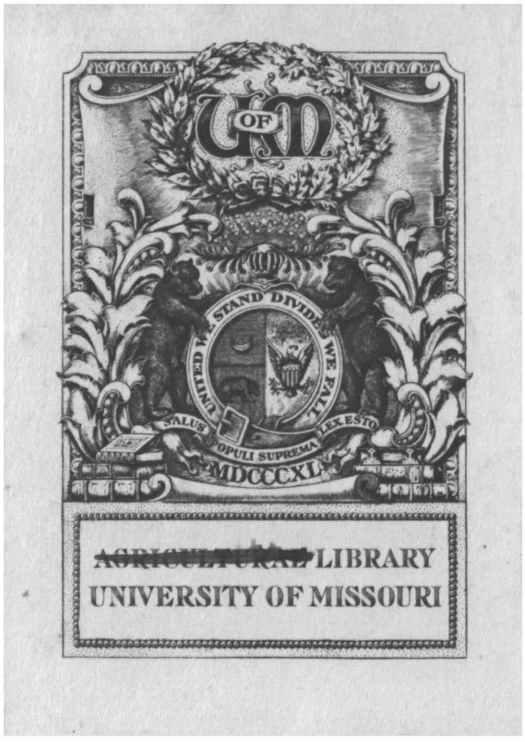

THE COEFFICIENT OF DIGESTION AS INFLUENCED BY THE PLANE OF NUTRITION OF THE ANIMAL

by

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THE COEFFICIENT OF DIGESTION AS INFLUENCED BY THE PLANE OF NUTRITION OF THE ANIMAL.

A review of the literature reporting digestion experiments shows that but few investigators have studied the problem of digestion from the point of view of the influence of the condition of the animal on its ability to assimilate food.

T. Katayama (1) fed two swine a ration consisting of potato chips, molasses cake, wheat bran, and rye meal. ~~The~~ Each digestion trial was divided into two periods of ten days each, in one of which ~~each~~ the animals received twice as much food as in the other. Between these two periods three days intervened during which time the animals received the ration of the last period.

The results obtained are summarized in the following table:

TABLE I

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N-free Extract ~~N.F.E.~~
5	10	1254.6	86.4	88.0	68.0	---	55.2	94.0
5	10	627.3	86.4	88.2	73.4	---	54.4	93.7
Difference			0.0	0.2	5.4		-0.8	-0.3
6	10	1254.6	86.0	87.6	66.9	---	54.3	94.0
6	10	627.3	86.1	87.8	72.3	---	54.4	93.6
Difference			0.1	0.2	5.4		0.1	-0.4

From this experiment the author concludes that the foregoing determinations show that the food in both of the periods was equally well digested and that the amount of the food has no influence on its assimilation.

In the total food of period one there was 15.5 grams of fat (ether extract). In the dung of swine number 5 there was found 17.3 grams and in the dung of number 6 there was found 18.8 grams of fat. In period two 7.8 grams of fat was found in the total ration while in the dung of number 5 for this period there was 8.7 grams and in the dung of number 6 there was found 9.8 grams of fat. The author concludes that the fact that there is more fat (ether extract) in the feces than was found in the total food is due to the presence in the feces of ether soluble metabolic products.

In the digestion of the protein he finds that in the small ration only 5.3 per cent (3.4 grams) more was digested than in the large ration. This slight difference he is inclined to attribute to an addition of nitrogen containing metabolic products rather than to the effect of the larger ration. He thinks that with a ration containing a small amount of protein and a large amount of carbohydrate, a much larger amount of these metabolic products will appear in the feces. By the use of pepsin-hydrochloric acid according to the recommendation of Th. Pfeiffer (31) he determined the amount of nitrogen in the metabolic products. Using the dry feces the following figures were obtained:

	Grams dung air dry	Total amt. protein %	Total amt. protein grams	Protein insol. in pepsin %	Protein insol. in pepsin grams	Protein sol. in pepsin grams
Swine 5 period 1	170.0	24.12	41.0	8.00	13.6	27.4
" 6 " 1	176.0	24.15	42.5	7.90	13.9	28.6
" 5 " 2	85.2	20.11	17.1	8.79	8.4	8.7
" 6 " 2	87.3	20.38	17.8	9.03	7.9	9.9

We see from these figures that the feces from the high ration contained much more pepsin soluble nitrogen containing substance than the smaller ration. But since the digestion with pepsin very possibly dissolves not only the metabolic products but also some of the protein nitrogen of the feces the author determined the amount of nitrogen which was soluble in ether and alcohol.

For this purpose a large amount of feces was thoroughly extracted with ether and the undissolved residue then treated with alcohol. He found in this way the amount of nitrogen which on the one hand was dissolved in ether and on the other was left in the feces after extraction with ether and alcohol. By this means he obtained the following figures:

	Protein in ether extract %	Protein in ether extract grams	Protein insol. in ether & alcohol %	Protein insol. in ether & alcohol grams	Crude protein soluble grams
Swine 5 period 1	0.33	0.56	20.68	35.2	5.8
" 6 " 1	0.43	0.76	20.73	36.5	6.0
" 5 " 2	0.27	0.23	18.23	15.5	1.6
" 6 " 2	0.33	0.29	18.17	15.9	1.9

From the above table it is easily seen that in period

one the feces contained a much larger amount of metabolic nitrogenous substance than in period 2. Very probably not all of the nitrogen in the ether and alcohol can be called metabolic, still he calculated the digestion coefficient of the protein on this basis. When he subtracted from the total feces nitrogen, that which was dissolved in ether and alcohol, and then calculated the digestion coefficient he obtained the following figures:

	5-1	6-1	Average	5-2	6-2	Average	Differ.
Digestion coefficient usual calculation	68.1	66.9	67.7	73.4	72.3	72.8	-5.3
Digestion coefficient above described calculation	72.6	71.6	72.1	75.8	75.2	75.5	-3.2

By this means he obtained a much closer agreement of the percentages of protein digested and concluded that the lower digestion coefficient with a large ration was due to the presence of a larger amount of metabolic nitrogenous substance in the feces.

Kellner (2) in experimenting with steers found that the amount of food eaten had a very marked effect on the per cent of food assimilated. He fed a ration consisting of timothy hay, molasses cake, rye meal, and cottonseed meal. Below are his results:

TABLE 2.

Animal No.	Days of Trial	Wt. Food Eaten Kg?	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
	13	10.84		76.1	71.0	63.5	62.8	82.0
	13	13.01		74.7	68.3	64.4	61.2	80.8
	13	15.18		72.8	65.8	64.2	59.2	79.0
	13	10.84		75.8	71.2	67.6	62.6	81.2

In this experiment there was found to be a decided decrease in the digestibility of the food, with the exception of fat, as the ration was increased. Kellner thinks this is due to the food remaining longer in the digestive tract if a small amount is taken and therefore more digestion by the juices and more absorption by the intestines.

From the above table it appears that the digestion depression due to the greater ration is not very large and Kellner thinks it appears to approach a limit which for exactness in such investigations must in general be taken. The author thinks it is certain that there are different conditions which influence the assimilation of food in larger amounts. He says that the length of time which the food remains in the stomach and intestines should be considered, for if the digestible foodstuff is here too short a time the digestion and absorption as well as the fermentation may be stopped too soon. And also since the elasticity of the digestive tract must have a limit, it is possible that when the volume of the food reaches or oversteps this limit, its passage through the intestines will be much faster than on a smaller ration. He also thinks that

it is possible that with a food of easily digestible substances the ability of the walls of the intestines to absorb is not exercised to the utmost and does not take out all of the nutrients that are in the intestines.

Henneberg and Stahmann (3) found that increasing amounts of feed lowered the digestibility. The same animals were used through this entire set of experiments.

The animals in table 3 received oats straw and bean meal; in table 3a they received bean straw and bean meal; in table 3b clover hay alone, and in table 3c timothy hay and bean meal. The following results were obtained:

TABLE 3

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
1	6	21.0		50.0	52.0	26.0	57.0	43.0
2	6	24.0		49.0	46.0	14.0	53.0	47.0

TABLE 3a

1	6	24.5			54.0	50.0	39.0	64.0
2	6	27.7			49.0	?	33.0	59.0

TABLE 3b

1	14	20.4		54.0	51.0	36.0	38.0	69.0
1	14	25.1		54.0	50.0	?	40.0	67.0
2	14	24.1		54.0	53.0	?	38.0	68.0
2	14	29.0		54.0	51.0	33.0	39.0	67.0

TABLE 3c

1	6	18.65			61.0	?	65.0	70.0
2	6	22.88			55.0	26.0	59.0	65.0

In another experiment (4) they found that with increase in size of the ration there was a decrease in the digestibility in one instance and an increase in the other, as the following table will show. These animals were fed timothy hay and each received in addition 50 grams of salt per day.

TABLE 4.

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
1		8.635		62.0	56.0	37.0	65.0	63.0
1		10.570		60.0	70.0	41.0	60.0	59.0
2		8.365		62.0	61.0	41.0	64.0	62.0
2		9.670		63.0	71.0	41.0	68.0	58.0

Although these men found a decrease in most cases in the food assimilated, as the ration increases, speaking of the results in respect to practical feeding they say that, within rather wide limits, the amount of roughage eaten really makes no difference in its assimilation.

Jordan and Jenter (5) ran digestion trials with four sheep on two different kinds of rations. Sheep numbers 1 and 2 were on full feed during both experiments while sheep numbers 3 and 4 were on half feed. Full ration number 1 consisted of 100 grams of timothy hay, 800 grams of corn silage, 100 grams of ground oats, and 120 grams of ground peas. Half ration number one consisted of just half of each of these constituents. Full ration number two consisted of 300 grams of timothy hay, 500 grams

of corn silage, 40 grams of malt sprouts, 60 grams of brewers grains, and 60 grams of Buffalo gluten feed. Half ration number two consisted of just one-half of each of these constituents. Below are the results obtained:

TABLE 5.

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
1	5	2325.4	69.5	71.8	70.7	79.3	59.0	75.7
2	5	2325.4	69.3	71.7	71.0	81.8	58.9	75.2
	Average		69.4	71.7	70.8	80.5	59.0	75.4
3	5	1177.5	75.7	77.2	76.0	82.1	70.3	79.4
4	5	1177.5	73.1	75.4	75.2	82.2	64.2	78.6
	Average		74.4	76.4	75.6	82.1	67.2	79.0
			Ration 2.					
1	5	2648.4	62.2	64.7	69.7	73.9	59.0	65.2
2	5	2648.4	61.1	63.8	60.9	73.8	61.1	64.9
	Average		61.6	64.2	65.3	73.8	60.0	65.0
3	5	1304.4	66.9	68.7	69.8	76.5	64.8	69.5
4	5	1304.4	65.1	67.4	71.7	75.7	59.9	69.0
	Average		66.0	68.0	70.7	76.1	62.3	69.2

In this experiment the digestion coefficients of numbers 3 and 4 on half ration are higher in both cases than the coefficients of numbers 1 and 2 on full ration. Concerning these results the authors say that the results of the comparison of the full and half ration show the latter to be uniformly more

fully digested. They think that this difference between the large and small ration is too large and too uniform to be explained by errors.

These same men in running an experiment (6) on a cow to determine the source of the fat in milk, fed her different amounts of the same food. In one period she received 10 pounds of timothy hay, 7 1/2 pounds of corn meal, and 5 pounds of ground oats. In the other period 6 2/3 pounds of timothy, 5 pounds of corn meal, and 3 1/3 pounds of ground oats was the ration. The feed used had all been extracted to remove the fat. The table below gives their results.

TABLE 6

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
Cow	6	22.5	60.1		44.9	52.6		63.0
"	10	15.0	55.6		39.6	51.4		59.1

H. Weiske (7) in making experiments with rabbits to determine the influence of different salts on the digestion, fed a number of them oats alone in differing amounts. These rabbits were the check animals in his experiments. Numbers 1 and 2 were rabbits from the same litter about six months old. Rabbit K was about three and one-half months old. Rabbit number 1 was about seven months old.

He says in discussing the results of these different experiments that he has found that with one and the same oats

when 100 grams of the air dry oats were fed, 18.3 per cent of the dry substance, 25.8 per cent of protein, and 18.6 per cent of N. F. E. less was digested than when the animals received only 55.5 grams of the air dry feed. In another experiment the animal had instead of 100 or 55.5 grams of air dry oats (93.5 and 52.0 grams of dry) 84.5 grams of dry oats, therefore the amount eaten lay midway between the amount eaten by the rabbits in the previous experiment.

If we now compare the digestion coefficients which were obtained in the different experiments by feeding rabbits oats without the addition of any salts, we obtain the following figures:

TABLE 7.

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
1		93.52	66.16	67.18	66.34	93.86	30.06	70.37
2		93.52	60.49	61.50	67.15	93.31	9.16	65.32
Average		93.52	63.3	64.3	66.8	93.6	19.6	67.9
1		84.5	76.2	77.0	81.3	94.3	10.4	84.2
K		52.0	81.6	82.3	92.6	93.1	34.7	86.5

From these results he concludes that it is evident that the digestion coefficient of oats (exclusive of ether extract) is in inverse proportion to the amount of food consumed, for with the greatest consumption there is the least digestion, and with the least consumption there is the greatest digestion while

the consumption of an amount between these gave a digestion coefficient about half way between the maximum and minimum.

E. Wolff et al. (8) experimented on a horse doing ordinary farm work. He was fed different rations and the digestion coefficient determined. At two different times he received timothy hay alone. Below are the results obtained:

TABLE 8.

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in %. Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
			Period 1					
5		8812.00	55.78	56.84	63.69	42.17	47.21	63.16
			Period 3					
5		10898.75	53.42	53.95	61.74	42.60	44.19	59.77

In the above experiment a slightly lower digestion of timothy hay was obtained when the animal received 12.5 kg. than when it received only 10 kg. However there was a difference of only two or three per cent in the total dry substance and the different constituents of the hay. For this reason the author (9) investigated this question farther to see whether if the animal ate differing amounts of one and the same roughage any influence on the digestion coefficient could be noticed. For this purpose pure luzern hay was used, which was cut from the fields of the experiment station in a fairly young condition, was cured well and was of a very good quality. The hay was fed in three periods following each other, in the following amounts:

8, then 10, and finally 12 kg. This amount could not be exceeded without leaving an uneaten residue. It is to be noticed that the horse was fed 10 kg. of hay of another cutting of the same field for 14 days before the beginning of this experiment.

Below are the results obtained:

TABLE 9

Animal No.	Days of Trial	Wt.Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
			Period 1					
5		6695,2	55.20	55.94	73.51	---	32.97	69.94
			Period 2					
5		8431.00	57.47	57.97	73.25	---	37.05	70.91
			Period 3					
5		9936.00	60.64	61.07	77.03	---	42.88	71.83

It is seen from this table that a depression of the digestion following an increase in the amount of roughage at least here is not the case; on the other hand, even though small there was a regular increase in the digestibility of the food.

In the previous winter the same horse was fed only hay at two different times far separated from each other, while in the interim the same hay along with oats and chopped straw was fed. The following table shows the results of this experiment:

TABLE 9a

Animal No.	Days of Trial	Wt.Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
			Period 1					
5		8584.0	47.27	50.21	58.02	21.47	38.44	57.89
			Period 8					
5		8652.0	48.62	50.26	54.08	21.37	39.27	58.81

We see that these figures are very close together. Of the organic matter about the same was digested in both cases. Only in the protein is there a difference. This difference, however, the authors say, often occurs in this kind of experiments and must be referred to the averaging of the analyses of the feeds.

In order to test the digestibility of the above kinds of roughage by ruminants, two two year old wethers were fed differing amounts of the luzern hay number 1. As in the experiments with the horse the sheep were given first 800, then 1000, and finally 1200 grams of the air dry hay per day per sheep. In the first and second periods of the experiment animal number 2 had a slight sickness and therefore could not be used. In the third period only did the animal come back to a normal condition and so for this period alone could the figures be used with safety.

TABLE 9b

Animal No.	Days of Trial	Wt. Food Eaten	Consitituents Digested in %				
			Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
			Period 1					
1	6	679.28	58.84	60.80	72.12	26.34	43.58	70.61
			Period 2					
1	6	850.00	60.34	61.87	74.76	30.84	48.46	68.28
			Period 3					
1	6	1005.68	60.96	62.43	73.94	31.72	47.46	70.53
2	6	953.50	61.31	63.28	73.83	33.96	49.09	70.64

In period 4 the digestion of total organic substance was almost the same as in period 1, however, the difference is

noticeable in the separate constituents for the protein and the total nitrogen free extract was somewhat less and the crude fiber somewhat better digested. Wolff believes that since both animals in each period were very uniform, the cause of the difference must have acted on each animal in the same way and must have been in the condition of the feed or in the body condition of the animal, or both.

It should be said that during the time between the two periods, the wethers were fed rather intensively with grain (oats) along with luzern hay and therefore at the end of the experiment were in a somewhat better condition than at the beginning. However, after many other kinds of experiments the longing for and ability to consume roughage was so regained that the author does not think it had any effect on the percentage digestion of the different constituents in the later experiments.

Phelps and Woods (10) fed four sheep soy bean meal and timothy rouen in differing amounts. In the first period each sheep received one half pound of soy bean meal and one pound of timothy, in the second period each sheep ate 3/4 pound of soy bean meal and 1 1/2 pounds of timothy. The time of the digestion trial was five days. Sheep A in the last trial pulled some wool from its side and may have eaten it.

The following table gives the results:

TABLE 10

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
A	5	3405		68.5	75.8	71.1	61.2	66.7
A	5	5100		67.0	77.0	74.1	59.7	62.2
B	5	3405		70.5	77.0	76.7	61.2	69.0
B	5	5100		69.5	77.4	73.3	63.1	66.5
C	5	3405		71.5	80.0	77.4	63.1	68.4
C	5	5100		66.9	78.5	72.0	66.8	63.5
E	5	3405		65.4	76.0	71.4	56.7	60.9
E	5	5100		73.7	80.0	73.1	69.5	71.8

Knight et al. (11) fed two wethers alfalfa hay in differing amounts. The hay used in these two trials was not exactly the same. Concerning this they say in the second experiment : "This alfalfa was practically the same as that used in experiment one."

TABLE 11

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
			Period 1					
K	5	3400	63.64		81.20	36.29	46.30	72.02
			Period 2					
K	5	4535	60.17		78.04	47.92	40.98	72.20
			Period 1					
KK	5	3400	63.49		80.64	33.87	47.33	72.21
			Period 2					
KK	5	4535	59.80		77.01	45.83	40.56	72.38

Concerning the results of period 1 the authors say: "The results, as would have been expected, are not markedly different from those obtained in the previous experiment. The

results are lower than in the first with the exception of the digestibility of the ether extract and the N. F. extract. It should also be noticed that although the alfalfa used in 1 and 2 was from the same field and was cut and cured at practically the same time and under similar conditions of weather, the analysis shows quite a range of composition."

Bryant and Milner (12) in studying the digestibility of vegetables by men fed a fairly constant ration. In determining the digestibility of the basal ration they fed the person first a large ration then a small one. Below are the results obtained:

TABLE 12

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
		6105.0		87.3	96.0	93.4		96.8
		4071.0		89.0	95.3	92.6		98.0

A diet consisting of meat, bread, butter, milk, and sugar was chosen, the same number and kind of material for each subject, and this was eaten for several meals, until each one had found what quantities would be agreeable to him. The diet thus decided upon was termed the basal ration, and an experiment of three days was then made with each subject to determine the digestibility of the ration he had chosen.

The two trials in the above table were carried out on the same person.

Tangl (13) conducted quite an extensive experiment with horses to determine if possible what influence the time of drinking (before, during or after a meal) had on the digesti-

bility of the ration. In these experiments he fed the animals differing amounts of the same feed and also changed the drinking time.

We have assembled, in the following tables, the data which was obtained from animals receiving the same feed and having the drinking period the same. This places the results on the same basis and a comparison can easily be made.

TABLE 13

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
1	4	19931.0		60.32	72.89	39.00	52.08	63.27
1	10	49828.0		58.86	70.50	39.93	49.98	62.41

TABLE 13a

1	5	27259.0		63.06	68.64	41.24	45.39	71.96
1	5	27259.0		62.63	68.64	46.25	47.79	68.97
1	4	21784.0		62.25	62.29	42.58	47.06	69.19
1	10	52091.0(?)		59.83	69.68	31.44	34.41	67.22

TABLE 13b

1	4	21784.0		61.05	57.54	48.41	41.65	69.45
1	4	21784.0		64.38	63.19	40.77	36.78	76.21
1	6	32675.0		64.13	62.51	42,08	38.99	75.05
1	6	43568.0		62.87	61.79	47.73	40.64	72.07

TABLE 13c

1	5	27230.0		61.72	63.09	51.35	36.51	70.42
1	10	54459.0		64.78	62.51	44.65	43.80	74.43

TABLE 13d

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N. F.E.
3	4	26067.0		40.24	49.88	15.69	18.49	51.69
3	5	37733.0		47.31	57.99	7.10	40.30	52.29

TABLE 13e

3	5	25156.0		46.85	60.89	5.40	42.51	49.13
3	5	25156.0		49.99	61.31	7.27	46.28	52.56
3	5	32581.0		44.42	60.59	21.89	23.60	53.96

TABLE 13f

3	5	31594.0		54.76	73.80	59103	34.13	59.19
3	6	37916.0		54.88	72.33	59.00	29.67	61.80

TABLE 13g

3	5	37086.0		54.63	73.19	53.82	30.66	62.82
3	6	44503.0		54.76	73.63	55.17	28.60	63.59

TABLE 13h

4	4	25200.00		45.27	68.47	23.08	32.20	49.02
4	5	31500.0		46.11	70.10	24.39	34.30	48.79

TABLE 13i

4	5	32110.0		58.37	74.68	59.69	42.64	60.80
4	5	31594.0		59.87	76.60	62.60	40.42	64.30
4	5	31594.0		61.54	76.34	62.60	45.94	64.97
4	6	44503.0		56.85	70.05	59.44	34.73	62.44
4	5	37086.0		56.05	69.08	58.20	36.30	60.72

TABLE 13j

Animal No.	Days of Trial	Wt.Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
4	4	25688.0		57.71	73.40	55.02	36.39	63.05
4	6	37916.0		61.96	75.71	57.39	45.36	66.51
4	5	31594,0		57.54	74.76	61.16	42.21	59.84
4	4	29669.0		56.09	71.35	58.79	32.42	61.75
4	4	29669.0		56.73	72.07	58.93	33.56	62.22

Tangl (14) also carried on experiments with different animals to determine the digestibility of different seeds. In the following table swine 1, 3 and 4 were fed broom corn.

TABLE 14

Animal No.	Days of Trial	Wt.Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
1	8	571.0	78.64	80.49	60.61	70.68	14.70	87.01
1	8	634.0	76.79	80.40	56.90	70.53	16.87	87.41
3	8	1666.0	76.30	78.04	62.23	54.73	30.84	85.80
3	8	2523.0	71.62	73.67	50.69	46.94	20.43	83.34
3	8	2541.0	68.37	70.31	32.19	31.77	18.10	83.03
4	8	1509.0	70.74	73.01	52.64	56.27	21.43	81.36
4	8	2128.0	76.62	78.29	64.10	59.86	35.46	85.13
4	8	2550.0	71.86	73.87	49.79	50.54	25.11	83.26

The same feed was fed a chicken with the following results.

TABLE 14a

15	83.0		81.81	95.37
12	59.0		90.30	95.47

Turkey number 1 received indian corn and turkey number 2 broom corn. The following table gives the results obtained:

TABLE 14b

Animal No.	Days of Trial	Wt.Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
2	5	150.0				80.28		92.84
2	6	200.0				80.85		93.45

With ducks receiving only broom corn the following results were obtained:

TABLE 14c

Animal No.	Days of Trial	Wt.Food Eaten	Constituents Digested in % Dry sub.	Organic	Pentosans	Fat	Fibre	N.F.E
1	10	230.0			25.36	73.53		71.31
1	10	268.0			18.08	65.18		60.29

In this experiment two geese were used. Number 3 received indian corn only and number 4 broom corn. The following table gives the results:

TABLE 14d

3	12	142.0			26.94	46.30		95.91
3	10	150.0			27.99	54.16		94.04
3	10	300.0			22.89	35.38		91.52
3	6	300.0			19.30	32.07		93.70
4	12	239.0			25.44	56.57		94.64
4	10	245.0			17.78	54.47		93.20
4	10	400.0			32.96	39.95		88.34
4	10	400.0			20.20	33.27		84.52

EXPERIMENTAL

The experimental part contains the digestion trials of steers Nos. 549, 551, and 559, which were carried out under the direction of the author for this thesis and also all of the trials which had a bearing on this subject, which have been conducted at this Station. The results obtained from the steers Nos. 549, 551, and 559 are not sufficient by themselves to allow us to draw any conclusions. For this reason therefore we have included them in Table 16.

The experiments at this Station were made on cows under the supervision of Prof. C. H. Eckles and on steers under the supervision of Dr. P. F. Trowbridge. All of the chemical analyses were made by the department of Agricultural Chemistry.

Eckles (15) made digestion trials with five cows on full feed and on maintenance to determine the requirements for milk production. In the full feed and maintenance rations the feed consumed was in the amounts given in the table below:

Pounds of grain per day	Pounds of hay per day	Pounds of silage per day
	Maintenance	
2.92 to 4.48	2.92 to 4.48	11.76 to 17.94
	Full Feed	
5.22 to 9.22	4.65 to 15.55	13.95 to 21.80

The grain ration was doubled in the full feed periods, the hay was about double in most cases, but the silage was not increase but about a third.

The grain ration consisted of corn meal 4 parts, wheat bran 2 parts, linseed oil meal 1 part. This grain mixture was fed in exactly this proportion to all of the animals throughout the entire investigation including the maintenance trials. The feeds were fed as nearly as possible in the following proportions: Grain 1 part, hay 1 part, and silage 4 parts.

The results obtained are summarized in the following tables:

TABLE 15

Animal No.	Days of Trial	Condition	Constituents Digested in % Dry sub.	Protein	Fat	Fibre	N. F. E.
206	10	Mainten.	70.5	71.1	75.7	67.8	79.9
206	10	Full feed	65.3	62.5	68.7	50.4	72.5
		Difference	5.2	8.6	7.0	17.4	7.4
400	10	Mainten.	69.9	69.7	75.1	62.8	77.7
400	10	Full feed	65.5	61.3	71.8	50.9	72.3
		Difference	4.4	8.4	3.3	11.9	6.4
304	10	Mainten.	69.6	73.5	78.1	63.4	70.1
304	10	Full feed	64.3	61.6	72.0	47.5	71.4
		Difference	5.3	11.9	6.1	15.9	6.4
27	10	Mainten.	73.8	67.3	73.2	55.3	82.1
27	10	Full feed	66.3	58.8	66.9	53.8	72.6
		Difference	7.5	8.5	6.3	1.5	9.5
62	10	Mainten.	72.2	65.5	73.9	52.1	81.0
62	10	Full feed	66.9	60.6	59.8	53.9	73.6
		Difference	5.3	4.9	14.1	-1.2	7.4

The experiments carried out by Trowbridge and his associates (16) were with steers in different conditions, namely, full feed, maximum growth without the laying on of fat, restricted growth, and maintenance.

The feed of steers Nos. 599, 588, 197, 48, 164 and 595

consisted of corn 8 parts, linseed 1 part and 0.4 as much alfalfa hay as grain.

Numbers 522, 529, 527, 509, 507, 502, and 501 were fed corn 6 parts, oats 3 parts, linseed 1 part, and 0.5 as much alfalfa hay as grain. In order to determine the influence of the different planes of nutrition on the digestion coefficients we have placed these animals in the order of the dry substance digested. The time of the digestion trial was 9 to 11 days.

TABLE 16

Condition of animal	No of animal	Constituents Digested in per cent. Dry sub.	Protein	Fat	Fibre	N.F.E.
Maintenance	197	83.750	78.502	82.032	49.193	91.059
Maintenance	588(1)	82.329	74.758	87.778	51.472	89.676
Maintenance	588(2)	81.806	74.559	83.098	42.093	90.379
Maintenance	18	79.000	68.381	87.084	44.778	87.596
Max. growth	599	77.521	69.614	83.781	43.296	85.478
Restricted	509	77.488	75.013	79.630	40.465	85.139
Maximum	502	75.449	70.820	73.265	40.045	83.601
Maintenance	164	74.239	61.776	64.378	29.547	85.224
Maximum	507	73.922	70.024	72.876	37.559	82.012
Maintenance	595	73.373	66.644	84.042	29.417	82.488
Full feed	501	72.721	67.587	77.188	37.282	88.229
Maintenance	529	72.501	79.657	90.248	43.454	73.277
Maintenance	522	71.435	68.361	78.214	29.706	79.971
Maximum	559	71.260	69.270	81.140	46.060	83.330
Maintenance	529	70.025	63.966	67.587	31.520	80.471
Full feed	527	69.839	65.720	78.589	47.138	74.563
Restricted	551	69.800	67.640	80.760	43.610	83.960
Restricted	549	68.230	66.250	76.510	39.050	81.620
Full Feed	48	67.163	61.639	75.868	43.320	71.598

We see here that the maintenance animals have a higher coefficient in general than the full fed, although there is no regular decrease in the coefficient as the plane of nutrition gets better. This is probably due to the individuality of the animals. Also these animals were not of the same age and this may also have an influence on the per cent assimilated.

Animal No. 529 was in the poorest condition of any yet we see that its coefficient is fifth from the bottom. Steer No. 527 was an animal of the same age as 529 but on full feed. His coefficient is fourth from the bottom. These two animals were almost the exact opposite in condition yet we see that they digested almost exactly the same per cent of food. No. 197 was a fat show steer seventeen months old that had been on maintenance three months when the digestion trial was made. His condition was still excellent altho he had lost a good deal of his surplus fat. His coefficient is the highest of all.

DISCUSSION

In spite of the fact that Katayama (page 1) has apparently proven that there is a much larger amount of metabolic nitrogen in the feces of period 1 (large ration) than there is in the feces of period 2 (small ration) it still remains that there was 3.2 per cent more protein digested in period 2 than in period 1. The results for most of the constituents, however, agree very closely.

In a pre-period of 8 days the swine were fed the large ration, then between the two periods of the experiments only three days intervened in which the animals received the smaller ration. If it takes 8 days of feeding a certain ration to get the animals in a condition so the digestion trial can be made safely, then it seems reasonable to suppose that three days is not sufficient time to adjust the animals to the new ration. True, these rations were of the same materials, but if the quantity of the large ration was above the needs for normal body growth then some would be stored and it would take longer than three days for the animal to be in need of a more thorough digestion of the feed consumed and to adjust itself to this need. In this experiment the feed contained in the half ration 64.2 grams of protein, 498.6 grams of nitrogen free extract, 7.8 grams of fat, 29.4 grams of crude fibre.

Henry (17) places the maintenance ration of the 100 pound pig (about five months old) at 0.87 pound of dry substance consisting of 0.4 pound of corn meal, 0.4 pound of wheat middlings, and 1.6 pounds of skim milk. This ration would contain 262.0 grams

of N.F.E., 73.0 grams of protein, 26.0 grams of fat, and 15.0 grams of fibre. The small ration fed by Katayama was almost twice as nutritive as was the maintenance ration of Henry.

In the work of Eckles, page 21, the animals on full feed ate only about twice as much grain and alfalfa and about one third as much more silage as when on maintenance. These cows were in full milk when the digestion trials on fell feed were run. The feed in this period did not contain much more than twice as much nutrients as the maintenance ration and it supplied all of the constituents of the milk. From this then we must conclude that the 627.3 grams fed the swine since it contained twice the nutrients needed for maintenance of a 100 pound hog, must have been ample for normal growth. If this were the case then we would not expect an increase in the digestion coefficient. Also this feed contained only a very small amount of crude fibre, 29.4 grams. Doubling this feed would not have increased the volume of the feces so greatly that it would have distended the intestines to their limit, and therefore have been forced through faster. For this latter reason according to Kellner, there would have been no difference in the per cent of food assimilated in the two rations.

We do not believe that an animal will digest any larger percentage of a small ration if it is above the needs of the body for normal growth. It is only when the food is insufficient that the digestive action is exerted to the utmost.

In our experiments at this Station it was desired to find the maintenance rations of some steers. The animals were in a good condition when the experiment started and the ration was just sufficient to maintain the body weight. For quite a while the weight remained stationary when although the feed was exactly the same the animals began to show a marked gain in weight and we were compelled to reduce the ration. It appears in this case that there was either a greater economy by the animal's body or there was a better digestion of the food.

From these facts it seems reasonable to suppose that since the small ration fed the swine was at least twice as nutritive as a maintenance ration it was above the needs for normal growth and therefore we should not expect the animals to have much if any higher coefficient of digestion than they did with the larger ration.

Kellner in his work with steers, page 4, found that there was an increase in the coefficient of digestion as the amount of food decreased with the exception of the fat. In nearly all of the digestion experiments along this line there has been found to be an increase in the fat digestion with increasing ration. This, as Katayama , page 1, pointed out, may be due to the varying amounts of ether soluble metabolic products in the feces.

Unfortunately the data in these experiments is rather incomplete for it does not tell us whether they were carried out on one or more animals nor how long a time elapsed between the different trials.

In the experiments of Henneberg and Stahmann (reported on page 6) the steers received a larger ration at one time than at another. In one instance steer No. 1 received 21 pounds per day and No. 2 received 24 pounds. In another instance No. 1 consumed 24.5 pounds and No 2, 27.7 pounds per day. In still another No. 1 ate 18.65 pounds and No. 2, 22.88 pounds per day. Different sized rations were not fed to the same animals and for this reason we can not say that the slight difference in the coefficient is due to the size of the ration. It may be only the individual variation of the animals. The time of the digestion trial was also too short as will be pointed out later in this paper.

In another experiment, however, the time of the trial, 14 days, was ample, and the same animal was fed different sized rations. The digestion coefficient of the steers was only slightly better with the smaller ration. The difference in this case we feel must be ascribed to the mechanical action of the volume of the feed. Kellner thinks that this increase of volume is the most important factor in the change of the digestion coefficients. In this case the amount of feed, 20 to 29 pounds of clover hay, has a very large volume, and Kellner's explanation may be sufficient here. However, he also says that it is possible that with a food of easily digestible substances the ability of the intestines to absorb is not exercised to the utmost and does not take out all of the nutrients that are in the intestines. We would modify this and say that when the animal is on a feed above the needs for normal development the

ability of the digestive tract to digest and absorb is not exercised as fully as when the animal is on a feed too small to maintain these normal conditions. It makes no difference whether the feed be concentrates or roughages.

Kellner seems to think that the coefficients of digestion of concentrates may be influenced in digestion by their amount and that roughage fed alone in different quantities may not have any influence on the per cent assimilated.

The evidence from Katayama's experiments with swine does not point to this for here there was only a very small quantity of crude fiber and the different amounts had no effect. We believe that the volume of indigestible matter has an influence on the digestion coefficient but not as great an infleunce as whether the animal is getting feed above or below the requirements for normal growth.

Jordan and Jenter (page 7) in their experiments with sheep fed Nos. 1 and 2 full feed all of the time and Nos. 3 and 4 half feed on both of the rations. From their results we see that the average coefficient of digestion of sheep Nos. 1 and 2 was lower than that of Nos. 3 and 4. The table below gives the average of their experiment.

Ration No. 1

Full Feed

No. of Animal	Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
1 and 2	69.4	71.7	70.8	80.5	59.0	75.4
		Half Feed				
3 and 4	74.4	76.4	75.6	82.1	67.2	79.0
Difference	5.0	4.7	4.8	1.6	8.2	3.6

Ration No. 2

Full feed.

No. of Animal	Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
1 and 2	61.6	64.2	65.3	73.8	60.0	65.0
		Half feed				
3 and 4	66.0	68.0	70.7	76.1	62.3	69.2
Difference	4.4	3.8	5.4	2.3	2.3	4.2

However, no definite conclusions as to the influence of the amount of food on the digestion coefficient can safely be draw from experiments conducted with different animals on different rations for the individual variation may be greater than that due to the quantity of feed.

This is well illustrated in the work of Weiske (17) who fed two sheep the same amount of feed. The following table gives his results:

Table 17

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
1	8	858.80	61.84	64.04	56.36	72.40	18.06	71.76
2	8	857.83	67.29	68.31	62.20	82.40	33.80	76.34
Difference			5.45	4.27	5.74	10.0	15.74	4.58

These animals were about the same age and weight and received identical rations, nevertheless No. 2 digested 5.45 per cent more dry matter, 4.27 per cent more organic substance, 5.74 per cent more protein, 10.0 per cent more fat, 15.74 per cent more fibre, and 4.58 per cent more N. F. E. than did No. 1. If now we compare the variation in the digestion coefficient as obtained by Jordan and Jenter and ascribed to the size of the ration to the variation

obtained by Weiske and ascribed to the individuality of the animal we will find that the individual variation is greater in almost every case than that found by Jordan and Jenter. These men found that with ration No. 1 there was a difference of 5 per cent dry substance, 4.7 per cent organic matter, 4.8 per cent protein, 1.6 per cent fat, 8.2 per cent fibre, and 3.6 per cent N. F. E. in favor of the smaller ration. These differences are not as large in most cases as are those obtained by Weiske with sheep Nos. 1 and 2 on identical rations.

However, if we compare the digestion coefficient of the animals on the same sized ration in Jordan and Jenter's experiment we will find that there is a very good agreement, the greatest difference being in the coefficients of digestion of the protein by Nos. 1 and 2 on ration No. 2, 8.8 per cent. Therefore it may very probably be that the difference observed by these men may not be due entirely to individual variations of the animals.

Another thing we must consider is the duration of the digestion trials, 5 days, which was entirely too short a time. The effect of a short trial has been very forcibly brought out in the digestion trials of the Dairy department of this Station with cow No. 304. This cow was fed a ration for the ten days of corn 8.31, bran 4.055, oilmeal 2.077, alfalfa 14.515, and silage 56.243, or a total of 8.5203 kg. per day. In the second trial of two days she received 1.452 kg. corn, 728 gr. bran, 364 gr. oil meal, and 7.628 kg. of alfalfa, or a total of 5.086 kg. per day. In both periods the cow was on maintenance; in the first,

however, she was in full milk and in the second in pregnancy. The food at both times was not the same as in the second period she received no silage. This difference, however, seems hardly to explain the great differences in the coefficients of digestion noticed. The results obtained are given in the following table:

Animal No.	Days of Trial	Wt. Food Eaten per day	Constituents Digested in per cent Dry sub.	Protein	Fat	Fibre	N.F.E.
304	10	8.520	69.6	73.45	78.12	63.38	79.09
			Period 2				
304	2	5.086	54.43	68.45	84.83	31.34	76.47
Difference			15.17	5.00	+6.77	32.04	2.62

We see that there is a difference of about 3 kg. per day of feed consumed but the animal was on maintenance during both periods. The enormous difference in the coefficients must then be ascribed to the short duration of the last digestion trial. The dung voided in these two days was above the average of the 10 day period. In the 10 day period 8.52 kg. of food was eaten per day and the dung per day contained 1.3706 kg. dry substance. In the two day period altho the animal consumed only 5.086 kg. of food per day there was in the dung 2.076 kg. of dry substance per day. This accounts for the great variation in the coefficient. An animal, especially on a low diet, does not void dung in exact quantities and so a long period must be taken to overcome this error. In our experiments on digestion we nearly always find that during the 10 day period the weight of dung voided varies from 1 to 2 kg. in the different days.

Concerning the length of time Katayama (1) says in discussing the experiments of others along this line, "It is to be noticed that these experiments only lasted 5 days which is entirely too short a time to get the average amount of feces voided."

Another experiment of Jordan and Jenter is the one reported on page 9 in which they endeavored to show the source of milk fat. This was an abnormal feed in that it did not contain any fat which could be extracted easily. The amount of food in the second period was about two-thirds what it was in the first. The trial in period 2 lasted 10 days and in period 1 only 6 days. This last was again too short. The digestion of the food stuffs was better in period 2 than in period 1.

It may very possibly happen that with a digestion trial of less than 10 days the average amount of feces will be voided and the coefficient may be all right. Since this is not always the case we are compelled to reject all results except those in which we are certain that the time of the trial was of sufficient length.

In Weiske's experiments on rabbits (page 9) we see another instance of the individual variation. Nos. 1 and 2 were about six months old and from the same litter. Therefore we would expect to find a much closer agreement in their digestion coefficients than between animals of different ages and litters. However, there is a difference between the degree of assimilation of Nos. 1 and 2 as great as any we have seen in the

foregoing experiments. For instance, there is a difference of 20.90 per cent in the digestion coefficient of the crude fibre.

The second rabbit, No. 1, was only 3 1/2 months old. This introduces another factor of uncertainty into the problem as does rabbit K which was 7 months old. Here we have the digestion coefficient of four rabbits only two of which are the same age and same feed. These rabbits show a difference in some cases larger than the difference between the different sized rations. It is easily seen that here the age of the rabbits may have a very marked influence on the assimilation of the food and that therefore no very definite conclusion can be drawn from this data.

E. Wolff (page 11) also only ran the trial 5 days in all of his digestion trials with the horse. In addition to this there was not a very great difference in the amounts of feed consumed in the different experiments: 10 to 12 and 8 to 10 to 12 kg. of hay.

We see from the experiments that when 10 kg. and later 12 kg. of hay was fed there was a slight decrease in the digestibility as the ration increased, while in the later experiment when 8 then 10 and finally 12 kg. was fed there was a regular increase. This in every case was only about 5 per cent at the most.

Now if we compare ~~to~~ with these figures those of an animal receiving the same ration in two digestion trials we will find that probably this difference is only a variation in the animal explainable by the short duration of the trial and is not due to the different quantities of the feed.

The following results obtained by Tangl (13) will illustrate this:

TABLE 18

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in per cent Organic	Protein	Fat	Fibre	N.F.E.
3	4	29669.0	56.36	71.96	53.38	34.80	61.50
3	4	29669.0	52.85	72.30	55.94	28.32	57.71
		Difference	3.51	0.34	2.56	6.48	3.79

TABLE 18a

3	3	22252.0	55.51	74.70	56.45	28.08	60.98
3	3	22252.0	51.18	74.61	54.74	26.68	54.84
		Difference	4.33	0.09	1.71	1.40	6.14

In these experiments horse No. 3 was fed 29.669 grams of feed in duplicate periods. There was a difference of 3.51 per cent of organic substance and corresponding differences in the other constituents between the coefficient of digestion from the two periods. At another time duplicate determinations were made with the same horse receiving 22252 grams of feed. In this case the difference between the two periods is even greater than in the former.

In Wolff's first experiment the difference between the high and low ration was 2.36 per cent dry substance, 2.89 per cent organic substance, 1.95 per cent protein, 0.43 per cent fat, 3.02 per cent fibre, and 3.39 per cent N. F. E. These differences are not as large as those in table 18 and 18a where the same animal was fed the same feed. In his second experiment the difference between the digestibility of the highest and lowest ration is only 5.44 per cent dry substance, 5.13 per cent organic, 3.52

per cent protein, 9.91 per cent fibre, and 1.89 per cent N. F. E. This again is only a little more than is seen in tables 18 and 18a. From the above comparison it appears safe to assume that the difference in the digestion of the hay by the horse can not be explained by assuming that the digestion coefficient is increased by the greater quantity but that on the other hand the figures given do not show the real coefficient due to the short duration of the trial.

In the digestion trials with sheep the same criticism holds. These animals were fed amounts not varying much and the trials were too short. The differences observed were no greater than those cited in tables 18 and 18a.

In Phelps and Woods' experiment with sheep (page 14) the ratio of the timothy hay to the soy bean meal was the same in both the large and small ration. These, then, can be compared.

The criticism of this work is that the duration of the experiment, 5 days, was too short. In most of the cases the coefficient increased with a decrease of the ration. In one instance only was there an increase with the larger ration.

The fat and fibre here, as in many of the other experiments, do not follow the variation of the remainder of the food constituents.

In these experiments each sheep was fed first a low ration and then a high ration. This eliminates the error of the individual difference which we noticed in the experiments of Jordan and Jenter.

Knight fed two wethers alfalfa hay which in the two trials was not exactly the same. Also the duration of the ex-

periment was too short, being only 5 days. For these reasons no very safe conclusions can be drawn. With the higher feed there was in nearly all of the food constituents a decrease in the coefficient of digestion.

Digestion trials such as are represented in tables 19 and 20 can not be used in the determination of the influence of the quantity of feed on the digestion coefficients for here a doubtful factor is introduced in the changing proportion of the constituents. The larger amount of feed may possibly have a depressing influence on the digestion, but the increased proportion of sugar beets, in this case may very likely increase the digestibility of the total ration because the sugar beets are so very much more easily digestible than the hay.

TABLE 19.

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry sub.	Organic	Protein	Fat	Fibre	N.F.E.
		1.7		79.42	71.48	---	---	98.48
		2.4		86.61	68.91	---	---	97.12
		3.1		87.91	49.12	---	---	98.40
			Part 2					
		1.7		86.61	57.92	---	---	90.85
		2.4		84.95	53.56	---	---	93.14
		3.1		81.05	33.99	---	---	90.11

In part 1 each sheep received 1 kg. of vetch hay, but the amount of sugar beets was changed, the first received 0.7, the second 1.4, and the third 2.1 kg. of sugar beets.

In part 2 each animal received 1 kg. of grummet and sugar

beets in the same amounts and arrangement as in part 1. In part 1 there was an increase of the digestion coefficient as the ration increased, in part 2 a decrease. The same two sheep were used in both parts.

In the experiment from which table 20 was obtained each animal received 10 kg. of timothy hay and 1 kg. of brewers grains in one period and 2 kg. of brewers grains in another.

TABLE 20

Animal No.	Days of Trial	Wt. Food Eaten	Constituents Digested in % Dry. sub.	Organic	Protein	Fat	Fibre	N.F.E.
A		11.0		74.45	99.5	75.0	92.6	57.8
A		12.0		64.10	78.5	42.5	52.2	61.2
B		11.0		76.6	104.1	90.0	77.8	63.4
B		12.0		69.2	81.9	62.5	32.0	75.1

In table 20 there was a decrease in the digestion coefficient as the food quantity increased. Here we believe that the increased digestibility of the ration due to the greater amount of the brewers grains was not sufficient to overcome the depressing effect of the increased ration.

Possibly this would happen in a great many cases but it is evident that the resulting effect depends on the ratio of the different substances. If the ratio of the easily and difficultly digestible constituents is not the same it is impossible to say whether the resulting effect is due to the larger ration or not.

The data obtained from Tangl's work on horses (page 17) does not give us any evidence either for or against the depressing

action of an increase of ration. In five cases there was an increase in the digestion coefficient with an increase of the ration, in four cases a decrease and in two cases the coefficient was the same. This variation, we believe, is due to the short duration of the period of the trial. We have shown in the discussion of other results that 3 to 6 days is not sufficient time to carry out a reliable digestion trial. Also the difference in the amount of feed consumed was not large enough to make a very great difference in the coefficient. Tangl did not get agreement of the coefficient on duplicate determinations. This is just another instance of the unreliability of short period digestion trials.

In his experiments, page 19, with feeding grain to different animals the trials are longer. When he fed broom corn alone to swine the coefficient was sometimes lower, sometimes higher on a larger ration. We believe that this is due to all of the rations being above the requirement for normal growth and development. In all cases the animals left some of the broom corn uneaten, 16 to 53 grams. This shows that the animals were receiving all that they needed.

With the chicken (page 19),on the other hand, the digestion coefficient decreased with the increase of the ration. With the turkey, No. 2, table 19b, there is a slight increase. The duck in table 19c gave a decrease in digestibility as the ration increased. Geese 3 and 4, table 19d, were found to digest less as the ration increased, in general.

It must be borne in mind that Knight et al., Bryant and Millner, and Tangl were not working on the problem of the in-

fluence of the plane of nutrition on the digestion coefficient. They were trying to solve totally different problems, but in our search of the literature of digestion trials we found that these men had fed animals differing amounts of the same food, and as we wished to have at hand all of the data that could possibly be considered to have any bearing on the subject we have used their results.

In our discussion we have endeavored to point out some of the errors which might explain the differing results of the different investigators. We saw that some men, as Wolff, decided that there was an increase in the per cent of assimilation of food as the ration increased, others, as Weiske and Jordan and Jenter, concluded that an increase of the ration lowered the coefficient , while others, as Katayama, and Henneberg, think it has no influence. Kellner seems to be of the opinion that different kinds of rations (concentrates and roughage) have differing effects.

We believe that a great many of the conflicting results can be explained by the fact that the experiments were of too short duration and in many cases were carried out without taking into consideration the individuality of the animals. In the experiments of Trowbridge and associates we saw that there was no regularity in the relation of the coefficient of digestion to the plane of nutrition. This, we feel, is due to the individuality of the animal.

We believe that in order to solve this problem it is necessary to feed the same animal different rations. The animal,

must, however, have been fed the ration for at least two weeks in advance of the trial. In fact, we seriously doubt if this is enough time for the animal to adjust itself to a lower ration. We contend that the difference in the amount assimilated is due to the adjustment of the animal to its new ration more than to the mechanical effect of the volume of food. This latter condition, that is, volume of food, we do believe has some effect but not as great an effect as the adjustment of the animal. It does not seem to us that an animal receiving more than is necessary for normal growth will digest any larger or smaller percentage if the ration is increased or decreased so long as it stays above this limit. We think this explains in part the conflicting results of Wolff and the negative ones of Katayama. In all of these cases the food in the small ration was at least as much as was needed to supply the nutrients for normal development. In the case of Eckles' experiment the animals when on maintenance were not receiving the amount necessary to maintain normal development and since they were on maintenance 150 days, they had ample time to adjust themselves to the new conditions. The volume of roughage, as we saw in the discussion, did not increase as much as the grain or total nutrients and therefore we do not believe the lower coefficient can be explained by assuming that it is due merely to the mechanical action of the volume.

CONCLUSIONS

Although the evidence is not sufficient to allow us to draw a definite conclusion as to the effect of the plane of nutrition on the digestion coefficient of the animal, we tentatively hold that an animal will digest more of a small ration only if it is needed for normal development, and that the volume of the food will have no effect except when it becomes so great as to distend the intestines to their limit and is therefore forced through faster. In other words, the digestion coefficient of an animal will be influenced above the amount required for normal development only by the volume of food consumed; below this amount by the adaptability of the animal to its condition of life. If time is not allowed for the animal to accommodate itself to these conditions there will be no difference in the percentage of food assimilated and also if the time of the digestion trial is not at least 10 days the results will be unreliable.

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