Digestion Trials with Steers--

Table I gives the dates of conducting the digestion trials, and the breed, age, treatment, and the weight of the steers used. Table II gives the composition of all the feeds fed; Table III gives the composition of the dung voided by steers during digestion trials. Tables IV, V, VI, and VII give the weight of each feed offered, feed refused, and dung voided during the trials. Tables VIII, IX, and X show, respectively, the weights of nutrients consumed, the weights of nutrients voided in the dung, and the weights of nutrients digested. Table XI is a tabulation of the coefficients of digestion of organic matter, protein, fat, nitrogen-free extract, crude fiber, and ash for all steers. Table XII shows the weight (grams) of total organic matter and digestible organic matter consumed per kilo of body weight per day by the steers during digestion trial periods.

Discussion of Results of the Digestion Trials with Steers--

The coefficient of digestibility for ash-- Table XI shows the coefficient of digestibility of ash to be negative in many cases; where the coefficient is positive it is rather variable. The steers on a low plane of nutrition, almost invariably, excrete more ash than they consume in their feed. Steer 529 (on maintenance) during his second digestion trial excreted 5,849.4 grams more of ash than he obtained from his feed (see Table X). This excess of ash excreted was so great in this case as to cause the coefficient of total dry matter to be negative (Table X).

There are two very probable causes for the variation in the ash coefficient. Salt, as stated before, was fed ad libitum. (A record was kept of the amount of salt fed to groups of animals, i.e., animals in the same feed lot, but no individual salt record was kept as for the feed fed.) This salt, however, should not greatly affect the ash coefficient. Sodium chloride is very readily absorbed from the intestines, and that which could affect the coefficient of digestion of ash would probably be sodium chloride thrown out in the metabolic products.

The other probable cause of the fluctuation in the ash coefficient would probably have considerable effect. This error is also hard to eliminate, in the digestion trials as conducted at the Missouri Station. As has been stated before, the digestion trials formed part of a general ''Use of Food'' experiment. The animals used were being fed to answer other questions beside those relating to digestion. It was desirable to keep these animals as nearly normal as possible. When the animals were removed to metabolism stalls or tied up (as is now practiced) for digestion trials, it is obvious that their condition would not be entirely normal. The period during which they were confined was therefore made as small as possible--the actual length of the digestion trial. These animals just prior to being put on digestion trials had had the run of a small feed lot. The steers, especially those on a low plane of nutrition, have the habit of picking up dirt from the feed lot. Since this earth, which was ingested, consists chiefly of ash, and this ash consists largely of insoluble siliceous material, we should expect it to raise the percentage of ash in the dung for the first few days of the trial.

A daily moisture and ash determination was made on the dung voided by Steer 551. (Recent trial not reported here). The percent of ash in the dry matter is as follows:

	Per cent of Ash
First day	18.432
Second day.	18.049
Third day	15.405
Fourth day	16.355
Fifth day	13.689
Sixth day	12.198
Seventh day	13.121

The percentage of ash seems to decrease during the first four days. After the fourth day the per cent of ash seems to be rather constant.

In the digestion trials with swine the dung from the first five days and the dung from the second five days was analyzed separately. The greatest difference is shown by an animal in poor condition--Gilt 5. The air-dry dung of Gilt 5 for the first five days contained 28.248 per cent ash, while for the second five days it contained only 16.193 per cent ash. Gilt 5 is an extreme case. So far as general observation is concerned those animals receiving a liberal food supply and in good condition do not seem to have the habit of picking up earth as badly as those animals receiving a limited ration.

Since the ash coefficient is subject to error in all of these trials, it will not be further considered in the discussion.

The coefficient of digestibility for total dry matter--It is very obvious that fluctuations in the ash coefficient would affect the total dry matter coefficient. For this reason the coefficient for total dry matter is not shown.

The coefficient of digestibility for total organic matter--The coefficient of digestibility for total dry matter being subject to error, the best remaining coefficient for comparing the total digestibility is the coefficient for the total organic matter. An examination of Table XI will show this coefficient to be the least subject to variation. In one respect it is a better figure than the coefficient of digestibility of total dry matter, since it shows the amount of energy producing substance digested.

<u>The relative value of the coefficients of digestibility of protein, fat, nitrogen-free extract, and crude fiber</u>--In Rations II and III better than sixty per cent of the dry matter is nitrogen-free extract. Because of this large per cent of nitrogen-free extract any considerable variation in its digestibility would affect the digestibility of the total organic matter, The coefficients of nitrogen-free extract and total organic matter, therefore, vary simultaneously in most cases.

The coefficient of digestibility for protein is subject to more variation than either the coefficient of total organic matter or the coefficient of nitrogen-free extract. It is a valuable figure, however, because of the importance of protein in metabolism. The variations probably are to some extent caused by the differing quantities of metabolic products in the feces.

The coefficients for crude fiber and crude fat are subject to more variation than any of the other organic constituents. The presence of metabolic products may explain the variations in the coefficient of digestibility for fat. Since fat is present in very small amounts in the ration (Table VIII) and the weight of crude fiber actually assimilated is small, and the coefficients of these substances also vary considerably, it is not possible to draw as definite conclusions as for the other coefficients.

The per cent of total organic substance digested seems to be the most important figure. The coefficients of digestibility of nitrogen-free extract and protein seem to be of about equal importance.

<u>The coefficient of digestion for Steer 592</u>--It has been previously mentioned that Steer 592 ate some of the matting from his stall while on the digestion trial. The amount of crude fiber voided exceeded that in the feed by 166.8 grams. The coefficient of digestion for all nutrients was 64.954.

We have the digestion coefficients for crude fiber of four other young thin steers as follows:

Steer 529	31.521
Steer 595	29.417
Steer 164	29.547
Steer 522	29.706
Average	30.048

Assuming that Steer 592 did not digest more than 30.048 per cent of the crude fiber in his feed and that the matting was all crude fiber, a correction in his coefficient was made. This correction raised the coefficient of digestion for total organic nutrients to 70.559. This calculated coefficient is not of much value, but since it tends in the same direction as that of other thin young animals this coefficient will be mentioned in the discussion.

The coefficients of digestion for the third digestion trials with Steers 549, 551, and 559--Steers 549, 551, and 559 during the third trial with these animals were not receiving twice as much grain as hay such as Ration III specifies. A comparison of the calculated coefficients of the regular Ration III and of these rations (Table XIV) shows that these rations (designated as IIIa) are slightly less digestible than Ration III. It seems to be safe to assume that Rations IIIa were at least no better digestible than Ration III.

The comparative digestibility of the rations fed to steers--Table XIV shows the calculated[29] and the actual average coefficients of Rations I, II, III, and IIIa. Ration I is certainly less digestible than Rations II, III, or IIIa both according to the calculated and actual coefficients of digestion, with the exception of the coefficient of digestibility for crude fiber. The calculated coefficient for crude fiber for Ration I is larger than the calculated coefficients for Rations III or IIIa, and the actual coefficient is larger than the actual coefficient for either Ration II or III.

According to the calculated coefficients (Table XIV) the coefficients of digestibility for total organic matter, fat, nitrogen-free extract, and crude fiber are larger for Ration II than for Ration III. The digestibility of protein is about the same. The actual average coefficients differ in the same way as do the calculated coefficients. The actual average digestibility of both rations in all cases except fat is less than the calculated digestibility.

It is hardly fair, however, to call Ration III as much less digestible than Ration II as is shown by these calculated and actual average coefficients of digestion. Referring to Table I it will be found that the average for Ration III is affected by the coefficients of digestion of three full-fed animals, while the average for Ration II contains the coefficients of digestion of only one full-fed animal. The average for Ration II is largely made up of coefficients for older animals on maintenance, which we should expect to be high. The coefficient of digestion for organic matter for Ration II varies from 67.1 to 83.7, while in Ration III it varies from 69.8 to 77.5 (or 80.9)*. Steers 509 and 599 were animals of very similar condition. Steer 509 (Ration III) digests 77.5 per cent of organic matter of his feed, and Steer 599 (Ration II) digests 77.5 per cent of the organic matter of his feed also. A comparison of the coefficients of digestibility for the four full-fed steers, 48, 501, 522, and 527, (Table XI) does not show any advantage for Ration II. If there is any difference in the digestibility of the two rations it is in favor of Ration II, but this difference is probably not so large as indicated by the calculated and actual average digestion coefficients.

A comparison of Rations III and IIIa shows the calculated

*If Ration IIIa is included with Ration III.

digestibility to be somewhat less for Rations IIIa (Table XIV). Steer 559 digests about the same per cent of organic matter of Ration IIIa as he did of Ration III, while Steers 549 and 551 digest considerably more of the organic matter of Ration IIIa. Steers 549 and 551 also digest a much higher per cent of crude fiber than usual when on Ration IIIa. This may be attributed to the lowering of the amount of easily digestible nitrogen-free extract in the ration.

The ration of milk and alfalfa hay fed to Steer 529(1) differs in digestibility from the other rations in some respects. The coefficients of digestion for protein and fat are rather high, while the coefficient for nitrogen-free extract is rather low.

The individuality of the animal-- The individuality of the animal is a factor which must always be considered in work of this nature. It is unfair, however, to ascribe too many differences to this factor. In many cases what appears to be a difference in individuality may actually be a difference due to the condition, treatment, etc., of the animal. A very few of the animals to be discussed here appear to show greatly marked individual variation. Steer 501 appears to be a case of variation in the appetite of the animal rather than in his digestive ability (See Table XII). Steer 164 certainly seems to be a case of individual variation. The fact that he was a ridgeling may partially explain this.

Generally speaking, individual variation seems to be smallest among those animals in a good, thrifty condition, on a medium ration. Animals extremely full-fed and very low-fed seem to be subject to more variation.

The influence of breed-- No difference due to breed can be detected in the data from the steers used. Most of the steers used (Table I) were either Hereford or Shorthorn or a cross between these two breeds. Steer 522 was a Jersey and Steer 588 was an Angus. If any variation due to breed was present these two last mentioned animals should show it, since they are of rather different type than the other steers used. Both animals, however, show normal coefficients of digestion when their respective treatments are taken into consideration.

The influence of the age of the animal--In Table XV the digestion coefficients of young and old steers on maintenance (fed Ration II) are compared. The average coefficients of digestibility for organic matter, nitrogen-free extract, and crude fiber are somewhat larger for the older animals. The coefficients of protein and fat are larger for the younger animals. The variation between animals of the same age is so great as to indicate that there is another factor present. Steer 197, 18 months of age, digests over ten per cent more organic matter than does Steer 595, also 18 months old. The difference in previous treatment and condition seem to influence the coefficiant more than the age (this will be discussed later). The calculated coefficient of Steer 592 (Table XI) shows that he digested only 70.559 per cent of organic matter. This steer was 19 months old and was on submaintenance.

Table XVI compares the coefficients of digestion of young and old animals on a limited ration. Steer 509 at 12 months of age digests considerably more of his food than Steer 549 at 18 and 25 months. The coefficient of digestibility of organic matter is greater for 509 at 12 months than for 551 at 18 months; Steer 509 and 551 have about the same coefficients of digestion for organic matter when they are, respectively, 12 and 25 months old.

The coefficients of organic matter, protein, and nitrogen-free extract increase with age in Steers 549 and 551. At 37 months of age both steers digest a greater per cent of organic matter, nitrogen-free extract, and protein than 509 does at 12 months of age. Steers 549 and 551 had been fed as Group III animals from birth, while 509 was not placed in this group until about five months of age. The growth of Steers 549 and 551 was much more retarded than that of Steer 509, since these animals when 25 months old weighed less than Steer 509 at 12 months of age (see Table I). While at 37 months of age Steers 549 and 551 have a better coefficient of digestion than Steer 509 at 12 months, yet if we take into consideration the quantity of food fed to these steers per kilo of body weight (Table XII) it seems very possible that this increase may be due to a decrease in the quantity of food fed.

If we assume the digestibility of Rations II and III to be practically the same we can compare the coefficients of digestion of old and young animals on full feed. (Table XVII). The variations in the digestion coefficients of animals on full feed certainly do not indicate that there is any influence due to age. Steer 48 at 42 months of age, on a ration which is just as digestible as the one the young steers were receiving, digests less of all nutrients except crude fiber than any of the younger steers. The older animal in this case certainly does not seem to have any superiority over the younger animal so far as the digestion of food is concerned. The variations among these steers do not follow the age, but appear to follow the quantity of food fed, as will be shown later (Plate I).

So far, the influence of age on animals which were on a very high plane of nutrition, or on a very low plane of nutrition has been considered. Table XVIII shows the coefficients of digestibility of animals on a medium plane of nutrition (Group II) at the ages of 12, 18, 25, and 37 months. The difference in the digestibility of organic matter and nitrogen-free extract for the different ages is very small. The other coefficients certainly do not indicate any influence of age. It is interesting to note also that the difference due to individuality appears to be negligible so far as these three steers are concerned.

From the comparisons made, it appears that young animals on maintenance or a very limited ration do not digest their food as well as older animals on maintenance. This is shown by comparing the coefficients of Steers 595 and

593 with those of the older animals. Steer 529(2) shows the same tendency (Table XI). This difference can hardly be ascribed to age, however, but is possibly due to another factor or factors. The age may be the indirect but not the direct cause of this difference. When animals in medium condition, and fed a medium ration are compared (Group II, Table XVIII) no influence of age is observed. Other factors seem less liable to be present in the Group II animals. The age of the animal does not seem to influence the animal's digestive power, if only the age of the animal is considered as a factor.

The influence of the plane of nutrition or the quantity of food fed-- The plane of nutrition and the quantity of food fed are somewhat synonymous. The plane of nutrition, however, refers to the amount of food fed to keep the animal in a given condition or to cause a definite amount of growth or fattening. The actual quantity of food fed per kilo of body weight does not take into consideration the weight, condition, age, or stage of growth of the animal. When comparing animals of different ages and different weights the plane of nutrition is probably a better unit of reference. Comparisons will be made, however, using both units.

The influence of the plane of nutrition will be considered first. The groups of steers receiving the different rations will be compared separately. Ration II (Table XIX) was fed to one steer on full feed, to one steer on supermaintenance, and to five steers on maintenance. Table XIX shows that Steer 48 receiving full feed digested a smaller per cent of the organic matter, protein, and nitrogen-free extract of his feed than any of the other steers. Steer 164 was a ridgeling and Steer 595 was a young animal on maintenance. These animals have low coefficients of digestibility. Factors, other than the plane of nutrition, probably influenced their coefficients of digestion. Even if these two steers are left in the average for steers on maintenance, the average coefficients for organic matter, protein, and nitrogen-free extract are higher than those of the supermaintenance steer (599) or those of the full fed steer (48). If these two steers are left out of the average, however, the average coefficients for all nutrients are higher for the maintenance animals than for either the supermaintenance or the full fed animal.

Table XIX seems to indicate that the coefficient of digestion increases as the plane of nutrition is lowered, providing, however, that the plane of nutrition is not lowered too far.

A comparison of the steers receiving Ration III (Table XX) shows the same tendency as has been observed for those receiving Ration II. The significance of Group I, II, and III has already been explained, and no repetition is needed here. All of the Group II animals are able to digest a larger per cent of organic matter, protein, and nitrogen-free extract than any of the Group I animals. The average coefficients of digestion for Groups I and II show that the Group

II animals are superior in digestive ability for all nutrients except fat. Between Groups II and III there does not seem to be as much difference as between Groups I and II. The average coefficients of digestion for all steers in Group III show these coefficients to be a little higher for all nutrients, for Group III, than for Group II. As has been stated before, however, Steers 549 and 551 had received a rather different treatment. If the coefficients of digestion for Steer 549(1 and 2) and 551(1) are excluded from the average the average digestion coefficients for all nutrients for Group III are still higher than those for Group II. If only the third trials of Steers 549 and 551 (when they received a slightly different ration) are excluded from the average, the average coefficients of digestibility are very nearly the same for Groups II and III, with the exception of the coefficient of digestion for crude fiber, which is lower for Group III. Because of the difference in previous treatment and wide variations among the individuals in Group III it is hard to draw any definite conclusions regarding the relative digestive ability of Groups II and III. Steer 549 for his first two digestion trials has coefficients of digestibility for organic matter as low as some of the animals on full feed.

Steer 529(2) on maintenance it will be noticed has very low coefficients of digestion (Table XX). The coefficient of digestion for organic matter is lower than that of Steers 501 or 522 on full feed. The same tendency is noted here as with animals on Ration II; the coefficient of digestion increases as the plane of nutrition is lowered--to a certain point. When the plane of nutrition is lowered too far a decrease in the coefficient of digestion appears to occur. It seems reasonable to believe that Steer 549(1 and 2) and Steer 551(1), considering the previous treatment of these steers, were on too low a plane of nutrition, and their coefficients of digestion therefore are depressed.

If the coefficients of digestion of Steers 549(1 and 2) and 551(1) are considered as depressed and eliminated from the Group III average then it may be said that Group III animals digest their food better than Group II animals.

While there may be some difference of opinion as to the relative digestive ability of Group II and III animals, there does not seem to be much doubt that both Group II and Group III animals digest their food better than Group I animals.

So far the animals on different ration have been considered separately. Previously it has been shown that the probable difference in the digestibility of Rations II and III is small. In Table XXI it has been assumed that the difference in digestibility of the two rations is negligible. In this table the different digestion trials are arranged in ascending order of the   of the coefficient of digestibility for organic matter. The animals receiving a full feed are found near the top of the table, while the medium animals are found mid-way in the table. The older animals on maintenance are found near the bottom, but the younger animals on maintenance are found nearer the top. The general tendency even with all animals included seems to be that the animals on a low plane of nutrition digest a larger per cent of their food than those on a high plane of nutrition.

If those animals which for various reasons may be considered as abnormal are struck out of this table it makes the sequence almost ideal. When Steers 529(2), 549(1 and 2), 595, 164, and 551(1) are left out, the order is as follows: full fed, full fed, full fed, full fed, medium, medium, medium, medium, medium, low, low, supermaintenance (low), maintenance, low, low, maintenance, maintenance, maintenance. The coefficient of digestibility appears to increase as the plane of nutrition is lowered.

The steers will now be comparéd as to the influence of the quantity of food fed per kilo of body weight. In this comparison the same assumption is made as in the foregoing comparison, i.e., that the digestibility of Rations II and III is practically the same. Table XII gives the grams of organic matter consumed and the grams of digestible organic matter per kilo of body weight. It will be interesting to note from Table XII that while Steers 48 and 527 digest a much smaller per cent of their food than any of the other animals, yet they assimilate a larger quantity of nutrients per kilo of body weight.

Plates I to V show the weight of organic matter per kilo of body weight plotted against the coefficients of digestibility of organic matter, protein, fat, nitrogen-free extract, and crude fiber. Certain trials, which were considered abnormal, have not been included in these diagrams.

The coefficients of digestibility of organic matter, protein, and nitrogen-free extract, seem to decrease as the quantity of food increases. The quantity of food seems to have little if any influence on the digestibility of fat and crude fiber.

Plates I, II, and IV certainly show a very marked tendency for the digestibility to decrease as the quantity of food increases.

No matter how the different digestion trials are compared there seems to be a general tendency for the coefficient of digestion to increase as the plane of nutrition or the quantity of food fed is lowered--provided it is not lowered too far.

Why do the steers on full feed digest a smaller per cent of their food? The dung of the steers contained whole particles of grain in varying quantities. This grain must be considered as grain which had escaped mastication. This unmasticated grain was washed out of a quantity of dung and its weight and composition determined for some steers. Table XXII shows the per cent of grain unmasticated by steers on various planes of nutrition. It is very evident from this table that those steers on full feed did not masticate their food as well as those on lower planes of nutrition.

From these figures it would seem that the difference in thoroness of mastication might probably account for all of the differences in the coefficients of digestion. This is not the case, however. The quantities of nutrients in the unmasticated grain were determined and then were subtracted from the quantities of nutrients consumed, and the digestion coefficient for ''masticated'' food calculated. Table XXIII shows the digestion coefficients for total food consumed and for masticated food. While the coefficients of digestion for the masticated food for the steers on full feed are considerably higher than for total food, yet they lack a great deal of reaching the coefficients of digestibility of those steers on a lower plane of nutrition. In fact, the order of the coefficients of digestibility for organic matter for the total food and the masticated food are the same. The difference in mastication will account for part of the difference in the digestive ability of animals on different planes of nutrition, but certainly not for all of it.

The bulk of food might have an effect on the digestion because of the rapidity with which it would pass thru the intestines. Various investigators[19], however, have found that the quantity of roughage fed had no influence on its digestibility. If difference in bulk had any effect a difference in quantity of roughage certainly should show it.

It has also been suggested that the intestine is unable to absorb all of the dissolved nutrients. This may be true, but considering the enormous absorptive power of the intestines it is hard to imagine that any dissolved nutrients would escape absorption. The inability of the organs of secretion to produce a sufficient quantity of digestive enzymes seems to be a more likely cause.

The influence of the condition or vitality of the animal--It has been noted in the discussions concerning other factors that young animals when held at body weight (maintenance) do not seem to be able to digest their food as well as older animals on maintenance, or as well as animals of the same age on a more liberal ration. Steer 529(2) has a much lower digestive ability than some of the steers of the same age on a more liberal ration. Steer 595 at 18 months (maintenace) of age has a much lower coefficient of digestion than Steer 599 at 20 months. Steer 599 was on a supermaihtenance ration. The coefficient of digestion for Steer 592 (on submaintenance) is subject to criticism, but the fact that this calculated figure is even lower than the coefficient for Steer 595 is certainly significant.

The coefficients of 197 and 595 have been compared before in considering the influence of age. Steer 197 had only been on maintenance 4 months at the time of the digestion trial. Steer 595 had been put on maintenance in February and the digestion trial was conducted in November. Steer 595 was in very good condition when put on maintenance. Steer 197 was a very fat show steer previous to being put on maintenance.

The best explanation for this lowering of the coefficient of digestion in these young animals on a limited ration seems to be that their low vitality caused a lowering in the digestion coefficient.

It has been observed that young animals on a limited ration were sluggish and unthrifty in appearance and were not very active. Furthermore, these animals seemed to be very susceptible to disease. Nearly all of the losses by deaths during the progress of the various experiments have been animals on a low plane of nutrition.

The younger animals on a more liberal ration were thrifty and rather active. The older or mature animals on maintenance were thrifty in appearance and generally somewhat active except when they were rather fat. There seems to be no question that the vitality of these young animals on maintenace was very low.

The retarding of the growth and the lowering of vitality seemed to be correlated somewhat. It has been shown at this Station[30] that young animals on maintenance or even on submaintenance actually grow in size of skeleton.

The following explanation is tentatively offered for the lowering of vitality and its influence upon the animal's ability to digest its food. The young animal will use the energy supplied to him by his food for these purposes, viz., the general up-keep or maintenance of his body, for growth, and for laying on of fat. The tendency for growth in the young animal is so great, however, that very little of the energy is used for laying on of fat[31]. The young animal persists in using the excess energy fed to him for growth, and must be liberally fed before he can be made to lay on any appreciable fat. When an animal is held at body weight, it is assumed that he is being fed just enough energy to repair the losses due to metabolism. When the young animal is put on maintenance, however, it persists in using some of the energy for growth, and does so apparently at the expense of the general up-keep or maintenance of the body. If there has been any fat deposited, this of course will be used first. Since there will be an insufficient supply of energy for repairing the daily losses, a low vitality is to be expected in a young animal on maintenance.

When a mature animal is placed on maintenance the condition will be somewhat different. The mature animal uses the energy of its food for two general purposes, viz., the up-keep or repair of the body, and the excess is used for the laying on of fat. This laying on of fat, however, is probably not essential to the health of the animal, and can be dispensed with. When the mature animal is placed on maintenance, he will stop the laying on of fat. Some of the fat already stored up may be used for other purposes. The mature animal has stopped growing and therefore needs food only for the general up-keep and repair of the body.

How does the low vitality influence the digestion?

When an animal's vitality is low, less glandular activity would be expected, and therefore a smaller quantity of digestive enzymes would be secreted.

The muscular movements of the stomach and intestines would probably not be as efficient if the animal's vitality were low.

The absorptive power of the intestines might possibly be less. The most reasonable cause, however, seems to be the insufficient quantity of enzymes secreted.

If the foregoing theory is applied not only the low coefficients of 529, 595, and 592 can be explained, but the low coefficients of 549(1 and 2), and 551(1) may be explained. Steers 549 and 551, when 25 months old, did not weigh as much as Steer 509 at 12 months of age (Table I). Steer 509, when 12 months old, weighed 244.85 kilos. Steers 549 and 551 weighed, respectively 166.24 and 165.79 kilos, when 18 months old. Steer 509 was not mature at 12 months, but he certainly was more nearly mature than either 549 or 551 at 18 months, or even at 25 months. The impetus for growth would probably be less marked, therefore, in 509, at 12 months, than in 549 or 551 at 18 months. For other reasons* than his low digestion coefficients Steer 549 seems to be a rather subnormal individual. He did not seem to be able to withstand the low plane of nutrition as well as Steer 551.

Taking into consideration that Steer 197 was very fat at the time he was put on maintenance and that he had only been on maintenance about 4 months at the time of the diges-

*An attempt to put this animal on full feed failed.

tion trial, the difference between his coefficients of digestion and those of Steer 595 do not seem unreasonable. While Steer 595 was in good condition he was not as fat as Steer 197. Assuming that both animals, if treated alike, would have grown equally well, Steer 595 certainly had not been allowed to grow (increase in weight) as much as Steer 197. Steer 197 when 18 months old weighed 503.81 kilos, and Steer 595 only weighed 271.39 kilos. It certainly seems reasonable to conclude that Steer 197 was more nearly mature than Steer 595, and considering also the previous condition and the length of time on maintenance, Steer 197 was probably in better condition, and had much more vitality*

Steer 529, it is conceded by all who had an opportunity to observe him, was exceedingly low in vitality. The same applies to Steer 592.

The low coefficient of digestion for Steer 164 cannot be explained by the lack of vitality. As has been stated before, he was a ridgeling, and was of a rangy type, and also very nervous and active. His nervousness might account for his poor digestive ability.

The influence of the vitality of the animal, and of the plane of nutrition may well be summarized as follows: that the coefficient of digestion increases as the plane of nutrition is lowered, provided it is not lowered enough to lower the general vitality of the animal.

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*When slaughtered, still in maintenance condition, Steer 197 showed the presence of a much greater amount of fat than did Steer 595.

B. Digestion Trials with Swine

Method of Conducting Trial--

The ration fed--All of the swine used for digestion trials received the same ration. This ration consisted of four parts of ship stuff, two parts of corn chop, two parts of bran, and one part of linseed meal (old process).

Preliminary feeding period--The swine were fed the above ration continuously. The same quantity of the ration was fed for at least two weeks before the digestion trial.

Feeding and sampling of feeds.--The animals were fed twice daily. The different feeds were mixed in the proportion desired before weighing out the feed for each animal. The quantity of feed for each animal was accurately weighed. A representative sample of each of the unmixed feeds was taken for analysis.

Methods of analysis for feeds--Same as for steers.

Collection of feces--The swine were confined in crates during the digestion trials. These crates were wide enough and high enough to give freedom of movement, but were small enough to prevent the animal from turning around. A gate in the front of the crate allowed access to the feeding trough during feeding time. The animal was held in, at the back of the crate, by two iron bars which could be adjusted in position so as to accommodate animals of different sizes. The floor of the crate at the rear end was covered with zinc. A pan was placed under the rear edge of the floor to catch any urine not caught by the attendant. The animals were taken from these crates and exercised daily.

The dung and urine were collected in dippers by an attendant. In case the dung or urine was not caught in dippers, it fell on the zinc covered floor or drained into the pan, where it could easily be recovered. The dung for each defecation was weighed at once, and also the urine for each urination. The dung was placed in a can provided with a tight-fitting cover. The urine was placed in a stoppered bottle. Every 24 hours the dung and urine weights were added up, and checked with the actual weight in the containers. The dung and urine were collected ten days. Every 24 hours an aliquot of the dung and urine was taken and preserved for analysis. The dung and urine for the first five days, and second five days, were composited separately for analysis.

Methods of analysis for the dung--Large samples (30 to 40 grams) of the well mixed composite were weighed out in triplicate for the moisture determination, into tared porcelain dishes. These samples were dried to constant weight in a vacuum over sulphuric acid. The dry residues from this determination were ground so as to pass thru a 1 mm. sieve and analyzed for moisture, fat, ash, and crude fiber (see method used for dung of steers). The per cent of nitrogen was determined in the fresh feces, using the same method as for steers.

Total solids, ash, and nitrogen were determined on the urine.

Description of the Animals Used--

The swine used were pure bred Duroc-Jersey gilts from the Animal Breeding Experiment to study the ''effect of the periods of gestation and lactation upon the growth and composition of swine''. Gilts 5, 6, 9, and 10 were used for digestion trials. Gilt 5 was born March 1, 1914; Gilt 6, March 24, 1914; Gilt 9, March 7, 1914; and Gilt 10, March 7, 1914. Gilts 5 and 9 were bred in November, 1914. The first digestion trial was conducted from January 23 to February 2, 1915. Gilts 5 and 9 were pregnant at this time, but Gilts 6 and 10 were not. The second digestion trial was conducted from April 27 to May 7, 1915. Only three gilts were used in this trial, Gilt 10 having been slaughtered in the meanwhile. Gilt 5 farrowed March 10, 1915; Gilt 9 farrowed March 5, 1915. Gilt 5 gave birth to three males and three females, and was suckling these six pigs at the time of the digestion trial. Gilt 9 gave birth to five pigs, four females and one male. These pigs were taken away from Gilt 9 soon after farrowing and given to another gilt who was suckling pigs.

Results of the Digestion Trials with Swine--

Table XXIV gives the composition of the feeds used in the digestion trials with gilts. Table XXV gives the composition of the dung (calculated to fresh material) voided by the gilts during digestion trials. Table XXVI shows the weight of each feed consumed, and the weight of dung voided by the gilts during digestion trials. Tables XXVII, XXVIII, and XXIX give respectively, the weights of nutrients consumed, the weights of nutrients voided in the dung, and the weights of nutrients digested by the gilts. Table XXX is a tabulation of the coefficients of digestion for all digestion trials with gilts. Table XXXI shows the average weights of the gilts in kilos at the time of the digestion trial, and the grams of organic matter and grams of digestible organic matter consumed per kilo of body weight per day.

Discussion of the Results of Digestion Trials with Swine (Gilts)

The ash coefficient--Table XXX shows that the ash coefficient is not only quite variable, but is also negative in two cases. The steers, as has been mentioned before, had access to mineral matter other than that in their feed. The gilts also had access to mineral matter other than that in their feed, and the coefficient of digestion for ash is just as unreliable as for steers.

The relative value of the coefficients of digestion of of different nutrients--In general, the relative value of the various coefficients seems to be about the same as for the steers.

The influence of the period of gestation or pregnancy on the coefficients of digestion--Table XXXI shows that the pregnant gilts digest a larger per cent of the organic food constituents except crude fiber. Whether or not this difference is due to pregnancy, however, is a question. The gilts in this trial were fed the same quantity of feed per head. Table XXXI shows that Gilts 5 and 9 weighed considerably more than Gilts 6 and 10. Therefore, Gilts 6 and 10 were fed a larger quantity of food per kilo of body weight (Table XXXI). The apparent difference due to gestation, therefore, might very well be caused by the difference in the plane of nutrition. Plate VI shows the grams of organic matter consumed per kilo of body weight per day plotted against the coefficients of digestibility of organic matter (as in steers) for these four trials. The same tendency is noted as in steers; the coefficients of digestion vary inversely as the quantity of feed consumed. Certainly more factors than the influence of gestation are present here and no definite conclusion regarding the influence of the period of gestation can be drawn. From the results obtained with steers it seems more probable that the apparent influence of gestation is really the influence of the plane of nutrition, and that the period of gestation does not influence digestion.

The influence of other factors-- Gilts 5, 6 and 9 in their second digestion trial digested a larger per cent of the organic matter of their feed than they did previously. The difference in the plane of nutrition might account for the difference in digestive ability of Gilt 6 at different times, but it will not account for the differences in the coefficients of digestion for Gilts 5 and 9 at different times. The coefficient of digestion of the non-pregnant gilt is explainable, but the coefficients of digestion of the gilts that have been pregnant are not. At first glance, one might say that this difference in digestive ability at different times was due to the age of the animal. Such a conclusion, however, is hardly tenable considering that other factors probably are present.

If the first digestion trial is disregarded altogether, and also the influence of the plane of nutrition, then it may be said that the gilt suckling young (5(2)) has a lower digestive ability than the other two gilts. If this were so it could be explained by the poor condition of Gilt 5. This gilt was extremely emaciated at the time of the second digestion trial, due to the drain of suckling six pigs. The data on these points is rather conflicting, and no definite conclusions can be drawn.

Part III. Summary and Conclusions

In the foregoing discussion of the experimental data animals which apparently were abnormal for the particular point under discussion have been omitted. As much as possible, however, the general tendency has been pointed out with all animals considered, and the tendency is also shown when these animals are eliminated. The following general conclusions seem warranted.

1. The digestibility of the ration of alfalfa hay and oat straw (Ration I) is considerably less than a ration of alfalfa hay, corn, and linseed (Ration II), or a ration of alfalfa hay, corn, oats, and linseed meal (Ration III).

2. The ration of alfalfa hay, corn, and linseed (Ration II) is probably slightly more digestible than the ration of alfalfa hay, corn, oats, and linseed (Ration III). The difference does not seem to be as great as the calculated digestibility of the two rations tends to show.

3. The difference in the age of the animal does not influence the digestive ability of animals on a medium ration or on full feed. Young animals on maintenance (or on a limited ration slightly above maintenance) will digest less of their feed than older animals on maintenance.

4. The plane of nutrition or the quantity of food fed influences the coefficient of digestion. The general tendency appears to be for the coefficient of digestibility to increase as the plane of nutrition is lowered--provided the

plane of nutrition is not lowered enough to affect the general health or vitality of the animal.

5. The less thoro mastication of food by steers on full feed may account for part of the depression in the digestion coefficient for these animals, but not for all of it.

6. If the plane of nutrition is lowered to a point where the general health of the animal suffers and its vitality is lowered, the digestion coefficient will be depressed.

7. In the digestion trials with swine an apparent effect of the period of gestation may be an effect due to the difference in the plane of nutrition. The data on swine is not sufficient to allow any definite conclusions to be drawn.

APPENDIX

Tables I to XXXII

Plates I to VI

Bibliography

Table I. Breed, Age, Ration, Treatment, and Weight of Steers in Digestion Trials.

Animal	Breed of Animal	Date of Trial	Age of Animal in Months at Time of Trial	Ration Fed	Plane of Nutrition	Average Live Weight during Trial Kilos
18	Grade Shorthorn	10/30 to 11/8, 1907	30	II	Maintenance	356.30
48	Grade Shorthorn	10/30 to 11/8, 1907	42	II	Full Fed	563.23
164	Grade Hereford (Ridgeling)	4/21 to 4/30, 1908	25	II	Maintenance	420.03
197	Registered Shorthorn	4/21 to 4/30, 1908	18	II	Maintenance	503.81
501	Grade Hereford	4/1 to 4/11, 1908	12	III	Full Fed	380.25
502	Hereford-Shorthorn	4/1 to 4/11, 1908	12	III	Medium	285.77
507	Hereford-Shorthorn	4/1 to 4/11, 1908	12	III	Medium	291.35
509	Grade Hereford	4/1 to 4/11, 1908	12	III	Low	244.85
522	Jersey	4/1 to 4/11, 1908	15	III	Full Fed	252.97
527	Hereford-Shorthorn	11/6 to 11/15, 1908	13	III	Full Fed	422.48
529(1)	Hereford-Shorthorn	4/21 to 4/30, 1908	6	Milk and Alfalfa	Very Low	91.76
529(2)	Hereford-Shorthorn	11/6 to 11/15, 1908	12	III	Maintenance	93.03
549(1)	Shorthorn	10/10 to 10/20, 1913	18	III	Low	166.24
549(2)	Shorthorn	5/27 to 6/6, 1914	25	III	Low	231.43
549(3)	Shorthorn	5/29 to 6/8, 1915	37	III	Low	283.63
551(1)	Shorthorn	10/10 to 10/20, 1913	18	III	Low	165.79
551(2)	Shorthorn	5/27 to 6/6, 1914	25	III	Low	225.94
551(3)	Shorthorn	5/29 to 6/8, 1915	37	III	Low	304.36
559(1)	Shorthorn	10/10 to 10/20, 1913	18	III	Medium	308.99
559(2)	Shorthorn	5/27 to 6/6, 1914	25	III	Medium	357.84
559(3)	Shorthorn	5/29 to 6/8, 1915	37	III	Medium	392.54
582	Hereford-Shorthorn	5/29 to 6/8, 1915	13	I	Low	104.42
586	Shorthorn	5/29 to 6/8, 1915	13	I	Low	111.90
588(1)	Registered Angus	10/30 to 11/8, 1907	35	II	Maintenance	561.05
588(2)	Registered Angus	4/21 to 4/30, 1908	40	II	Maintenance	553.84
592	Hereford-Shorthorn	11/6 to 11/15, 1908	19	II	Submaintenance	222.44
595	Pure Bred Hereford	11/6 to 11/15, 1908	18	II	Maintenance	271.39
599	Hereford-Shorthorn	11/6 to 11/15, 1908	20	II	Supermaintenance	388.82

Table II. Composition of Feeds Used in Digestion Trials With Steers.

Feed

Feed	Laboratory Number	Per Cent Moisture	Per Cent Protein (N X 6.25)	Per Cent Fat (Ether Sol.)	Per Cent Nitrogen-Free Extract	Per Cent Crude Fiber	Per Cent Ash
Alfalfa Hay	07-12-95	5.150	13.769	1.660	35.675	35.688	8.060
Alfalfa Hay	08-4-16	6.140	17.480	2.630	40.370	24.530	8.860
Alfalfa Hay	08-4-26	5.280	13.750	1.760	38.400	32.090	8.720
Alfalfa Hay	08-11-4	4.250	13.900	3.460	34.845	34.900	8.645
Alfalfa Hay	08-11-5	3.540	13.894	2.800	40.786	29.060	9.920
Alfalfa Hay	13-10-543	6.873	13.775	2.015	36.939	33.145	7.253
Alfalfa Hay	14-6-39	9.140	13.513	0.620	38.962	28.550	9.215
Alfalfa Hay	15-6-45	11.180	15.813	2.605	37.689	24.490	8.223
Oat Straw	15-6-50	11.613	7.350	2.450	37.404	33.400	7.783
Milk	08-4-79	88.244	2.988	3.250	4.818	none	0.700
Corn	07-12-96	11.630	8.612	4.298	72.560	1.792	1.110
Corn	08-4-15	13.670	7.830	4.250	71.620	1.350	1.280
Corn	08-4-20	13.360	7.790	3.500	72.630	1.540	1.180
Corn	08-11-2	8.790	9.313	4.640	73.807	2.000	1.450
Corn	13-10-545	10.627	9.269	4.780	71.906	2.030	1.388
Corn	14-6-18	12.440	9.550	3.930	70.527	2.200	1.353
Corn	15-6-44	14.365	9.525	3.973	68.492	2.360	1.285
Oats	08-4-14	9.180	11.720	5.310	61.750	8.880	3.160
Oats	08-11-3	7.120	11.556	5.770	60.034	11.680	3.840
Oats	13-10-544	10.033	12.531	4.715	58.918	10.313	3.490
Oats	14-6-21	11.850	11.881	3.120	59.971	9.700	3.478
Oats	15-6-48	12.975	11.813	3.773	56.248	11.678	3.513
Linseed	07-12-108	8.950	34.531	6.598	36.480	8.095	5.340
Linseed	08-4-13	8.690	33.330	6.560	37.170	9.080	5.170
Linseed	08-4-21	8.690	35.200	6.520	36.650	7.670	5.270
Linseed	08-11-1	6.550	34.000	7.310	38.570	8.030	5.540
Linseed	13-10-546	9.403	33.225	7.148	35.701	8.738	5.785
Linseed	14-6-19	10.520	35.925	6.370	34.100	8.000	5.085
Linseed	15-6-46	10.770	35.425	5.620	34.932	7.898	5.355
Refused Feed	07-12-88	5.750	10.406	1.542	34.211	41.153	6.938
Refused Feed	08-4-24	6.210	13.800	4.160	61.810	9.370	4.650
Refused Feed	08-4-25	6.300	13.840	3.750	60.730	10.890	4.490
Refused Feed	08-11-24	3.970	14.831	2.690	42.639	25.000	10.870
Refused Feed	08-11-25	8.330	11.269	3.910	67.551	6.180	2.760

Table III. Composition of Dung Voided by Steers

Calculated to Fresh Basis.

Animal	Laboratory Number	Per Cent Moisture	Per Cent Protein (N X 6.25)	Per Cent Fat (Ether Sol.)	Per Cent Nitrogen-Free Extract	Per Cent Crude Fiber	Per Cent Ash
18	08-1-23	76.380	3.781	0.474	7.225	6.510	5.630
48	08-1-24	75.490	3.731	0.743	13.701	4.446	1.889
588(1)	08-1-25	72.760	4.025	0.652	8.067	7.475	7.021
501	08-4-1	81.110	3.169	0.672	7.525	5.381	2.143
502	08-4-3	75.856	3.850	1.063	9.108	6.491	3.659
507	08-4-5	77.034	3.763	1.026	9.504	6.431	2.242
509	08-4-7	74.109	3.956	0.972	9.905	7.735	3.323
522	08-4-9	77.787	3.525	0.764	9.280	6.486	2.158
588(2)	08-4-80	74.889	3.863	0.710	7.483	8.196	4.859
197	08-4-81	78.152	3.600	0.836	7.697	7.841	1.874
164	08-4-82	77.360	3.863	0.996	7.729	6.637	3.415
529(1)	08-4-84	76.144	3.413	1.261	8.976	7.311	2.895
599	08-11-11	74.075	3.544	0.679	8.065	6.228	7.409
527	08-11-12	77.816	3.306	0.762	11.494	4.771	1.851
595	08-11-13	72.471	3.188	0.548	7.984	6.318	9.491
592	08-11-14	70.366	2.763	0.489	6.945	7.747	11.690
529(2)	08-11-15	74.820	3.463	1.067	8.371	6.796	5.483
549(1)	13-10-540	76.659	3.638	0.780	8.238	7.151	3.534
551(1)	13-10-541	73.754	4.031	0.835	8.447	7.822	5.111
559(1)	13-10-542	74.558	3.856	0.731	9.133	7.526	4.196
549(2)	14-6-26	78.070	3.231	0.633	7.691	7.452	2.923
551(2)	14-6-27	76.438	3.475	0.795	7.230	8.720	3.342
559(2)	14-6-28	74.037	3.613	0.902	8.893	7.520	5.035
549(3)	15-6-20	80.067	3.350	0.871	7.025	5.746	2.941
551(3)	15-6-21	77.682	3.756	0.866	7.369	6.607	3.720
559(3)	15-6-22	78.713	3.500	0.724	6.672	5.809	4.582
582	15-6-23	78.779	2.763	0.582	7.674	7.250	2.952
586	15-6-24	81.347	2.381	0.521	6.355	6.237	3.159

Table IV, Showing Weight of Feed Offered and Refused, and Dung Voided during Digestion Trial with 582 and 586.

Animal	Total Weight of Feed Offered During Trial Grams	ALFALFA Laboratory Number	ALFALFA Weight Offered During Trial Grams	OAT STRAW Laboratory Number	OAT STRAW Weight Offered During Trial Grams	REFUSED FEED Laboratory Number	REFUSED FEED Weight of Feed Refused During Trial Grams	DUNG Laboratory Number	DUNG Weight of Dung Voided During Trial Grams
582	22,679.50	15-6-45	13,607.70	15-6-50	9,071.80	none refused		15-6-23	41,625.95
586	22,679.50	15-6-45	13,607.70	15-6-50	9,071.80	none refused		15-6-24	49,268.95

Table V, Showing Weights of Feed Offered, Feed Refused, and Dung Voided during Digestion Trial with Steers 18, 48, 164, 197, 592, 599, and 595.

Animal	Total Weight of Feed Offered During Trial Grams	ALFALFA Laboratory Number	ALFALFA Weight Offered During Trial Grams	Total Grain Offered During Trial Grams	CORN Laboratory Number	CORN Weight Offered During Trial Grams	LINSEED Laboratory Number	LINSEED Weight Offered During Trial Grams	REFUSED FEED Laboratory Number	REFUSED FEED Weight of Feed Refused During Trial Grams	DUNG Laboratory Number	DUNG Weight of Dung Voided During Trial Grams
18	31,751.80	07-12-95	9,071.90	22,679.90	07-12-96	20,157.90	07-12-108	2,522.00	none refused		08-1-23	32,246.00
48	133,355.50	07-12-95	40,823.10	102,057.80	07-12-96	90,718.00	07-12-108	11,339.80	07-12-88	9,525.40	08-1-24	168,177.00
164	35,153.15	08-4-26	10,205.78	24,947.37	08-4-20	22,175.44	08-4-21	2,771.93	none refused		08-4-82	40,647.00
197	47,626.98	08-4-26	13,607.70	34,019.28	08-4-20	30,239.36	08-4-21	3,779.92	none refused		08-4-81	33,191.02
588(1)	36,741.36	07-12-95	10,205.93	26,535.43	07-12-96	23,587.05	07-12-108	2,948.38	none refused		08-1-25	27,938.00
588(2)	35,153.25	08-4-26	10,205.78	24,947.37	08-4-20	22,175.44	08-4-21	2,771.93	none refused		08-4-80	27,054.00
592	9,922.28	08-11-4	2,834.94	7,087.34	08-11-2	6,299.91	08-11-1	787.43	none refused		08-11-14	17,367.00
595	26,076.89	08-11-4	7,370.84	18,706.05	08-11-2	16,628.61	08-11-1	2,077.44	none refused		08-11-13	34,317.00
599	42,807.56	08-11-4	12,190.23	30,617.33	08-11-2	27,215.40	08-11-1	3,401.93	none refused		08-11-11	46,178.00

Table VI, Showing Weight of Feed Offered and Refused, and Dung Voided by Steer 529 (first trial)

Animal	Total Weight of Feed Offered During Trial Grams	ALFALFA Laboratory Number	ALFALFA Weight Offered During Trial Grams	MILK Laboratory Number	MILK Weight Offered During Trial Grams	REFUSED FEED Laboratory Number	REFUSED FEED Weight of Feed Refused During Trial Grams	DUNG Laboratory Number	DUNG Weight of Dung Voided During Trial Grams
529	70,306.45	08-4-26	6,803.85	08-4-79	63,502.60	none refused		08-4-84	16,887.00

Table VII. Showing Weights of Feed Offered and Refused, and Dung Voided during Digestion Trials with Use of Food Steers 501, 502, 507, 509, 522, 527, 529, 549, 551, and 559.

Animal	Total Weight of Feed Offered During Trial Grams	ALFALFA Laboratory Number	ALFALFA Weight Offered During Trial Grams	Total Weight of Grain Offered During Trial Grams	CORN Laboratory Number	CORN Weight Offered During Trial Grams	OATS Laboratory Number	OATS Weight Offered During Trial Grams	LINSEED Laboratory Number	LINSEED Weight Offered During Trial Grams	REFUSED FEED Laboratory Number	REFUSED FEED Weight of Feed Refused During Trial Grams	DUNG Laboratory Number	DUNG Weight of Dung Voided During Trial Grams
501	89,810.8	08-4-16	29,936.9	59,873.9	08-4-15	35,924.3	08-4-14	17,962.2	08-4-13	5,987.4	08-4-24	25,287.7	08-4-1	88,555.0
502	56,131.8	08-4-16	18,710.6	37,421.2	08-4-15	22,452.7	08-4-14	11,226.4	08-4-13	3,742.1	none refused		08-4-3	57,540.0
507	52,389.6	08-4-16	17,463.2	34,926.4	08-4-15	20,955.9	08-4-14	10,477.9	08-4-13	3,492.6	none refused		08-4-5	56,452.0
509	44,905.5	08-4-16	14,968.5	29,937.0	08-4-15	17,962.2	08-4-14	8,981.1	08-4-13	2,993.7	none refused		08-4-7	38,358.0
522	73,595.1	08-4-16	24,267.1	49,328.0	08-4-15	29,596.8	08-4-14	14,798.4	08-4-13	4,932.8	08-4-25	20,184.7	08-4-9	64,118.0
527	94,403.4	08-11-5	31,467.8	62,935.6	08-11-2	37,761.4	08-11-3	18,880.7	08-11-1	6,293.6	(Hay 08-11-24 (Grain 08-11-25	11,425.9 1,980.0	08-11-12	106,717.0
529(2)	8,504.8	08-11-5	2,834.9	5,669.9	08-11-2	3,401.9	08-11-3	1,701.0	08-11-1	567.0	none refused		08-11-15	11,447.5
549(1)	23,813.5	13-10-543	7,937.8	15,875.7	13-10-545	9,525.4	13-10-544	4,762.7	13-10-546	1,587.6	none refused		13-10-540	29,442.0
549(2)	27,215.4	14-6-39	9,071.8	18,143.6	14-6-18	10,886.2	14-6-21	5,443.1	14-6-19	1,814.4	none refused		14-6-26	33,399.0
549(3)	36,287.2	15-6-45	13,607.7	22,679.5	15-6-44	13,607.7	15-6-48	6,803.9	15-6-46	2,268.0	none refused		15-6-20	36,069.5
551(1)	23,813.5	13-10-543	7,937.8	15,875.7	13-10-545	9,525.4	13-10-544	4,762.7	13-10-546	1,587.6	none refused		13-10-541	24,905.0
551(2)	27,215.4	14-6-39	9,071.8	18,143.6	14-6-18	10,886.2	14-6-21	5,443.1	14-6-19	1,814.4	none refused		14-6-27	25,958.0
551(3)	38,555.2	15-6-45	13,607.7	24,947.5	15-6-44	14,968.5	15-6-48	7,484.2	15-6-46	2,494.8	none refused		15-6-21	32,808.2
559(1)	47,627.0	13-10-543	15,875.7	31,751.3	13-10-545	19,050.8	13-10-544	9,525.4	13-10-546	3,175.1	none refused		13-10-542	48,729.0
559(2)	40,823.1	14-6-39	13,607.7	27,215.4	14-6-18	16,329.2	14-6-21	8,164.6	14-6-19	2,721.5	none refused		14-6-28	41,273.0
559(3)	47,627.0	15-6-45	18,143.6	29,483.4	15-6-44	17,690.0	15-6-48	8,845.0	15-6-46	2,948.3	none refused		15-6-22	57,796.4

Table VIII. Weight of Nutrients Consumed by Steers during Digestion Trials.

Animal	Weight of Dry Matter Consumed Grams	Weight of Organic Dry Matter Consumed Grams	Weight of Protein (N X 6.25) Consumed Grams	Weight of Fat (Ether Sol.) Consumed Grams	Weight of Nitrogen-Free Extract Consumed Grams	Weight of Crude Fiber Consumed Grams	Weight of Ash Consumed Grams
18	28,715	27,625	3,856.0	1,183.4	18,782.0	3,802.8	1,089.6
48	120,097	115,855	16,358.3	5,178.1	81,126.7	13,191.8	4,242.0
164	31,412	30,114	4,107.3	1,136.5	21,041.0	3,829.1	1,297.7
197	42,542	40,799	5,558.4	1,544.3	28,573.6	5,122.3	1,742.6
501	57,179	54,365	8,657.3	2,608.7	35,501.4	7,597.7	2,813.5
502	50,559	48,066	7,591.6	2,287.9	31,957.3	6,229.5	2,493.4
507	47,189	44,862	7,085.5	2,135.4	29,826.8	5,814.2	2,327.2
509	40,448	38,453	6,073.3	1,830.4	25,565.9	4,983.6	1,994.7
522	47,361	45,016	7,144.2	2,248.5	29,707.2	5,916.2	2,345.3
527	75,389	71,943	10,292.5	3,797.9	48,221.4	9,631.6	3,446.2
529(1)	13,910	12,872	2,832.6	2,183.6	5,672.2	2,183.4	1,037.8
529(2)	7,947	7,520	1,100.0	376.8	4,907.0	1,136.1	427.3
549(1)	21,629	20,663	3,100.6	953.3	13,154.4	3,454.3	966.0
549(2)	24,196	22,931	3,564.0	769.5	15,095.3	3,502.6	1,264.8
549(3)	31,684	30,030	5,055.0	1,279.3	19,068.1	4,627.3	1,654.3
551(1)	21,629	20,663	3,100.6	953.3	13,154.4	3,454.3	966.0
551(2)	24,196	22,931	3,564.0	769.5	15,095.3	3,502.6	1,264.8
551(3)	33,644	31,936	5,345.3	1,371.8	20,462.0	4,756.8	1,707.8
559(1)	43,257	41,325	6,201.3	1,906.6	26,308.7	6,908.5	1,932.0
559(2)	36,294	34,397	5,345.9	1,154.2	22,642.7	5,253.9	1,897.2
559(3)	41,592	39,404	6,643.2	1,674.9	24,959.4	6,126.6	2,187.9
582	20,105	18,280	2,818.4	576.7	8,521.8	6,362.5	1,825.0
586	20,105	18.280	2,818.4	576.7	8,521.8	6,362.5	1,825.0
588(1)	33,209	31,967	4,454.8	1,377.7	21,831.3	4,303.4	1,241.9
588(2)	31,412	30,114	4,107.3	1,136.5	21,041.0	3,829.1	1,297.7
592	9,196	8,816	1,248.5	448.0	5,941.3	1,178.6	380.2
595	24,265	23,172	3,279.5	1,178.5	15,642.7	3,071.8	1,093.4
599	39,674	38,037	5,385.5	1,933.3	25,646.7	5,071.9	1,636.9

Table IX. Nutrients Voided in Dung by Steers during Digestion Trials.

Animal	Weight of Dry Matter Voided Grams	Weight of Organic Dry Matter Voided Grams	Weight of Protein (N X 6.25) Voided Grams	Weight of Fat (Ether Sol.) Voided Grams	Weight of Nitrogen-Free Extract Voided Grams	Weight of Crude Fiber Voided Grams	Weight of Ash Voided Grams
18	7,617	5,801	1,219.3	152.9	2,329.8	2,099.2	1,815.5
48	41,221	38,044	6,275.1	1,249.6	23,041.9	7,477.2	3,176.9
164	9,202	7,814	1,570.0	404.8	3,141.6	2,697.7	1,388.1
197	7,252	6,630	1,194.9	277.5	2,554.7	2,602.5	622.0
501	16,728	14,830	2,806.1	595.1	6,663.8	4,765.1	1,897.7
502	13,908	11,803	2,215.3	611.7	5,240.7	3,734.9	2,105.4
507	12,965	11,699	2,124.3	579.2	5,365.2	3,630.4	1,265.7
509	9,932	8,657	1,517.4	372.8	3,799.4	2,967.0	1,274.6
522	14,243	12,859	2,260.2	489.9	5,950.2	4,158.7	1,383.7
527	23,674	21,699	3,528.3	813.2	12,266.1	5,091.5	1,975.3
529(1)	4,029	3,540	576.3	213.0	1,515.8	1,234.6	488.9
529(2)	8,532	2,255	396.4	122.1	958.3	778.0	6,276.7
549(1)	6,873	5,832	1,071.1	229.7	2,425.4	2,105.4	1,040.5
549(2)	7,324	6,348	1,079.1	211.4	2,568.7	2,488.9	976.3
549(3)	7,190	6,129	1,208.3	314.2	2,533.9	2,072.6	1,060.8
551(1)	6,537	5,264	1,003.9	208.0	2,103.7	1,948.1	1,272.9
551(2)	6,117	5,249	902.0	206.4	1,876.8	2,263.5	867.5
551(3)	7,323	6,102	1,232.4	284.1	2,417.6	2,167.6	1,220.5
559(1)	12,398	10,353	1,879.0	356.2	4,450.4	3,667.3	2,044.7
559(2)	10,716	8,638	1,491.2	372.3	3,670.8	3,103.7	2,078.1
559(3)	12,303	9,655	2,022.9	418.5	3,856.2	3,357.4	2,648.2
582	8,833	7,604	1,149.9	242.3	3,194.4	3,017.9	1,228.8
586	9,190	7,634	1,173.2	256.7	3,131.0	3,072.9	1,556.4
588(1)	7,611	5,649	1,124.5	182.2	2,253.8	2,088.4	1,961.5
588(2)	6,794	5,479	1,045.1	192.1	2,024.5	2,217.4	1,314.6
592	4,625	2,595	479.8	84.9	1,206.1	824.5	2,030.2
595	9,447	6,190	1,094.0	188.1	2,739.9	2,168.2	3,257.0
599	11,971	8,550	1,636.4	313.6	3,724.3	2,876.0	3,421.3

Table X. Weight of Nutrients Digested by Steers during Digestion Trials

Animal	Weight of Total Dry Matter Digested Grams	Weight of Organic Dry Matter Digested Grams	Weight of Protein (N X 6.25) Digested Grams	Weight of Fat (Ether Sol.) Digested Grams	Weight of Nitrogen-Free Extract Digested Grams	Weight of Crude Fiber Digested Grams	Weight of Ash Digested Grams
18	21,098	21,824	2,636.7	1,030.6	16,453.2	1,703.6	- 725.8
48	78,876	77,811	10,083.2	3,928.5	58,084.7	5,714.6	1,065.1
164	22,210	22,300	2,537.3	731.7	17,899.3	1,131.4	-90.4
197	35,290	34,169	4,363.4	1,266.9	26,018.8	2,519.8	1,120.6
501	40,451	39,535	5,851.2	2,013.6	28,837.6	2,832.6	915.8
502	36,652	36,264	5,376.3	1,676.3	26,716.6	2,494.6	388.0
507	34,225	33,163	4,961.2	1,556.2	24,461.6	2,183.8	1,061.5
509	30,517	29,797	4,555.9	1,457.5	21,766.5	2,016.6	720.1
522	33,119	32,157	4,884.1	1,758.7	23,757.1	1,757.5	961.6
527	51,715	50,244	6,764.2	2,984.8	35,955.4	4,540.1	1,470.9
529(1)	9,881	9,332	2,256.4	1,970.6	4,156.5	948.8	548.9
529(2)	- 584	5,265	703.6	254.7	3,948.7	358.1	-5,849.4
549(1)	14,756	14,831	2,029.5	723.7	10,728.9	1,348.9	- 74.5
549(2)	16,872	16,583	2,484.9	558.1	12,526.5	1,013.7	288.6
549(3)	24,495	23,901	3,846.6	965.1	16,534.2	2,554.8	593.5
551(1)	15,092	15,399	2,096.7	745.3	11,050.6	1,506.2	-306.9
551(2)	18,080	17,683	2,662.0	563.1	13,218.5	1,239.1	397.3
551(3)	26,321	25,834	4,111.9	1,087.6	18,044.4	2,589.2	487.4
559(1)	30,799	30,972	4,322.3	1,550.4	21,858.3	3,241.2	-172.7
559(2)	25,578	25,759	3,854.8	781.9	19,072.3	2,150.2	-180.9
559(3)	29,289	29,749	4,620.3	1,256.4	21,103.3	2,769.2	-460.4
582	11,271	10,675	1,668.5	334.5	5,327.5	3,344.6	596.2
586	10,915	10,646	1,645.3	320.1	5,390.8	3,289.6	268.6
588(1)	25,598	26,318	3,330.3	1,195.6	19,577.5	2,215.1	-719.7
588(2)	24,618	24,635	3,062.4	944.4	19,016.5	1,611.8	-16.9
592	4,571	6,221	768.8	363.1	4,735.2	354.2	-1,650.0
595	14,718	16,982	2,185.5	990.4	12,902.9	903.7	-2,263.6
599	27,703	29,487	3,749.1	1,619.7	21,922.4	2,195.9	-1,784.4

Table XI. Digestion Coefficients for all Trials with Steers.

Animal	Date of Trial	Per Cent Organic Dry Matter Digested	Per Cent Protein (N X 6.25) Digested	Per Cent Fat (Ether Sol.) Digested	Per Cent Nitrogen-Free Extract Digested	Per Cent Crude Fiber Digested	Per Cent Ash Digested
18	10/30 to 11/8, 1907	79.001	68.379	87.084	87.596	44.798	negative
48	10/30 to 11/8, 1907	67.163	61.639	75.868	71.598	43.320	25.109
164	4/21 to 4/30, 1908	74.051	61.776	64.378	85.069	29.547	negative
197	4/21 to 4/30, 1908	83.750	78.502	82.032	91.059	49.193	64.306
501	4/1 to 4/11, 1908	72.721	67.587	77.188	81.229	37.282	32.550
502	4/1 to 4/11, 1908	75.449	70.820	73.265	83.601	40.045	15.560
507	4/1 to 4/11, 1908	73.922	70.024	72.876	82.012	37.559	45.614
509	4/1 to 4/11, 1908	77.488	75.013	79.630	85.139	40.465	36.098
522	4/1 to 4/11, 1908	71.435	68.361	78.214	79.971	29.706	41.002
527	11/6 to 11/15, 1908	69.839	65.720	78.589	74.563	47.138	42.681
529(1)	4/21 to 4/30, 1908	72.501	79.657	90.248	73.277	43.454	52.894
529(2)	11/6 to 11/15, 1908	70.017	63.962	67.588	80.471	31.521	negative
549(1)	10/10 to 10/20, 1913	71.777	65.455	75.910	81.562	39.049	negative
549(2)	5/27 to 6/6, 1914	72.317	69.722	72.524	82.983	28.942	22,816
549(3)	5/29 to 6/8, 1915	79.590	76.097	75.442	86.717	55.210	35.876
551(1)	10/10 to 10/20, 1913	74.525	67.622	78.185	84.007	43.604	negative
551(2)	5/27 to 6/6, 1914	77.111	74.690	73.181	87.567	35.376	31.412
551(3)	5/29 to 6/8, 1915	80.894	76.945	79.288	88.185	54.431	28.537
559(1)	10/10 to 10/20, 1913	74.948	69.700	81.317	83.084	46.916	negative
559(2)	5/27 to 6/6, 1914	74.887	72.106	67.746	84.232	40.926	negative
559(3)	5/29 to 6/8, 1915	75.498	69.550	75.016	84.550	45.200	negative
582	5/29 to 6/8, 1915	58.399	59.199	57.995	62.515	52.568	32.669
586	5/29 to 6/8, 1915	58.238	58.374	55.493	63.259	51.703	14.718
588(1)	10/30 to 11/8, 1907	82.329	74.758	86.778	89,676	51.472	negative
588(2)	4/21 to 4/30, 1908	81.806	74.559	83.098	90.379	42.093	negative
592	11/6 to 11/15, 1908	70.559	61.574	81.043	79.699	30.048	negative
595	11/6 to 11/15, 1908	73.287	66.644	84.042	82.485	29.417	negative
599	11/6 to 11/15, 1908	77.521	69.614	83.781	85.478	43.296	negative

Table XII. Organic Matter Per Kilo Per Day.

Animal	Average Live Weight During Trial Kilos	Grams Organic Dry Matter Consumed Per Kilo Per Day During Trial	Grams of Digestible Organic Dry Matter Consumed Per Day Per Kilo During Trial
18	356.30	7.75	6.12
48	563.23	20.57	13.82
164	420.03	7.17	5.31
197	503.81	8.10	6.78
501	380.25	13.00	9.45
502	285.77	15.29	11.54
507	291.35	14.00	10.35
509	244.85	14.28	11.06
522	252.97	16.18	11.55
527	422.48	17.03	11.89
529(1)	91.76	14.03	10.17
529(2)	93.03	8.08	5.67
549(1)	166.24	12.43	8.92
549(2)	231.43	9.91	7.16
549(3)	283.63	10.59	8.43
551(1)	165.79	12.46	9.29
551(2)	225.94	10.15	7.83
551(3)	304.36	10.49	8.49
559(1)	308.99	13.38	10.02
559(2)	357.84	9.61	7.20
559(3)	392.54	10.04	7.58
582	104.42	17.51	10.23
586	111.90	16.34	9.52
588(1)	561.05	6.33	5.21
588(2)	553.84	5.44	4.45
592	222.44	3.97	2.80
595	271.39	8.54	6.26
599	388.82	9.78	7.58

Table XIII. Comparative Digestibility of the Different Rations.

	Per Cent Nutrients Digested				
Animal	Organic Matter	Protein (N X 6.25)	Fat (Ether Sol.)	N. F. E.	Crude Fiber
Ration I					
582	58.399	59.199	57.995	62.515	52.568
586	58.238	58.374	55.493	63.259	51.703
Average for Ration I	58.319	58.787	56.744	62.887	52.136
Ration II					
18	79.001	68.379	87.084	87.596	44.798
48	67.163	61.639	75.868	71.598	43.320
164	74.051	61.776	64.378	85.069	29.547
197	83.750	78.502	82.032	91.059	49.193
588(1	82.329	74.758	86.778	89.676	51.472
588(2	81.806	74.559	83.098	90.379	42.093
595	73.287	66.644	84.042	82.485	29.417
599	77.521	69.614	83.781	85.478	43.296
Average for Ration II	77.364	69.484	80.883	85.418	41.642
Ration III					
501	72.721	67.587	77.188	81.229	37.282
502	75.449	70.820	73.265	83.601	40.045
507	73.922	70.024	72.876	82.012	37.559
509	77.488	75.013	79.630	85.139	40.465
522	71.435	68.361	78.214	79.971	29.706
527	69.839	65.720	78.589	74.563	47.138
529(2	70.017	63.962	67.588	80.471	31.521
549(1	71.777	65.455	75.910	81.562	39.049
549(2	72.317	69.722	72.524	82.983	28.942
551(1	74.525	67.622	78.185	84.007	43.604
551(2	77.111	74.690	73.181	87.567	35.376
559(1	74.948	69.700	81.317	83.084	46.916
559(2	74.887	72.106	67.746	84.232	40.926
Average of Ration III not including last trials with 549,551, 559	73.572	69.291	75.093	82.340	38.348
Ration IIIa					
549(3	79.590	76.097	75.442	86.717	55.210
551(3	80.894	76.945	79.288	88.185	54.431
559(3	75.498	69.550	75.016	84.550	45.200
Average of Ration IIIa	78.661	74.197	76.582	86.484	51.620
Average of all Ration III	74.526	70.211	75.372	83.117	40.836
Milk and Alfalfa					
529(1	72.501	79.657	90.248	73.277	43.454

Table XIV. Comparison of the Actual Average Digestibility and the Calculated Digestibility of the Rations Fed.

Per Cent Nutrients Digested

	Organic Matter	Protein	Fat	N.F.E.	Fiber
Ration I					
Calculated Digestibility	57.6	53.6	38.4	63.6	49.8
Actual Average Digestibility	58.3	58.8	56.7	62.9	52.1
Ration II					
Calculated Digestibility	80.6	74.4	77.0	86.4	53.0
Actual Average Digestibility	77.4	69.5	80.9	85.4	41.6
Ration III					
Calculated Digestibility	75.3	74.8	73.2	83.0	47.9
Actual Average Digestibility (not including last trials of 549, 551, and 559)	73.6	69.3	75.1	82.3	38.3
Actual Average Digestibility (all trials)	74.5	70.2	75.4	83.1	40.8
Ration IIIa					
549 Calculated Digestibility	74.3	74.6	71.0	82.3	47.6
Actual Digestibility	79.6	76.1	75.4	86.7	55.2
551 Calculated Digestibility	74.8	74.7	72.2	82.7	47.8
Actual Digestibility	80.9	76.9	79.3	88.2	54.4
559 Calculated Digestibility	74.2	74.5	70.7	82.2	47.6
Actual Digestibility	75.5	69.6	75.0	84.6	45.2

Table XV. Effect of Age--Comparison of Young and Old Animals on Maintenance on Ration II.

Per Cent Nutrients Digested

Animal	Age Months	Organic Matter	Protein (N X 6.25)	Fat (Ether Sol.)	N. F. E.	Crude Fiber
197	18	83.750	78.502	82.032	91.059	49.193
595	18	73.287	66.644	84.042	82.485	29.417
Average of young animals		78.519	72.573	83.037	86.772	39.305
164	25	74.051	61.776	64.378	85.069	29.547
18	30	79.001	68.379	87.084	87.596	44.798
588(1)	35	82.329	74.758	86.778	89.676	51.472
588(2)	40	81.806	74.559	83.098	90.379	42.093
Average of older animals		79.297	69.868	80.335	88.180	41.978

Table XVI. The Effect of Age--Comparison of Group III Animals Fed Ration III.

Animal	Age Months	Organic Matter	Protein (N X 6.25)	Fat (Ether Sol.)	N. F. E.	Crude Fiber
509	12	77.488	75.013	79.630	85.139	40.465
549(1)	18	71.777	65.455	75.910	81.562	39.049
551(1)	18	74.525	67.622	78.185	84,007	43.604
549(2)	25	72.317	69.722	72.524	82.983	28.942
551(2)	25	77.111	74.690	73.181	87.567	35.376
549(3)	37	79.590	76.097	75.442	86.717	55.210
551(3)	37	80.894	76.945	79.288	88.185	54.431

Table XVII. Comparison of Young and Old Animals on Full Feed.

Animal	Age Months	Organic Matter	Protein (N X 6.25)	Fat (Ether Sol.)	N. F. E.	Crude Fiber
501	12	72.721	67.587	77.188	81.229	37.282
527	13	69.839	65.720	78.589	74.563	47.138
522	15	71.435	68.361	78.214	79.971	29.706
48	42	67.163	61.639	75.868	71.598	43.320

Table XVIII. The Effect of Age--Comparison of Group II Animals at Different Ages on Ration III.

Animal	Age Months	Organic Matter	Protein (N X 6.25)	Fat (Ether Sol.)	N. F. E.	Crude Fiber
502	12	75.449	70.820	73.265	83.601	40.045
507	12	73.922	70.024	72.876	82.012	37.559
559(1)	18	74.948	69.700	81.317	83.084	46.916
559(2)	25	74.887	72.106	67.746	84.232	40.926
559(3)	37	75.498	69.550	75.016	84.550	45.200

Table XIX. Animals on Ration II Compared as to Plane of Nutrition.

Per Cent Nutrients Digested

Animal	Organic Matter	Protein	Fat	N. F. E.	Fiber
Full Fed					
48	67.163	61.639	75.868	71.598	43.320
Supermaintenance or similar to Group III					
599	77.521	69.614	83.781	85.478	43.296
Maintenance					
18	79.001	68.379	87.084	87.596	44.798
164	74.051	61.776	64.378	85.069	29.547
197	83.750	78.502	82.032	91.059	49.193
588(1)	82.329	74.758	86.778	89.676	51.472
588(2)	81.806	74.559	83.098	90.379	42.093
595	73.287	66.644	84.042	82.485	29.417
Average of all on Maintenance	79.037	70.770	81.235	87.711	41.087
Average of all excluding 164 and 595	81.722	74.050	84.748	89.678	46.889

Table XX. Animals Receiving Ration III Compared as to Plane of Nutrition.

Per Cent Nutrients Digested

Animal	Organic Matter	Protein (N X 6.25)	Fat (Ether Sol.)	N. F. E.	Crude Fiber
Group I					
Full Fed					
501	72.721	67.587	77.188	81.229	37.282
522	71.435	68.361	78.214	79.971	29.706
527	69.839	65.720	78.589	74.563	47.138
Average of Group I	71.332	67.223	77.997	78.588	38.042
Group II					
502	75.449	70.820	73.265	83.601	40.045
507	73.922	70.024	72.876	82.012	37.559
559(1)	74.948	69.700	81.317	83.084	46.916
559(2)	74.887	72.106	67.746	84.232	40.926
559(3)	75.498	69.550	75.016	84.550	45.200
Average of Group II	74.941	70.440	74.044	83.496	42.129
Group III					
509	77.488	75.013	79.630	85.139	40.465
549(1)	71.777	65.455	75.910	81.562	39.049
549(2)	72.317	69.722	72.524	82.983	28.942
549(3)	79.590	76.097	75.442	86.717	55.210
551(1)	74.525	67.622	78.185	84.007	43.604
551(2)	77.111	74.690	73.181	87.567	35.376
551(3)	80.894	76.945	79.288	88.185	54.431
Average of Group III	76.243	72.221	76.309	85.166	42.440
Average of Group III excluding 549(1 and 2) and 551(3)	78.771	75.686	76.885	86.902	46.371
Average of Group III excluding 549(3) and 551(3)	74.644	70.500	75.886	84.252	37.487
Maintenance					
529(2)	70.017	63.962	67.588	80.471	31.521

Table XXI. Steers Arranged According to the Coefficient of Digestion of Organic Matter.

Per Cent Nutrients Digested

Animal	Plane of Nutrition	Organic Matter	Protein	Fat	N. F. E.	Fiber
48	Full Fed	67.163	61.639	75.868	71.598	43.320
527	Full Fed	69.839	65.720	78.589	74.563	47.138
529(2)	Maintenance	70.017	63.962	67.588	80.471	31.521
522(1)	Full Fed	71.435	68.361	78.214	79.971	29.706
549(1)	Low	71.777	65.455	75.910	81.562	39.049
549(2)	Low	72.317	69.722	72.524	82.983	28.942
501	Full Fed	72.721	67.587	77.188	81.229	37.282
595	Maintenance	73.287	66.644	84.042	82.485	29.417
507	Medium	73.922	70.024	72.876	82.012	37.559
164	Maintenance	74.051	61.776	64.378	85.069	29.547
551(1)	Low	74.525	67.622	78.185	84.007	43.604
559(2)	Medium	74.887	72.106	67.746	84.232	40.926
559(1)	Medium	74.948	69.700	81.317	83.084	46.916
502	Medium	75.449	70.820	73.265	83.601	40.045
559(3)	Medium	75.498	69.550	75.016	84.550	45.200
551(2)	Low	77.111	74.690	73.181	87.567	35.376
509	Low	77.488	75.013	79.630	85.139	40.465
599	Supermaintenance (low)	77.521	69.614	83.781	85.478	43.296
18	Maintenance	79.001	68.379	87.084	87.596	44.798
549(3)	Low	79.590	76.097	75.442	86.717	55.210
551(3)	Low	80.894	76.945	79.288	88.185	54.431
588(2)	Maintenance	81.806	74.559	83.098	90.379	42.093
588(1)	Maintenance	82.329	74.758	86.778	89.676	51.472
197	Maintenance	83.750	78.502	82.032	91.059	49.193

Table XXII. Per Cent of Grain Unmasticated.

Animal	Plane of Nutrition	Per Cent of Grain Unmasticated
48	Full Fed	8.196
501	Group I Full Fed	5.903
522	Group I Full Fed	3.944
502	Group II Medium	3.322
507	Group II Medium	5.763
509	Group III Scant	1.984
18	Maintenance	1.059
164	Maintenance	1.195
197	Maintenance	0.451
588(1)	Maintenance	0.367
588(2)	Maintenance	0.460

Table XXIII. Comparison of Coefficients of Digestibility of Total and Masticated Food.

Per Cent Nutrients Digested.

Animal	Total Org.Matter Digested	Masticated Org. Matter Digested	Total Protein Digested	Masticated Protein Digested	Total Fat Digested	Masticated Fat Digested	Total N. F. E. Digested	Masticated N. F. E. Digested	Total Fiber Digested	Masticated Fiber Digested
48	67.163	73.131	61.639	64.430	75.868	76.736	71.598	78.331	43.320	44.080
501	72.721	75.594	67.587	69.255	77.188	80.500	81.229	84.906	37.282	38.355
522	71.435	73.569	68.361	69.657	78.214	80.544	79.971	82.714	29.706	30.338
502	75.449	77.171	70.820	71.918	73.265	74.964	83.601	85.808	40.045	40.599
507	73.922	76.985	70.024	71.905	72.876	75.858	82.012	85.866	37.559	38.559
509	77.488	78.543	75.013	75.714	79.630	80.585	85.139	86.469	40.465	40.840
18	79.001	79.644	68.379	68.613	87.084	87.137	87.596	88.531	44.798	44.928
164	74.051	74.886	61.776	62.029	64.378	64.583	85.069	86.131	29.547	29.683
197	83.750	84.038	78.502	78.620	82.032	82.162	91.059	91.444	49.193	49.276
588(1)	82.329	82.552	74.758	74.858	86.778	86.839	89.676	89.971	51.472	51.563
588(2)	81.806	82.090	74.559	74.665	83.098	83.207	90.379	90.767	42.093	42.165

Table XXIV. Composition of Feeds used in Digestion Trials with Swine

Feed	Laboratory Number	Per Cent Moisture	Per Cent Protein (N X 6.25)	Per Cent Fat (Ether Sol.)	Per Cent Nitrogen-Free Extract	Per Cent Crude Fiber	Per Cent Ash
Ship Stuff	15-2-63	11.720	20.194	4.670	52.208	6.490	4.718
Ship Stuff	15-6-16	12.740	19.006	4.723	53.291	5.985	4.255
Corn Chop	15-2-64	13.408	8.544	3.520	71.585	1.805	1.138
Corn Chop	15-6-15	15.203	9.025	3.335	69.374	2.018	1.045
Bran	15-2-61	9.588	17.744	4.835	51.985	9.168	6.680
Bran	15-6-17	11.215	18.225	4.550	50.437	9.155	6.418
Linseed	15-2-62	10.785	36.288	6.365	33.104	7.970	5.488
Linseed	15-6-18	10.585	37.494	5.178	33.538	7.940	5.265

Table XXV. Composition of Dung Voided by Gilts during Digestion Trials.

Animal	Laboratory Number	Per Cent Moisture	Per Cent Protein (N X 6.25	Per Cent Fat (Ether Sol.)	Per Cent Nitrogen-Free Extract	Per Cent Crude Fiber	Per Cent Ash
9	15-2-8	77.610	3.575	1.705	10.203	4.048	2.859
5	15-2-9	76.854	3.569	1.653	11.142	3.871	2.911
6	15-2-10	77.018	3.950	1.922	10.729	3.720	2.661
10	15-2-11	77.943	3.856	1.836	10.495	3.232	2.638
9	15-2-12	77.760	3.419	2.073	10.068	3.858	2.822
5	15-2-13	77.216	3.763	2.214	10.118	3.917	2.772
6	15-2-14	76.051	3.981	2.213	11.189	3.961	2.605
10	15-2-15	77.528	3.738	2.068	10.398	3.711	2.557
5	15-5-5	73.666	3.988	1.509	8.561	3.883	8.393
9	15-5-6	73.153	3.988	1.534	10.030	4.392	6.903
6	15-5-7	74.468	4.000	1.475	11.317	4.323	4.417
5	15-5-8	76.401	3.981	1.585	9.690	3.937	4.406
9	15-5-9	75.278	3.831	1.507	9.701	4.078	5.605
6	15-5-10	76.226	4.069	1.926	10.525	4.362	2.892

Table XXVI. Showing Weights of Feed Fed and Dung Voided by Swine During Digestion Trials

Animal	Total Weight of Feed Fed During Trial Grams	SHIP STUFF Laboratory Number	SHIP STUFF Weight Consumed During Trial Grams	CORN CHOP Laboratory Number	CORN CHOP Weight Consumed During Trial Grams	BRAN Laboratory Number	BRAN Weight Consumed During Trial Grams	LINSEED Laboratory Number	LINSEED Weight Consumed During Trial Grams	DUNG (First 5 days) Laboratory Number	DUNG (First 5 days) Weight Voided During Trial Grams	DUNG (Second 5 days) Laboratory Number	DUNG (Second 5 days) Weight Voided During Trial Grams
5(1)	22,679.5	15-2-63	5,039.9	15-2-64	2,519.9	15-2-61	2,519.9	15-2-62	1,260.0	15-2-9	13,857.2	15-2-13	13,866.3
5(2)	28,122.6	15-6-16	6,249.5	15-6-15	3,124.7	15-6-17	3,124.7	15-6-18	1,562.4	15-5-5	18,270.6	15-5-8	16,778.3
6(1)	22,679.5	15-2-63	5,039.9	15-2-64	2,519.9	15-2-61	2,519.9	15-2-62	1,260.0	15-2-10	14,623.7	15-2-14	13,784.6
6(2)	27,215.4	15-6-16	6,047.9	15-6-15	3,023.9	15-6-17	3,023.9	15-6-18	1,512.0	15-5-7	12,804.9	15-5-10	14,882.3
9(1)	22,679.5	15-2-63	5,039.9	15-2-64	2,519.9	15-2-61	2,519.9	15-2-62	1,260.0	15-2-8	14,392.4	15-2-12	14,310.8
9(2)	27,215.4	15-6-16	6,047.9	15-6-15	3,023.9	15-6-17	3,023.9	15-6-18	1,512.0	15-5-6	12,872.9	15-5-9	16,161.4
10	27,679.5	15-2-63	5,039.9	15-2-64	2,519.9	15-2-61	2,519.9	15-2-62	1,260.0	15-2-11	15,961.8	15-2-15	14,324.4

Table XXVII. Weight of Nutrients Fed to Swine during Digestion Trial.

Animal	Weight of Total Dry Matter Fed Grams	Weight of Organic Dry Matter Fed Grams	Weight of Protein (N X 6.25) Fed Grams	Weight of Fat (Ether Sol) Fed Grams	Weight of Nitrogen-Free Extract Fed Grams	Weight of Crude Fiber Fed Grams	Weight of Ash Fed Grams
5(1)	20,067.3	19,059.4	4,274.8	1,052.2	12,324.4	1,408.0	1,007.9
5(2)	24,548.6	23,385.9	5,250.2	1,244.9	15,196.3	1,694.4	1,162.7
6(1)	20,067.3	19,059.4	4,274.8	1,052.2	12,324.4	1,408.0	1.007.9
6(2)	23,756.8	22,631.5	5,080.9	1,204.7	14,706.1	1,639.8	1,125.3
9(1)	20,067.3	19,059.4	4,274.8	1,052.2	12,324.4	1,408.0	1,007.9
9(2)	23,756.8	22,631.5	5,080.9	1,204.7	14,706.1	1,639.8	1,125.3
10	20,067.3	19,059.4	4,274.8	1,052.2	12,324.4	1,408.0	1,007.9

Table XXVIII. Weight of Nutrients Voided in Dung during Digestion Trial with Swine.

Animal	Weight of Total Dry Matter Voided Grams	Weight of Organic Dry Matter Voided Grams	Weight of Protein (N X 6.25) Voided Grams	Weight of Fat (Ether Sol.) Voided Grams	Weight of Nitrogen-Free Extract Voided Grams	Weight of Crude Fiber Voided Grams	Weight of Ash Voided Grams
5(1)	6,376.6	5,578.8	1,016.2	536.1	2,947.0	1,079.6	797.8
5(2)	8,770.9	6,498.2	1,396.6	541.6	3,190.0	1,370.0	2,272.7
6(1)	6,662.1	5,913.9	1,126.4	586.1	3,111.3	1,090.0	748.2
6(2)	6,807.4	5,811.4	1,117.7	475.5	3,015.5	1,202.7	996.0
9(1)	6,405.1	5,589.8	1,003.8	542.1	2,909.3	1,134.7	815.3
9(2)	7,451.4	5,656.9	1,132.4	441.0	2,859.0	1,224.4	1,794.5
10	6.739.6	5,952.3	1,150.9	589.3	3,164.6	1,047.5	787.3

Table XXIX. Weight of Nutrients Digested by Swine during Digestion Trial.

Animal	Weight of Total Dry Matter Digested Grams	Weight of Organic Dry Matter Digested Grams	Weight of Protein (N X 6.25) Digested Grams	Weight of Fat (Ether Sol.) Digested Grams	Weight of Nitrogen-Free Extract Digested Grams	Weight of Crude Fiber Digested Grams	Weight of Ash Digested Grams
5(1)	13,690.8	13,480.7	3,258.6	516.1	9,377.5	328.5	210.1
5(2)	15,777.7	16,887.7	3,853.7	703.3	12,006.4	324.4	-1,110.0
6(1)	13,405.2	13,145.5	3,148.3	466.1	9,213.1	318.0	259.7
6(2)	16,949.4	16,820.1	3,963.2	729.2	11,690.6	437.0	129.3
9(1)	13,662.3	13,469.7	3,271.0	510.2	9,415.2	273.3	192.6
9(2)	16,305.4	16,974.6	3,948.5	763.7	11,847.1	415.3	-669.2
10	13,327.7	13,107.2	3,123.9	462.9	9,159.8	360.6	220.5

Table XXX. Per Cent of Nutrients Digested by Swine during Digestion Trial.

Animal	Date of Trial	Per Cent Organic Dry Matter Digested	Per Cent Protein (N X 6.25) Digested	Per Cent Fat (Ether Sol.) Digested	Per Cent Nitrogen-Free Extract Digested	Per Cent Crude Fiber Digested	Per Cent Ash Digested
5(1)	1/23 to 2/2, 1915	70.730	76.228	49.053	76.088	23.330	20.849
5(2)	4/27 to 5/7, 1915	72.213	73.400	56.491	79.008	19.146	negative
6(1)	1/23 to 2/2, 1915	68.971	73.649	44.296	74.755	22.587	25.762
6(2)	4/27 to 5/7, 1915	74.322	78.002	60.531	79.495	26.653	11.488
9(1)	1/23 to 2/2, 1915	70.672	76.519	48.484	76.394	19.412	19.104
9(2)	4/27 to 5/7, 1915	75.004	77.712	63.393	80.559	25.328	negative
10	1/23 to 2/2, 1915	68.770	73.077	43.995	74.322	25.608	21.882

Table XXXI. Weight of Gilts during Digestion Trial, and Grams of Organic Matter and Digestible Organic Matter per Kilo of Body Weight per Day.

Animal	Average Weight in Kilos at Time of Trial	Grams Organic Matter per Kilo per Day	Grams Digestible Organic Matter per Kilo per Day
5(1)	105.9	18.00	12.73
5(2)	88.9	26.31	19.00
6(1)	84.5	22.56	15.56
6(2)	114.7	19.73	14.66
9(1)	102.1	18.67	13.19
9(2)	123.7	18.29	13.72
10	89.3	21.34	14.68

Table XXXII. Comparison of Pregnant and Non-Pregnant Gilts.

		Per Cent Nutrients Digested				
Animal	Condition	Organic Matter	Protein	Fat	N. F. E.	Fiber
5(1)	Pregnant	70.730	76.228	49.053	76.088	23.330
9(1)	Pregnant	70.672	76.519	48.484	76.394	19.412
Average for Pregnant		70.701	76.374	48.769	76.241	21.371
6(1)	Open	68.971	73.649	44.296	74.755	22.587
10	Open	68.770	73.077	43.995	74.322	25.608
Average for Non-Pregnant		68.871	73.363	44.146	74.539	24.098

The Influence of the Quantity of Organic Matter Fed on the Digestibility of the Organic Matter.

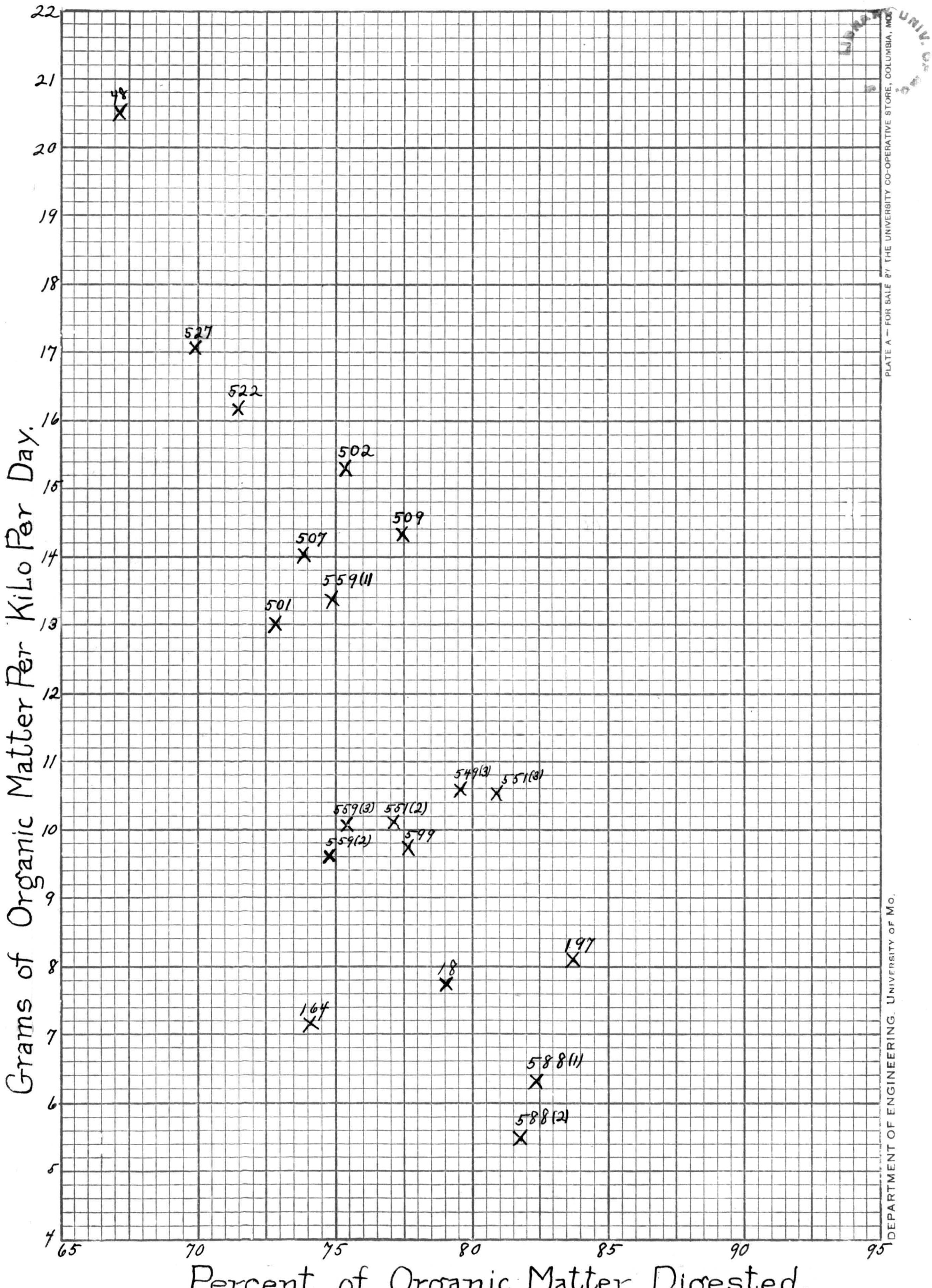


PLATE I

The Influence of the Quantity of Organic Matter Fed on the Digestibility of the Protein. (N x 6.25)

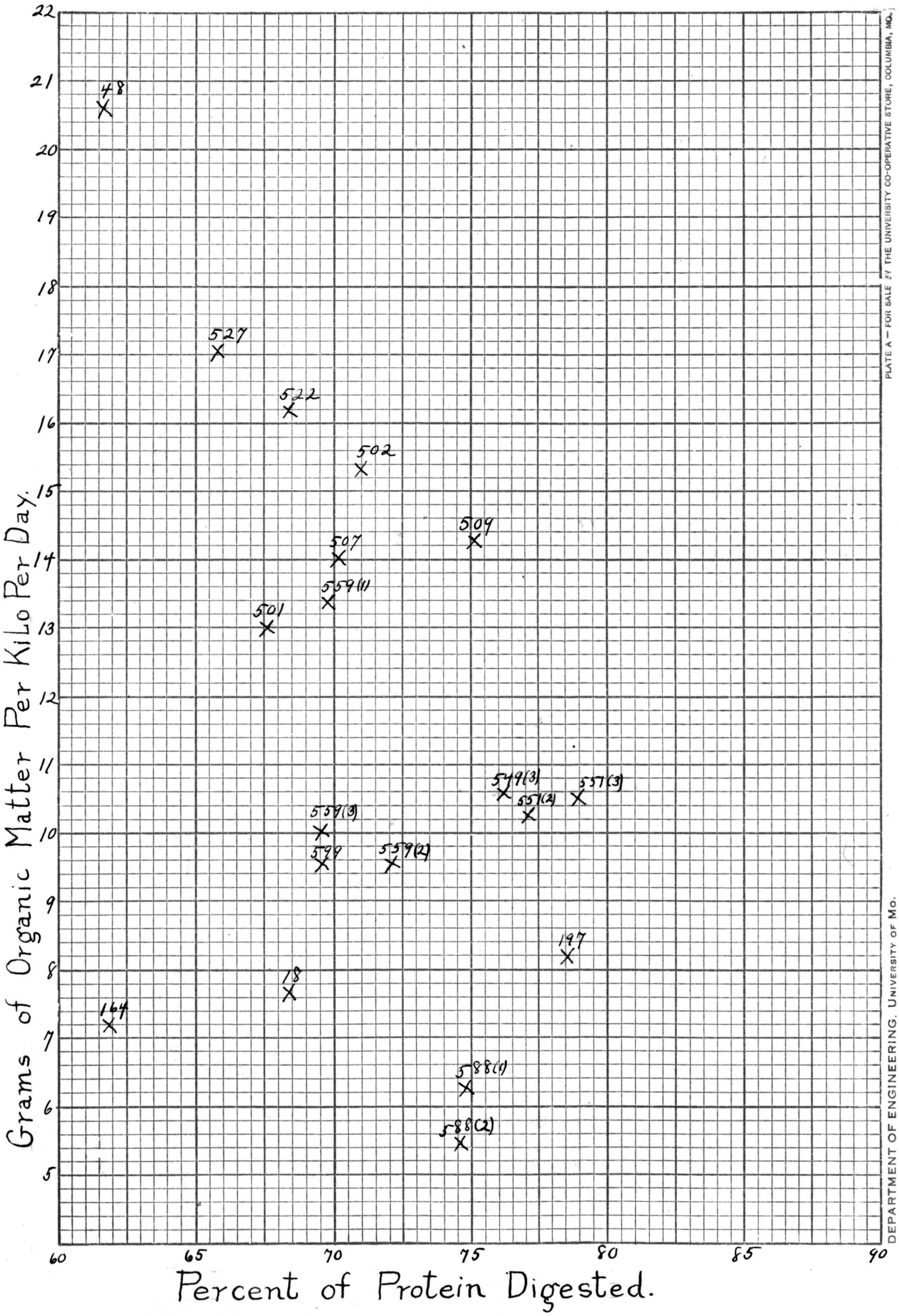
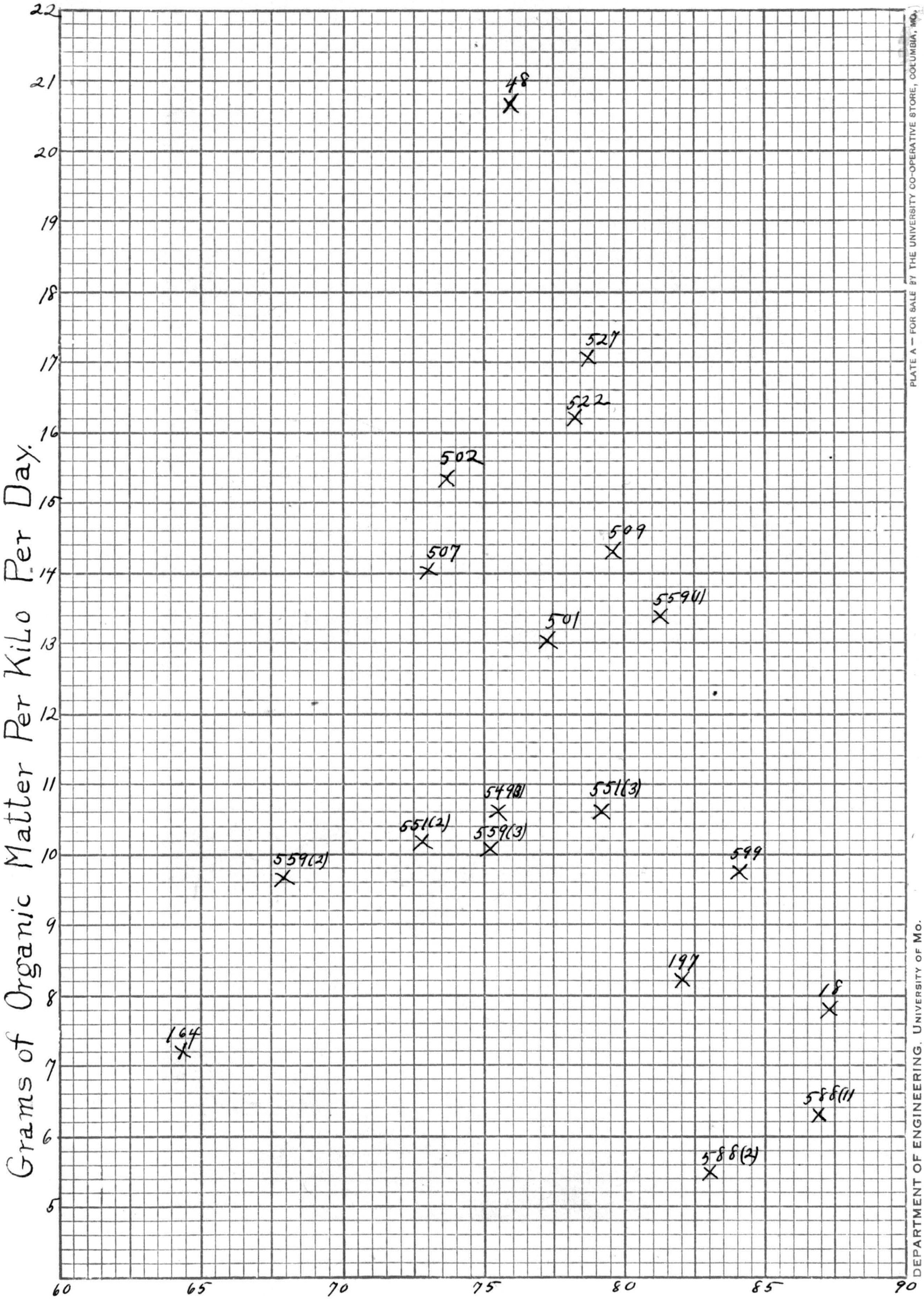


PLATE II

The Influence of the Quantity of Organic Matter Fed on the Digestibility of the Crude Fat.



Percent of Fat Digested

PLATE III

The Influence of the Quantity of Organic Matter Fed on the Digestibility of the Nitrogen-Free Extract.

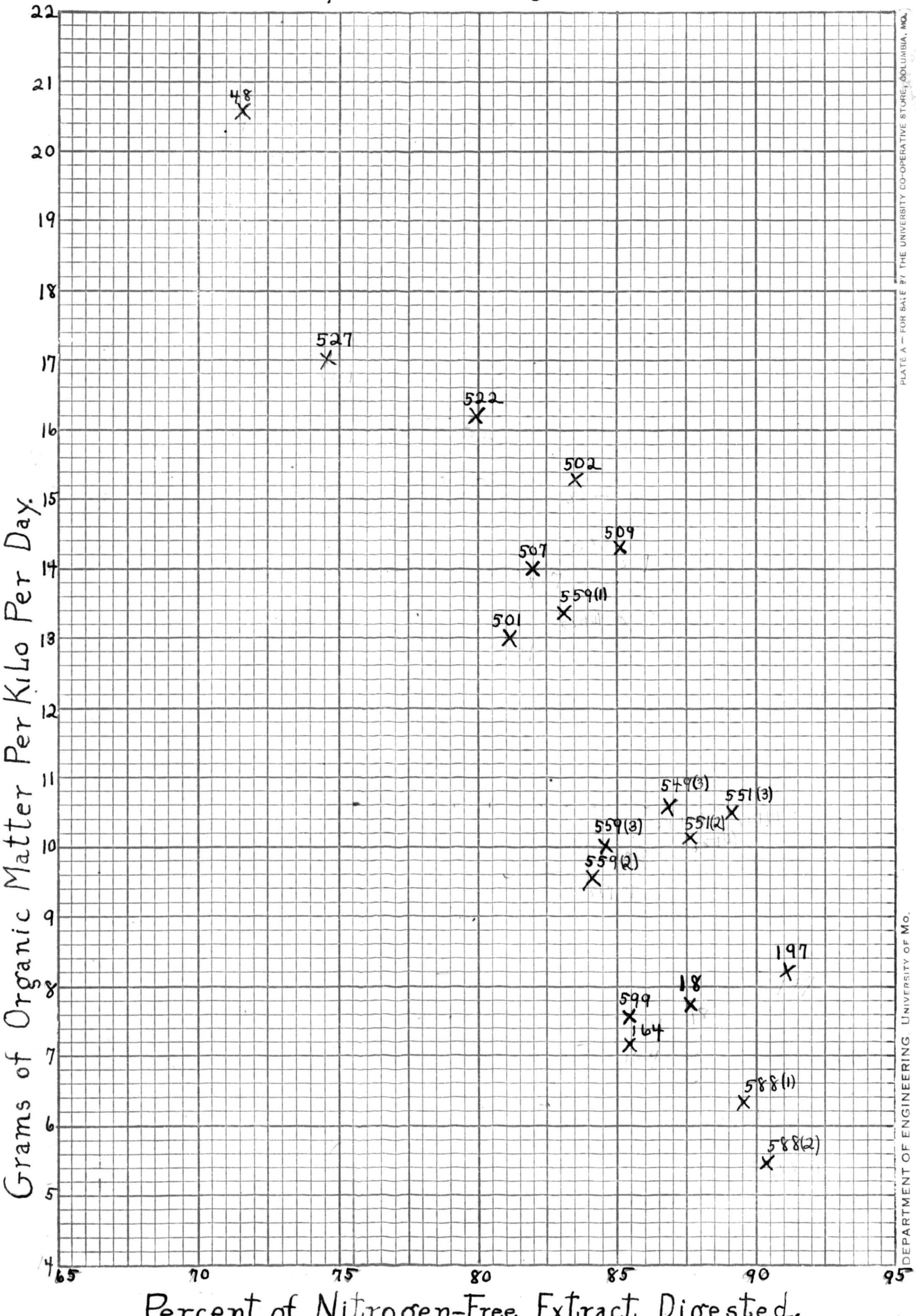


PLATE IV

The Influence of the Quantity of Organic Matter Fed on the Digestibility of the Crude Fiber.

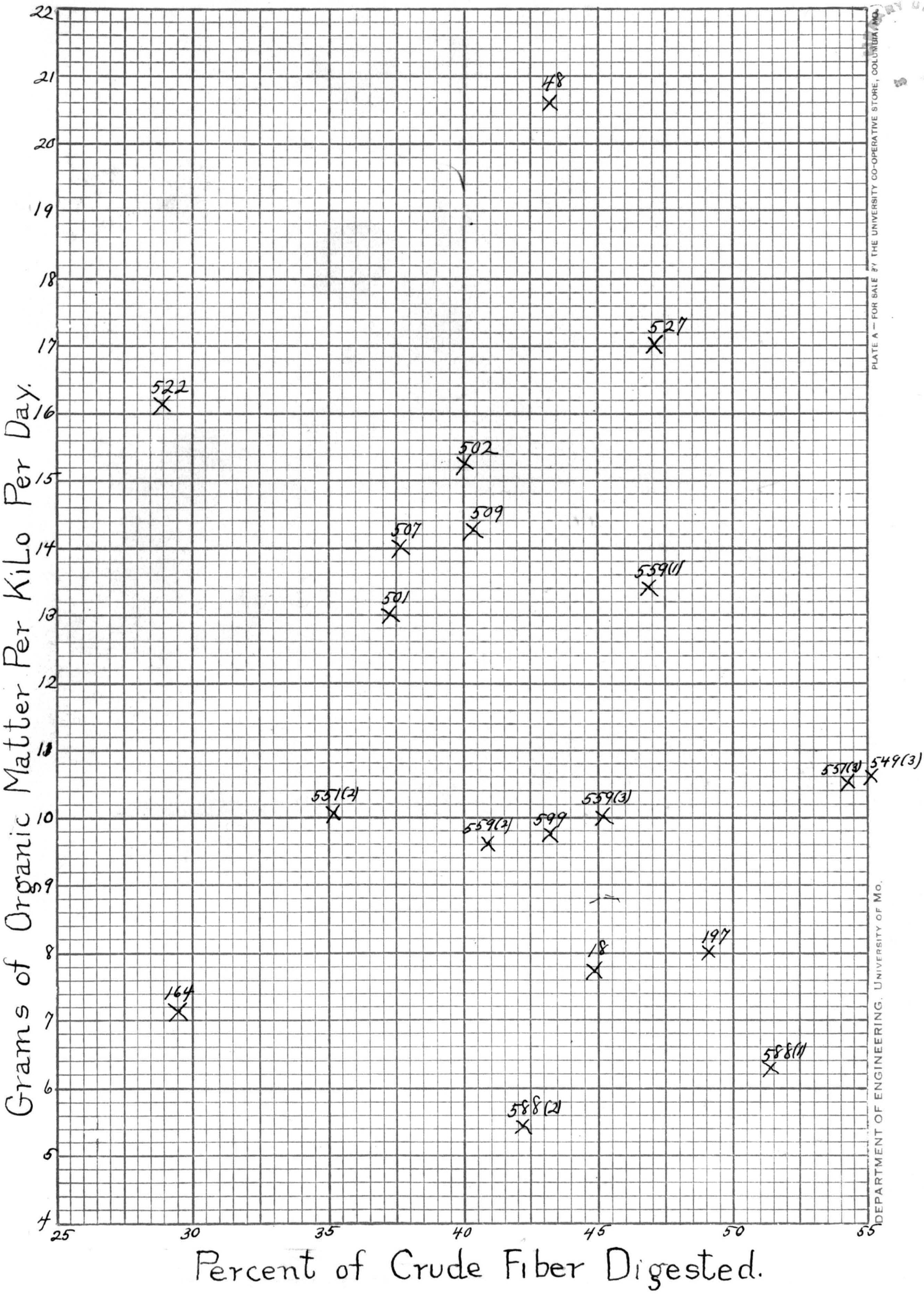


PLATE V

The Influence of the Quantity of Organic Matter Fed on the Digestibility of the Organic Matter.

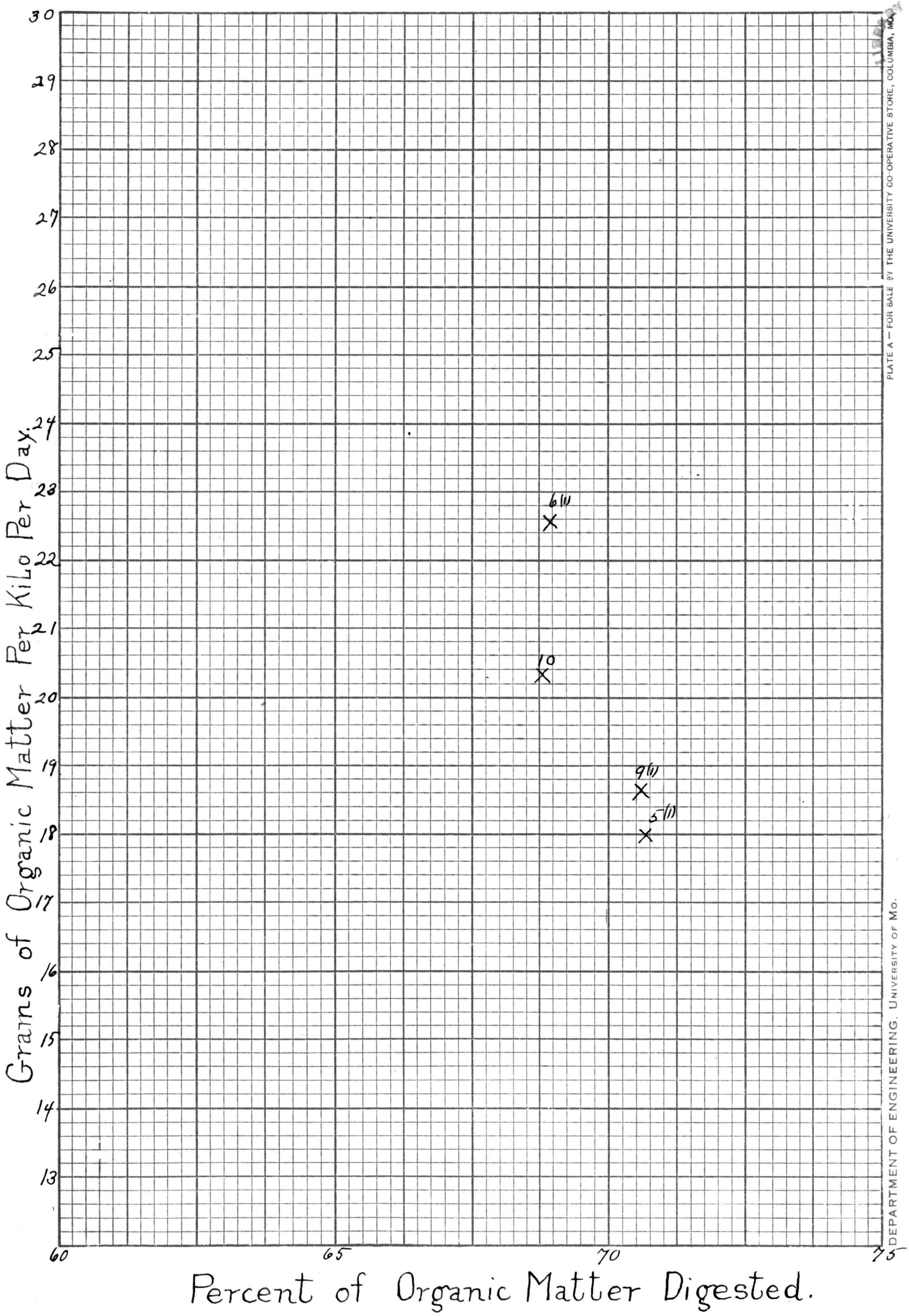


PLATE VI

Bibliography

1. Trowbridge--unpublished data.
2. Fraps and Rather, Texas Bulletin 150.
3. McDowell, Experiment Station Record Vol. 19, p. 867.
4. Fraps, Texas Bulletin 175.
5. Kellner, Die Ernahrung der landwirtschaftlichen Nutz Tiere.
6. Ewing and Wells, Georgia Station Bulletin 115.
7. E. Wolff, Landw. Jahr. 22, p. 605, and 24, p. 199.
8. Volhard, Landw. Ver. Stat. 61, p. 305.
9. G. Fingerling, Jour. Landw. 52, pp. 145-146.
10. Michael and Kennedy, Iowa Station Bulletin 113.
11. Kellner, Experiment Station Record, Vol. 9, p. 509.
12. Armsby, Frear, and Caldwell, Penna. Station report, 1890, part II, p. 43.
13. Bartlett, Maine Bulletin 110.
14. E. Wolff, Landw. Jahr. 1 (1872), p. 533.
15. Armsby and Fries, Penna. Station Bulletion 105.
16. E. Wolff, Land. Ver. Sta. 20, p. 34.
17. Christensen and Simpson, New Mexico Station Bulletion 91.
18. E. Wolff, Land. Ver. Sta. 20, p. 34.
19. E. Wolff, Land. Ver. Sta. 21, pp. 19 and 38.
20. Henneberg and Stohman, Futterung der Wiederkauer, p. 327.
21. Jordan and Jentner, New York (Geneva) Bulletin 143, p. 703.
22. Jordan and Jentner, New York (Geneva) Bulletin 132.
23. H. Weiske, Experiment Station Record, Vol. 5, p. 531.
24. T. Katayama, Landw. Ver. Stat. 68, p. [illegible]5.
25. Eckles, Missouri Station Research Bulletin 4.

26. Phelps and Woods, Connecticut Station Report, 1895, pp.191-99.

27. Mumford, Grindley, et.al, Illinois Bulletin 172.

28. H. Weiske, Experiment Station Record, Vol. 5, p. 531.

29. Henry and Morrison, Feeds and Feeding, tables in appendix.

30. Trowbridge, unpublished data.

31. Trowbridge, unpublished data.

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