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PIG FEEDING.

IN a former number of this Journal we published a paper under the title of '*Sheep Feeding and Manure*,' in which we gave the amount of *Increase in Live weight of Animal*, obtained by the consumption of known quantities of food of various kinds—the chemical composition of such food being also given—and we promised to follow up the subject in our next with an account, first, *of the Composition of the Increase in Live weight*, and afterwards, *of that of the Manure obtained*. The main object, indeed, of the investigation—as stated both at the commencement and conclusion of that paper—was, to illustrate the general economy of the feeding process, *as one of the great features of farming practice;* that is to say, as producing *Manure* as well as Meat, rather than as comparing one food with another in regard to its *feeding* value merely.

Sheep had at that time received the greatest share of our attention; and, owing to the difficulty and labour involved in extending the field of experiment in like detail to other animals, it was intended, if possible, to complete our subject of *Meat* and *Manure-making* by almost exclusive reference to the animals which had given the title to our paper. The further we progressed, however, the more were we convinced, that in spite of the difficulties and necessary postponement of publication, the inquiry must be extended to other animals, to enable us at all satisfactorily to explain the connection between the composition of the food consumed by farm stock generally, and that of the increase, and manure, obtained.

Viewing the feeding process as one of the chief means of obtaining *manure*, it is of the utmost importance that the farmer should be possessed of some principles by which to judge of the productive power of such manure, especially in relation to the composition and value of the food consumed. And, as in this country there is employed a constantly increasing amount both of purchased and saleable food, and of artificial manures, it is essential that the farmer should possess a clearer conception of the principles both of *Feeding* and of *Manuring*.

The importance of such general propositions in agriculture cannot be over-estimated; nor will they be undervalued when

farmers more clearly recognise and appreciate the influence of chemical composition in determining the value of manure, and how far it is a question merely of *economy*, whether the fertility of the soil shall be kept up by manures produced in the yard and the stall, or by those which are purchased in the market. We do not mean to say that it is unimportant in what state, or in what manner, a manure is supplied, but in illustration of the general truth which we would have kept in view, we may here call attention to the fact which we have frequently noticed, namely, that a crop of wheat, of more than the average yield of the neighbourhood under the ordinary course of cultivation, has for several successive years been grown in the same field on this farm, by the supply of *pure chemical salts* alone. Let it, then, we repeat, be clearly understood, that, in a certain point of view, it is a matter of indifference whether we purchase food for cattle, or direct manures—and that in some respects therefore the two classes of manures can to a great extent mutually replace each other.

Let this be a settled idea in the farmer's mind, and he will more clearly see the importance of a better understanding of the feeding process, and also of those circumstances which must determine the *economy* of the mutual substitution of artificial manures and those derived from the fattening animal.

In prosecuting our inquiries into the general laws of *Meat and Manure-making*, we have found it necessary to extend our experiments from Sheep, as at first undertaken, to Oxen and Pigs.

Our results, in relation to both these descriptions of animal, as well as the sheep, will eventually be considered in reference to *Manure* as well as *Increase;* but we think it desirable to bring forward the whole of the *feeding* experiments, before entering upon those relating to manure. In pursuance of this plan, a portion of the present paper on *Pig feeding* was actually in type nearly three years ago, when that subject was somewhat prominently before the agricultural public; but owing to other engagements, its completion has necessarily been delayed until the present time.

The necessity of including Pigs in an inquiry relating to the production of meat and manure on the farm, is further seen when we come to consider the character of the food supplied to them. Compared with that of sheep or bullocks, its dry substance consists, weight for weight, of much more highly nutritive vegetable products, and it is consequently generally much more costly to purchase. Thus, whilst the food of *fattening* sheep or oxen, is principally composed of grass, hay, and roots, with a comparatively small proportion of cake or corn, that of the pig, whose digestive apparatus is very differently

constituted, is almost exclusively corn, or contains scarcely any indigestible woody-fibre, and abounds more largely in starch, fatty matters, and nitrogenous compounds. We should expect, then, a very different rate of increase in relation to gross weight of dry food consumed in the two cases; whilst in the excrements of the pig we should look for a manure commensurate with the cost and richness of the food which has been its source.

Setting aside what may be termed the incidental food of the pig, such as wash, potatoes, and other roots, it may be said that his staple *fattening* foods in England are the *leguminous seeds*, such as beans, peas, tares, and lentils, all of which are characterised by containing a high per-centage of nitrogenous compounds; and, in still larger quantity, some of the *grains*—especially *barley*—the inferior qualities of which are almost exclusively devoted to his use.

The *grains*, as compared with the leguminous seeds, contain scarcely half the quantity of nitrogenous compounds, upon which so materially depends the quality of the manure; but they abound much more in starch and other *non*-nitrogenous compounds, which are believed to provide the chief of the respiratory and fat-forming food of the animal. The quantity of actual *fatty-matter* in the two classes of foods is variable; but it is on an average rather greater in the grains than in the leguminous seeds.

Pollard and *bran* are also much used as pig-foods. They contain a large amount of woody-fibre; but the bran more especially contains a much higher per-centage both of *nitrogen* and of *fatty-matter* than the entire grain from which it has been derived.

Of the several articles of food enumerated above, *barley* is undoubtedly most in favour as the fattening food of the pig; but as *nitrogen* is so important a constituent in *manure*, and as barley, as we have said, contains scarcely half so much of this substance as the leguminous seeds, it is evidently a matter of importance to consider, whether the latter might not advantageously be employed more largely than at present—even supposing that *barley* had some slight superiority, so far as the animal alone was concerned.

That the profit of feeding, indeed, is to be sought *within* the limits of the value of the manure, and that it is, therefore, much dependent on the quality of the latter, and, consequently, on the judgment exercised in the selection of the foods, and the management of the animals and of the manure—is a view which seems to be supported at once by the convergent testimony of current experience, and by a consideration of the laws which regulate the price of all articles in general use. Admitting that the prices of

all such articles are regulated by the *cost of production*, and that they cannot long either be produced at a loss, or be sold at a price which will yield more than a fair profit upon the capital and labour employed in their production—and, applying this view to the subject before us, we should certainly decide, that the selling price of the meat *alone* produced upon the farm must be less than that of the food consumed—and that the profit of the feeding process is to be found in the remaining product, namely, in those parts of the food which are rejected by the animal, and which, under the title of *Manure*, give fresh fertility to the soil, and thus supply a *second product* for the market.

Were it true, indeed, that as a rule the difference between the purchasing and selling price of the fattening animal was equal to, or more, than the cost of his food, it is evident that the profit of the feeding process would cease to depend, as at present supposed, only upon the *united* value of meat and manure—and the latter might then be obtained, in any quantity, *free of expense!* On such a supposition as this, the economical employment of imported and artificial manures would, of course, be at an end; and, unless the rule applied equally to the consumption of the expensive green crops, as to purchased and saleable food, it might even be a question whether the principles of rotation were not entirely fallacious, and its practice ruinous!

Much as we anticipate that careful scientific investigation will conduce to the improvement of our national agriculture, we are far from expecting any important revolution in the main principles involved in the current practice of the best farmers. On the other hand, it is our firm conviction, that it is to a more thorough and generally diffused understanding of those principles—such as shall ensure the more complete fulfilment, in the daily practices of the farm, of the ends they are calculated to attain—that we must look for any such improvement. Far be it from us to assert that the mutual relationship between breeding, feeding, manuring, and the growth of green crops and of corn, as already fixed by experience, will always remain as at present. That this relationship will be subject to fluctuation, or even to modifications of a more permanent kind—as the result, as well of the progress of knowledge as of causes of a commercial character—we do not doubt; but we would have it more generally understood, that the most legitimate and useful province of agricultural chemistry, at least for the present, is to investigate and explain the recognised practices of the day, and thereby provide such data for the guidance of the intelligent farmer as shall enable him more fully and economically to carry out the principles therein involved.

In the arrangement of our experiments on the feeding of *Pigs*, it was our object to ascertain, not only the amount of increase

obtainable from a given quantity of certain approved foods, but to determine the most advantageous proportion of the highly nitrogenous foods to those which are less so; and within what limits this proportion may be varied with a view to the quality of the manure, and at the same time consistently with the profitable progress of the animal. With this view, the selection of the foods in the *First Series* of experiments was considered less in reference to their cost than to their composition, it being desired to provide such as contrasted strongly with each other in this respect. It was thought that greater definiteness of result would thus be attained; and that the principle once elicited by this means, the more economical substitutes for the foods employed, could afterwards be easily pointed out. Thus:—

As the *highly nitrogenous* food—a mixture of equal weights of *Beans* and *Lentils*, was employed.

As the comparatively *non*-nitrogenous food—*Indian corn meal.*

As providing a large amount of inert woody fibre—a constituent apparently so essential in the food of the ruminant—*Bran.*

Before entering upon the detail of the experiments it may be remarked, that it was not the object of them to compare one breed of pigs with another; nor are they calculated to determine the several practical points—such as the most profitable age for rapid fattening, &c.; so that, after giving a full account of the circumstances of our own experiments, we must leave it to the intelligent reader to decide how far the results obtained by us are to be reached, or improved upon, under the perhaps different circumstances of his own practice.

In the selection of animals, it was only sought to get such as resembled one another in character, age, and weight, in the several pens; and, with this view, a competent person was employed to go to the various styes and markets in the neighbourhood to purchase animals suited to our object.

It would have been quite impossible to collect, and accurately weigh and sample for analysis, the excrements throughout the whole of so extensive a set of experiments as that we are about to describe; and it was determined, therefore, to devote a few animals separately to the subject of *manure* as well as increase. These were placed upon rafters, which allowed the excrements to pass through upon a sheet of zinc below, and to be collected for analysis as described in our paper on "Sheep-feeding." In the other cases the animals were kept well littered with straw, in pens 7 feet by 8 feet, which were fitted up for the purpose in a spacious barn. The food was, of course, in all cases accurately weighed; and the animals themselves were put into the scales every fourteen days.

Experiments with Pigs—Series I.

For this Series, which comprised 12 pens of 3 pigs each, 40 animals were purchased, as nearly as possible of the same character, and all supposed to be about 9 or 10 months old. They were bought in three separate lots, of 6, 20, and 14 respectively, between January 22nd and February 2nd, 1850. On the latter day they were all weighed, marked, and allotted, 3 to each of the 12 pens, in such manner as to get as nearly as possible the same weight in each pen. As will be supposed, this distribution by *weights* alone, did not secure animals of sufficiently equal feeding quality in the several pens. On the following day, therefore, they were changed from pen to pen, so as to provide as much as possible a similarity in this respect between pen and pen, and at the same time to retain a near equality in weight also. This being done, the weights stood as follows :—

Table I.

(Experments with Pigs.—Series I.)

Showing the Weights of the Pigs (in Pounds), when allotted to the Pens, Feburary 3, 1850.

Nos. of the Pigs.	Pen 1	Pen 2	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Pen 8	Pen 9	Pen 10	Pen 11	Pen 12
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	146	146	142	142	140	133	133	132	130	129	131	130
2	121	122	115	123	123	123	124	133	124	128	128	115
3	112	112	113	113	115	122	121	117	119	120	120	129
Total weights of 3 pigs	379	380	370	378	378	378	378	382	373	377	379	374

The allotment thus completed, the whole were supplied with as much as they chose to eat, of a mixture of one part bean-meal, one part lentil-meal, two parts Indian-corn meal, and four parts bran, these being the articles fixed upon for the subsequent experiment. Upon this mixture all were kept for 12 days, prior to commencing with the exact experiment, in order that they might become accustomed to their new situation, and reconciled to their new companions; for, in the allotment, the various purchases had necessarily been intermixed, in some cases greatly to the disapprobation and discomfort of the individuals of those purchases. For a time constant quarrels ensued, and the molested animals frequently jumped from pen to pen, until they fell in with their former associates. Indeed, at first, it was no uncommon occurrence, after they had been left for some time, to find some pens almost deserted, and others crowded. The use of the whip was found to be very efficacious in settling these disputes, and at length, all seeming to live amicably together, the exact experiment was commenced on February 14th, twelve days after the first allotment.

As would be expected, the increase during this preliminary period was far from uniform—those pigs having flourished most which had fallen in for the lion's share, whilst the weaker ones, which had been obliged to sulk in the rear until their more powerful companion had indulged to the full, clearly indicated their misfortunes by their weights. After that time, however, very little irregularity occurred from this cause, vigilant care being taken that each animal should have his share of food; and it soon happened, that the mere approach of the whip was sufficient to awe the pugnacious delinquent into humble retreat, while his weaker neighbour, in his turn, took precedence at the trough. These ill-tempers, though at first very troublesome, give way surprisingly by a little perseverance; and the evil of them, in a course of comparative experiments, is, after all, much less than in submitting to a faulty allotment.

The results of the second weighings, when the exact experiment was commenced, namely, on February 14th, are given below :—

Table II.

(Experiments with Pigs.—Series I).

Showing the Weight (in Pounds) gained during the twelve days of the preliminary period; and also the actual Weights at the commencement of the exact Experiment on February 14, 1850.

Nos. of the pigs.	Pen 1		Pen 2		Pen 3		Pen 4		Pen 5		Pen 6	
	Gain in 12 Days.	Weight Feb. 14.	Gain in 12 Days.	Weight Feb. 14.	Gain in 12 Days.	Weight Feb. 14.	Gain in 12 Days.	Weight Feb. 14.	Gain in 12 Days.	Weight Feb. 14.	Gain in 12 Days.	Weight Feb. 14.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	30	176	11	157	21	163	31	173	28	168	24	157
2	14	135	20	142	16	131	8	131	5	128	21	144
3	17	129	11	123	15	128	10	123	20	135	22	144
Totals	61	440	42	422	52	422	49	427	53	431	67	445

Nos. of the pigs.	Pen 7		Pen 8		Pen 9		Pen 10		Pen 11		Pen 12	
1	15	148	13	145	26	156	20	149	6	137	19	149
2	2	126	11	144	18	142	10	138	22	150	15	130
3	20	141	26	143	11	130	9	129	16	136	21	150
Totals	37	415	50	432	55	428	39	416	44	423	55	429

A glance at this table, by the side of the former one, will show that the gross weight in each pen was not nearly so uniform at

the second weighing as at the first. This irregularity is indeed undesirable; but is perhaps as small as we can hope for in any extensive experiments in which we have to deal with the subtle principle of animal life.

We have already stated that the articles of food selected for the First Series of experiments were—

1. A mixture of equal parts of Bean and Lentil meal, this being taken as the highly nitrogenous food.
2. Indian corn-meal, as containing, compared with the former, only a small quantity of nitrogen, but a comparatively large amount of the non-nitrogenous substances of the starch series, and also more of fatty matter. It is these various non-nitrogenous substances that are supposed more peculiarly to serve for the respiratory process, and for the formation of fat in the animal body.
3. Bran—characterised as containing a considerable amount of inert woody fibre and mineral matter, and comparatively but little of starch, sugar, and the like; it is not, however, deficient either in nitrogenous or fatty matters, being in these respects intermediate between the other two descriptions of food.

From these three standard food stuffs, twelve dietaries were arranged, as follows :—

Pen 1. Bean and Lentil mixture, ad libitum.
Pen 2. 2 lbs. per pig per day of Indian-corn meal; and Bean and Lentil mixture, ad libitum.
Pen 3. 2 lbs. of Bran per pig per day; and Bean and Lentil mixture, ad libitum.
Pen 4. 2 lbs. of Indian-corn meal, and 2 lbs. of Bran per pig per day; and Bean and Lentil mixture, ad libitum.
Pen 5. Indian-corn meal, ad libitum.
Pen 6. 2 lbs. of Bean and Lentil mixture per pig per day; and Indian-corn meal, ad libitum.
Pen 7. 2 lbs. Bran per pig per day; and Indian-corn meal, ad libitum.
Pen 8. 2 lbs. Bean and Lentil mixture, and 2 lbs. of Bran per pig per day; and Indian-corn meal, ad libitum.
Pen 9. 2 lbs.* of Bean and Lentil mixture per pig per day; and Bran, ad libitum.
Pen 10. 2 lbs.* of Indian-corn meal per pig per day; Bran, ad libitum.
Pen 11. 2 lbs. Bean and Lentil mixture, and 2 lbs. Indian-corn meal per pig per day; Bran, ad libitum.
Pen 12. Bean and Lentil mixture, Indian-corn meal, and Bran, each separately, and ad libitum.

* Increased to 3 lbs. after the first period of 14 days.

It will be seen, that by the arrangement of allowing a fixed and limited amount of one description of food, and another description to be taken ad libitum, a great variety in the proportions of the different classes of constituents is attained. And it will be readily understood, that—as in every case the animals were permitted to fix for themselves the limit of their consumption according to their natural wants and inclinations—and as the amount and composition of the food consumed was in each case known—the results obtained, would afford us the means of deciding, whether or not this limit of consumption, had been fixed by any common demand for either class of constituents which the food supplied.

But to explain the plan a little further. In the first 4 pens the highly nitrogenous *Bean and Lentil mixture* is given ad libitum; in Pen 1, without any other food; in Pen 2, with a limited quantity of Indian-corn meal; in Pen 3, with a limited amount of Bran; and in Pen 4, with a limited quantity both of Indian-corn meal and of Bran.

In Pens 5, 6, 7, and 8, the comparatively deficiently nitrogenous, but more highly starchy and fatty food, *Indian-corn meal* is given ad libitum; in Pen 5 alone; in Pen 6, with a limited amount of the Bean and Lentil mixture; in Pen 7, with a limited amount of Bran; and in Pen 8, with a limited amount both of the Bean and Lentil mixture, and of Bran.

In Pens 9, 10, 11, and 12, *Bran* is the food given ad libitum, but in no case alone; thus, in Pen 9, it is with a limited quantity of the Bean and Lentil mixture; in Pen 10, with a limited amount of Indian-corn meal; in Pen 11, with a limited amount both of the Bean and Lentil mixture and of Indian-corn meal; and in Pen 12, with both the Bean and Lentil mixture, and the Indian-corn meal, but, as before said, neither in this case given in limited quantity, each of the three descriptions of food being put into a separate trough, and the pigs allowed to take of either or all at their discretion.

In all cases the animals were fed three times a-day; namely, early in the morning, at noon, and about 5 o'clock. The limited food, if any, was mixed with a small quantity of that which was given ad libitum in the first two feeds of the day. Great care was taken in the management of the supply of food, both that the troughs should generally be cleared out before fresh food was put into them, and that the pigs should always have a liberal supply within their reach; and this, with a little attention and practice, was easily attained.

The pigs themselves were each weighed fortnightly; and the exact experiment extended over four such periods; namely, 8

weeks in all; at the termination of the feeding experiment all were killed; and the weights of the carcass, and of the total offal—and indeed of all the separate parts of it—were taken in each case. The slaughtering results will, however, not be given in the present paper; but will be reserved until we treat of the general question of the '*Composition of Animal Bodies.*'

In Table III., which follows, are given the particulars of the increase in weight, &c., of this First Series of Pigs.

Table III.

(Experiments with Pigs.—Series I).

Showing the *Gain in Weight* (in lbs.) upon each of the 12 different Dietaries, of *each Pig*, and of each *Pen of Three Pigs*, during each period of 14 Days, and during the entire experimental period of 8 Weeks.

Nos. of Pigs.	**Pen 1** Beans and Lentils (equal parts) Ad Libitum. 1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 days.	Total Period, 8 Weeks.	**Pen 2** 2 lbs. Indian Meal per Pig per Day; Beans and Lentils (equal parts) Ad Libitum. 1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.
1	27	32	22	22	103	37	35	32	32	136
2	26	24	24	20	94	28	33	23	11	95
3	24	27	26	29	106	31	26	29	19	105
3 pigs	77	83	72	71	303	96	94	84	62	336

	Pen 3 2 lbs. Bran per Pig per Day; Beans and Lentils (equal parts) Ad Libitum.					**Pen 4** 2 lbs. Indian Meal, 2 lbs. Bran, per Pig per Day; Beans and Lentils (equal parts) Ad Libitum.				
1	29	15	16	16	76	37	29	26	33	125
2	26	16	3	7	52	14	18	19	16	67
3	28	29	3	12	72	18	6	13	23	60
3 pigs	83	60	22	35	200	69	53	58	72	252

	Pen 5 Indian Meal Ad Libitum.					**Pen 6** 2 lbs. Beans and Lentils per Pig per Day; Indian Meal Ad Libitum.				
1	31	6	40	19	96	29	26	25	26	106
2	15	13	13	13	54	32	22	16	16	86
3	12	17	19	23	71	30	28	18	30	106
3 pigs	58	36	72	55	221	91	76	59	72	298

Table III.—*continued.*

	Pen 7 2 lbs. Bran per Pig per Day; Indian Meal Ad Libitum.					**Pen 8** 2 lbs. Beans and Lentils, and 2 lbs. Bran per Pig per Day; Indian Meal Ad Libitum.				
1	18	33	29	21	101	41	38	29	34	142
2	15	18	17	15	65	30	22	18	29	99
3	33	37	37	36	143	34	27	20	25	106
3 pigs	66	88	83	72	309	105	87	67	88	347

	Pen 9 2 lbs.* Beans and Lentils (equal parts) per Pig per Day; Bran Ad Libitum.					**Pen 10** 2 lbs.* Indian Meal per Pig per Day; Bran Ad Libitum.				
1	7	12	12	18	49	—8	13	12	10	27
2	2	2	0	2	6	10	16	8	10	44
3	0	16	17	12	45	3	12	15	13	43
3 pigs	9	30	29	32	100	5	41	35	33	114

	Pen 11 2 lbs. Beans and Lentils, 2 lbs. Indian Meal, per Pig per Day; Bran Ad Libitum.					**Pen 12** Bran, Beans and Lentils, and Indian Meal, each Ad Libitum.				
1	17	14	15	14	60	35	33	29	17	114
2	24	11	5	8	48	24	3	1	17	45
3	15	14	19	22	70	36	29	12	18	95
3 pigs	56	39	39	44	178	95	65	42	52	254

In this Table we have the particulars of the progress of each pig, and it is therefore deserving of some few remarks; though, the effects of the different foods must be estimated rather by the gross result of the pen of 3 pigs than by the progress of any single animal. Casting the eye over the figures showing the increase in weight of different animals in the same pen, with one and the same description of food, it is at once seen, that all have not progressed alike under these supposed similar circumstances. Some of the apparent discrepancies were easily accounted for by some *incidental* circumstance in the character or health of the animal; and in such cases the strictness of the result of the entire pen is, of course, in some degree interfered with. It is therefore necessary not to overlook these particulars in judging of the effects of any particular food.

In the majority of cases, however, we believe that the differ-

* Increased to 3 lbs. after the first Period.

ences in the progress of the pigs allotted together in the same pen and with the same food, arise from general differences of constitution; and if the irregularity in this respect were equal in every pen, it would certainly be an advantage, for our object is not to show the extraordinary increase of picked animals, but the probable average result obtainable from pigs which have been bred or selected for fattening with ordinary care and judgment. Indeed, as already observed, our chief object in the allotment was to get a variation of quality within each pen, with similarity between pen and pen in this respect; and the observations which were made at the end of the experiment, when the pigs were killed, clearly showed, that whilst on the same food, some had increased considerably in frame as well as flesh and fat, others had apparently accumulated fat almost exclusively. These variations of result, then, we attribute chiefly to the different constitutional tendencies of the animals. But, at the same time, though very great care was taken to prevent it, we do not pretend to say, that where the limited food was very decidedly of better quality than the remainder, the stronger animals did not sometimes obtain an advantage over the weaker ones. Perhaps in one or two instances, therefore, one pig in a pen may have done better, and another worse, than would have resulted from a due share of the allotted food. Supposing this to have been the case, however, it is still by no means certain that the results indicated by the whole pen are on this ground unfair as regards the effects of the total food supplied to it; for, although one pig may have increased much more than another upon a *supposed* equal diet, the gain of each may, in fact, be only commensurate with the food actually consumed in each case; and thus, with great variation in the different pigs, with diets from one cause or another themselves really different, the total increase of the entire pen may still indicate, with some truth, the effects of the total food consumed in it—the smaller increase of the one pig with a deficient share of food being compensated by the larger gain of the other upon at the same time a larger and better share of food.

But to turn to the figures of the table. In the first 4 pens the Bean and Lentil mixture is given ad libitum; in Pen 1, without any other food; and we find that, with this very highly nitrogenous food alone, there is nearly as high a total gain, and a greater regularity of progress among the different pigs, and also throughout the several periods, and the total period of the experiment, than in any other pen.

In Pen 2, besides the Bean and Lentil meal, there was an allowance of 2 lbs. of Indian-corn meal per pig per day; which, as we have said, contains much less of nitrogen, but more of the non-nitrogenous, starchy, and fatty matters, than the Beans and Lentils. Upon this mixed food the entire pen gives a greater increase than Pen 1 with its more highly nitrogenous diet. Pig No. 1 in this Pen 2 gave a much higher increase than either of the others, and a very regular one throughout the four periods; he was a large-framed hog, and grew very considerably as well as fattened. The other two pigs increased less than No. 1, though their increase is also very constant during the first three periods of the experiment; but, during the concluding fortnight, they seem to have made much less progress. When they were killed, however, both these pigs were pronounced to be well fattened; and we shall presently see that the *consumption of food* in this pen decreased very much during the fourth period of the experiment; so that the probability is, that the reason of these two animals not increasing at the same rate as before, was that they were already ripe; from which cause both consumption and increase would naturally be lessened.

In Pen 3, 2 lbs. of Bran per pig per day is the limited food, and the Bean and Lentil mixture the complementary or ad libitum food. The Bran, which constituted the *limited food* of this pen, contains, weight for weight, more nitrogen than the Indian meal of Pen 2, but less than the Bean and Lentil mixture, which was the only food in Pen 1. The Bran, however, contains rather more fatty matter than the Beans and Lentils, but much less of other non-nitrogenous constituents than either the Beans and Lentils, or the Indian corn. Excepting in the item of fatty matter, then—and of this the amount is, after all, inconsiderable—the Bran is much inferior to either the Beans and Lentils or Indian corn, but especially so in the non-nitrogenous starchy series of compounds. The result is, that, although all the animals start well on this food, they all afterwards more or less rapidly decline in their rate of increase. The character of the deficiency of the food in this pen is best seen by comparing the result with that of Pen 2, in which 2 lbs. of Indian corn—so rich in the non-nitrogenous constituents—are given, instead of the 2 lbs. of Bran. This comparison clearly points to the dependence of the animals upon a due supply of the non-nitrogenous constituents of food—however liberally they may be provided with the nitrogenous ones.

In Pen 4, with Beans and Lentils still as the ad libitum food, we have 2 lbs. per pig per day both of Indian meal and of Bran, as the limited food. This diet we should suppose to be decidedly superior to that of Pen 3, but inferior to that of Pen 2. The result is a much better *total* increase than in Pen 3, though less than in either Pens 1 or 2. There was, however, in this Pen 4, one pig which gained very rapidly, and indeed twice as much on the whole as either of its companions. This very prosperous

No. 1 pig was, compared with the others, a large-framed growing animal; and he was, moreover, a very obstinately masterful and selfish one, requiring the whip more frequently than any other of the entire Series. It is probable, therefore, that in spite of the care that was taken, he managed to secure more than his share of the best adapted food; and, besides this, he doubtless retarded the progress of the other two pigs by disturbing their repose and comfort.

In Pens 5, 6, 7, and 8, we have, instead of the Bean and Lentil mixture, Indian-corn meal as the ad libitum food; which, it will be borne in mind, contains much less of nitrogen, but much more of the non-nitrogenous constituents than the former.

In Pen 5 the Indian meal was given alone, ad libitum of course. One of the pigs on this food gained more than 2 lbs. a day during the first fortnight of the experiment; but the other two only about half as much. Before the end of this first period, however, it was observed, that this fast gaining pig, and one of the others, namely, No. 3, had large swellings on the side of their necks; and that at the same time their breathing had become much laboured. It was obvious that the Indian corn meal alone, was in some way a defective diet; and it occurred to us, that it was comparatively poor both in nitrogen and in mineral matter,—though we were inclined to suspect, that it was a deficiency of the latter, rather than of the former, that was the cause of the ill effects produced. We were at any rate unwilling so far to disturb the plan of the experiments as to increase the supply of nitrogenous constituents in the food; and accordingly determined to continue the food as before, but, at least, to try the effect of putting within the reach of the pigs, a trough of some mineral substances, of which they could take if they were disposed. The mixture which was prepared was as follows:—20 lbs. of finely sifted coal ashes, 4 lbs. of common salt, and 1 lb. of superphosphate of lime. A trough containing this mineral mixture was put into the pen at the commencement of the second period, and the pigs soon began to lick it with evident relish. From this time the swellings or tumours, as well as the difficulty in breathing, which probably arose from the pressure of the former, began to diminish rapidly. Indeed, at the end of this second period the swellings were very much reduced, and at the end of the third they had disappeared entirely. No. 1 pig, which increased the most of the three during the first, third, and total periods of the experiment, it is seen only gained 6 lbs. during the second period; he was, however, during that time the worst affected by disease as described above. As, however, his apparent increase was so great during the first and third periods, it is probable, that part at least of the deficiency in the intermediate period, was

due to some temporary circumstance connected with his health, owing to which the contents of his stomach, &c., were unusually small at the time of his second weighing. The other two pigs in this pen give considerably less total increase than No. 1, but their rate of progress is comparatively very regular; that of No. 2 is singularly so; and No. 3, which was one of those affected by the swellings, nevertheless gives a gradually increasing rate of gain from the commencement up to the end of the experiment. We shall find too, further on, that the animals were satisfied with less of this food, though so poor in nitrogen, in proportion to their weight, than, with one exception, of any of the others; it will also be seen, that in spite of the comparatively small supply of nitrogen, and the comparatively small actual increase in weight of the pigs, yet this increase is, in reality, somewhat high, when calculated in relation to the amount of food consumed. Nor could the quality of the meat have suffered much; for a dealer in pork, with a practised eye, selected and purchased the carcass of one of these pigs which had been diseased, from among the whole 36, after they had been killed and hung up. With these observations we may leave the result of this curious experiment for the present; but, before closing our statement of the facts of it, it may here be remarked, that, of the mineral mixture described above, 9 lbs. were consumed by the three pigs during the first fortnight of its use, 6 lbs. during the second, and 9 lbs. during the third.

In Pen 6, with Indian corn meal as the complementary or ad libitum food, 2 lbs. of Bean and Lentil meal constitutes the limited food. Upon this diet, which contains a larger amount of nitrogen than that of Pen 5, but still a very liberal supply of the *non*-nitrogenous constituents, all the pigs begin well, and Nos. 1 and 3 give a regular and high rate of increase up to the end of the experiment; averaging, indeed, very nearly 2 lbs. per head per day. No. 2 gives, indeed, the highest increase during the first fortnight, but a decreasing one in the succeeding periods of the experiment. This No. 2 pig, however, was much riper at the last than either of the others; so that his comparatively small rate of increase as the experiment proceeded, is in no way disparaging to the quality of the food, but rather otherwise. And if, as we shall find further on, less food is consumed in proportion to the weight of the animal as he approaches maturity, we may suppose that this pig still did ample justice to all the food he consumed. Taking this explanation of the comparatively small increase of the No. 2 pig, it may be said that the diet of this pen 6, has given, upon the whole, a good and uniform rate of increase.

In Pen 7 the limited food is 2 lbs. of Bran per head per day;

with still Indian corn as the ad libitum food. In this pen we have a very good total increase; but there is a great difference between the different pigs in this respect. No. 3 gives not only the highest total increase of any pig of the whole Series of 36, amounting to rather more than 2½ lbs. per day, but his gain is exceedingly constant throughout the whole experiment. No. 2, on the other hand, gives a pretty uniform rate of increase, but a total amount considerably less than half that of No. 3, and very much less than No. 1. The pig No. 2 was, however, from the beginning, very much molested by the thriving No. 3, and indeed, for a time, frequently jumped out of his pen to avoid the ferocious attacks of his greedy neighbour. There is little doubt that he was prevented taking as much food as he would otherwise have done; and his deficient increase can scarcely be wondered at. No. 1 pig was also at first much molested; indeed, he lost the greater part of his tail in one engagement; his increase, therefore, was comparatively small at the commencement, but afterwards it was much better, averaging upon the whole rather more than 1¾ lbs. per day. Eventually this pig was the fattest among the whole 36; and this full ripeness is doubtless the reason of the gradually declining rate of increase during the last three periods of the experiment. Upon the whole, this diet of a small allowance of Bran and a liberal supply of Indian corn, may be pronounced a very good food, and to have yielded well. The limited quantity of Bran served somewhat to increase the supply of nitrogenous and mineral matters, and the large allowance of Indian corn provided a liberal amount, especially of fatty matter, and of the other important non-nitrogenous constituents of food.

In Pen 8, two lbs. of the Bean and Lentil mixture and 2 lbs. of Bran per pig per day was the fixed allowance; and Indian meal the complementary or ad libitum food. In this diet there would be a more liberal allowance of nitrogen than in either pens 5, 6, or 7, whilst there would be at the same time, enough of the Indian corn meal to provide a liberal supply of the important non-nitrogenous constituents. Every pig in this pen gave a good, and, upon the whole, a pretty regular increase, though they differed somewhat from one another in this respect; and they all grew considerably as well as fattened. No. 1 on this diet gives the highest increase in the entire Series of Pigs with one exception; and his daily gain in weight seemed to be on an average more than 2½ lbs., with something like a gradually declining rate of increase from the commencement to the end of the experiment. No. 2 was not so fat as either of the others; and his increase, though still a fair one, was only about two-thirds that of No. 1. No. 3 increased nearly 2 lbs. per day, but less as he progressed, and, though well fattened, was by no means so fat as many others. The average

increase of this entire pen is more than 2 lbs. per head per day. It would appear that a small proportion of *Bran*, with otherwise highly nutritive food, is by no means unfavourable in the fattening food of the pig. The results of the next 4 pens, however, will show, that the limit of the usefulness of Bran as a fattening food is very soon reached; and that with 2 or 3 lbs. per pig per day of Beans and Lentils, or of Indian corn, or even of both, an unlimited supply of Bran in addition, is insufficient to enable the animals to do much more than keep up a good store condition.

In Pens 9, 10, 11, and 12, Bran was given as the unlimited or complementary food; in the three former with the other foods in limited quantity; in Pen 12, with all the foods ad libitum.

In Pen 9 the limited food during the first fortnight was 2 lbs. of Beans and Lentils per pig per day, with Bran ad libitum. Upon this diet No. 1 Pig only increased 7 lbs., No. 2, 2 lbs., and No. 3 nothing at all, during the fourteen days. In this food, with a limited supply of Beans and Lentils, and Bran ad libitum, which has yielded such a bad result, there was a more liberal supply of nitrogenous constituents than in many of the previous pens; and it will be seen further on that it was the *non*-nitrogenous matters that were wanting in this diet. We shall find, indeed, that beyond a somewhat narrow limit which is attained with almost any of our current fattening foods, any defect is much more likely to be connected with a deficiency of the important *non*-nitrogenous constituents than of the nitrogenous ones. This remark of course refers only to the quality of food *as such*, that is as a source of the support and increase of the animal, and not to its value as a means of *manure*, which, in its turn, depends almost entirely upon the amount of *nitrogen* which the food contains. With such plain indications as the results of this pen afforded during the first fortnightly period, it was determined to increase from that time the daily allowance of beans and lentils from 2 lbs. to 3 lbs. Notwithstanding this increase in the allowance of the food, which, when given alone and in large quantity in Pen 1, yielded so large an increase, the gain in this pen continued to be scarcely more than one-third as much as the average in many of the pens. Two of the pigs indeed in this pen, Nos. 1 and 3, gave a somewhat regular though but small increase; but No. 2 gained only 6 lbs. during the entire period of 8 weeks. Almost from the commencement of the experiment this No. 2 pig became unwell, being as it were paralyzed and deprived of the use of its limbs; but as he had progressed quite as well as the average during the period preliminary to the exact experiment, it was supposed that this was only the natural effect of the defective diet, and hence it was decided not to alter the food, but to let him take his course, in order to obtain the

full and marked effect of this food in comparison with that of the other pens.

In Pen 10, Bran was still the ad libitum food; but Indian-corn meal, instead of Beans and Lentils, as in Pen 9, was the limited food. The diet of Pen 10 would therefore contain less of the nitrogenous and more of the non-nitrogenous constituents, than that of Pen 9. The result of this is, upon the whole, a decidedly better rate of increase. During the first period, however, when only 2 lbs. of the limited food were given, there was, it is true, a loss of weight of 8 lbs. in one animal; but after the Indian corn was increased to 3 lbs. per pig per day, as the Beans and Lentils had been in Pen 9, this pig, as well as the others, gave a pretty regular, though still comparatively small increase in weight. The progress upon this diet, could however, scarcely be considered more than that of good store food; though nevertheless it is clear, that the addition of the low nitrogenous and highly-starchy Indian-corn to the unlimited Bran, gave a much better food, than when, instead of the former, the highly nitrogenous Beans and Lentils had been given, as in Pen 9.

In Pen 11, with Bran still as the complementary or unlimited food, the limited allowance is more liberal than in the two preceding pens; namely, 2 lbs. of the Bean and Lentil mixture, and 2 lbs. of Indian-corn meal also. The result is a marked improvement, as compared with Pens 9 and 10. The proportion of Bran in the food is, however, still apparently much too high for the purpose of rapid fattening. What really were the actual relative proportions of the limited to the unlimited food, is a question we need not stop to consider in this place; but full particulars on this point are given in Tables, pp. 33-35, in respect to the food in all the pens. To proceed, then, with the results of the food in this Pen 11, it may be remarked, that the pigs fed upon it grew rather than merely fattened; and eventually they were, compared with those in many of the other pens, little more than half-fat. From some unexplained cause, one of the pigs in this pen was less regular in his rate of progress than the rest; but we think that the results, as a whole, may safely be taken as giving a fair measure of the comparative feeding value of the food employed.

In the 12th, and last pen of this Series, as before observed, each of the three descriptions of food was allowed ad libitum; that is to say, one trough was kept constantly supplied with the Bean and Lentil mixture, another with Indian-corn meal, and another with Bran; so that in this case the pigs were allowed to fix for themselves entirely, the quantity and proportion of the several foods. It might have been supposed, that by this arrangement the animals would be placed under more favourable circumstances for rapid progress than in any of the other pens. But, if the result

were to be taken as a strict measure of the comparative productive value of the food consumed, we must decide quite otherwise. Thus one of the pigs, No. 2, though during the first fortnight he gave a pretty fair increase, from that time became unwell and lost the use of his limbs, as in the instance already noticed. He was entirely unable to walk, and could scarcely support himself at the trough, and, as seen in the Table, he only gained 3 lbs. in the second period, and only 1 in the third; though during the fourth he somewhat recovered, and then gave an increase of 17 lbs. The other two pigs in this pen, however, gave a very fair increase, at a gradually diminishing rate as the experiment proceeded, and eventually they gave the highest proportions of *dead*-weight to live, of any of the entire series of 36 pigs; and they were, therefore undoubtedly well ripened. We may perhaps fairly conclude that the bad result of the No. 2 pig seriously reduced the apparent productive value of the food in this pen; at any rate, it would seem contrary to the facts to suppose, that in consulting their own inclination, this was not calculated to guide the animals to the selection best adapted to their progress, when we find, that under this arrangement two of the pigs matured more completely than any others of the entire Series. It is to be regretted, that the exact proportions of the several foods actually consumed by the two pigs who gave such a good result, cannot be stated separately from that of the other and faulty pig. We shall find, however, that the results of the entire pen in this respect are still of considerable interest, as will be seen in the following table :—

TABLE IV.

(EXPERIMENTS WITH PIGS.—SERIES I)

Showing the Proportions in 100 Parts, in which the several Foods were consumed in Pen 12, during the 4 successive Periods of the Experiment.

	Beans and Lentils.	Indian Corn.	Bran.	Total Food.
1st Period of 14 Days .	63	30	7	100
2nd ditto .	51 1/3	45	3 3/8	100
3rd ditto .	38 1/4	56 1/4	5 1/2	100
4th ditto .	43 1/5	52	4 4/5	100
Mean of the 8 Weeks .	49 9/10	45 9/10	4 1/5	100

If we suppose, as we fairly may do, that the two healthy and flourishing pigs in this pen mainly determined these proportions, in which the several foods were taken, it is plain, that as they ripened, they naturally selected less of the nitrogenous and more of the starchy and fatty food. There is, indeed, a trifling exception to this rule in the last period of the experiment, during which

43⅛ per cent. of the food taken was Beans and Lentils; whilst in the previous period there had been consumed of these only 38¼ per cent.; and again, with 56¼ per cent. of the Indian-corn in the third period, there is only 52 per cent. in the fourth. But, as it was during the fourth period that the sickly pig improved and took its food more freely, may we not conclude that the increased proportion of the Bean and Lentil mixture consumed during this period was due to his freer consumption of it? Notwithstanding this irregularity, however, the proportion of Beans and Lentils consumed in the last period in the entire pen, is only two-thirds as great as that in the first; whilst, on the other hand, the Indian-corn, which in the first period only constituted 30 per cent. of the food consumed, amounted in the fourth period to as much as 52 per cent.

At any rate, the general fact of a considerably decreasing demand for nitrogenous constituents, and an increasing one for the non-nitrogenous ones, as the animals mature, is sufficiently marked. It is, too, of considerable interest, and serves to justify the practice of diminishing the supply of the leguminous seeds (peas, beans, &c.), and increasing that of barley-meal to the fattening pig as he approaches maturity, as is the pretty general custom when a liberal system of fattening is adopted.

Before leaving the last table it may be noticed, that the average proportion of Bran taken by these pigs was less than 5 per cent. of their total food.

We have thus far given an account of the selection and management of the pigs in this First Series of experiments—a statement of the weight of the animals—a general description of the foods allotted to the several pens—and a somewhat detailed account of the progress in each pen, and even of each pig, upon the 12 different dietaries which it comprised. We have thought it desirable, indeed, in reference at any rate to the First Series of experiments, somewhat minutely to call attention to any such irregularities within the pens as might be supposed to affect the legitimacy of comparisons founded upon the gross results of the entire pen. These observations will have given the reader a considerable insight into the general character of the results; and they will enable him to form his own conclusions respecting them. But we think it will be seen, that, notwithstanding the irregularities that have been pointed out, there is still much of consistency in the indications of the mere gross result of each pen, upon which henceforth we shall found our conclusions; and we shall therefore go into less detail on these points in the account of the other Series of experiments.

We have yet to consider however, much more minutely, the influence of the composition of the food upon the rate of consumption, and the progress of the pigs in this First Series of experiments. But these and some other points will be discussed with more advantage in reference to the results of all the series together. Before proceeding further, therefore, with this First Series, we shall describe thus far, the particulars and results of a Second and of a Third Series of experiments with Pigs.

The First Series of experiments in which Beans and Lentils were the highly nitrogenous food, Indian-corn meal the comparatively non-nitrogenous food, and Bran the more bulky and less nutritious one—had afforded very clear indications as to the comparative feeding values of the different classes of constituents which characterise these different foods. It was decided, therefore, to conduct the Second Series on a somewhat similar plan. In this case, however, the Indian-corn of the former series was substituted by the more usual pig-food, *Barley-meal*. It was also thought desirable to alter the proportions of the limited to the unlimited food—3 lbs. instead of 2 lbs. per pig per day of limited food being now given when it consisted of the Bean and Lentil mixture or of Barley-meal, and only 1 lb. when Bran. It was further determined in no case to give Bran alone, as the complementary or ad libitum food.

Like the former one, this Series consisted of 12 pens with 3 pigs in each. Pens 1, 2, 3, and 4 had, as before, the Bean and Lentil mixture as the ad libitum food. In Pens 5, 6, 7, and 8, Barley-meal was the ad libitum food. In Pens 9, 10, 11, and 12, there was no allowance of limited food; but in Pens 9 and 10 a mixture of certain proportions of the several foods was given ad libitum; and in Pens 11 and 12 a similar mixture, but containing different proportions respectively of the more and the less highly nitrogenised foods.

The following is a detailed description of the 12 dietaries of this Second Series:—

Pen 1. Bean and Lentil meal (equal parts), ad libitum.

Pen 2. 3 lbs. per pig per day of Barley-meal; and the Bean and Lentil mixture, ad libitum.

Pen 3. 1 lb. of Bran per pig per day; and the Bean and Lentil mixture, ad libitum.

Pen 4. 3 lbs. of Barley-meal and 1 lb. of Bran per pig per day; and Bean and Lentil mixture, ad libitum.

Pen 5. Barley-meal only, ad libitum.

Pen 6. 3 lbs. per pig per day of Bean and Lentil mixture; and Barley-meal, ad libitum.

Pen 7. 1 lb. of Bran per pig per day; and Barley-meal, ad libitum.

Pen 8. 3 lbs. of Bean and Lentil mixture and 1 lb. of Bran per pig per day ; and Barley-meal, ad libitum.

Pen 9. A mixture of 1 part Bran, 2 parts Barley-meal, and 3 parts Bean and Lentil mixture, ad libitum.

Pen 10. Duplicate of Pen 9.

Pen 11. A mixture of 1 part Bran, 2 parts Bean and Lentil mixture, and 3 parts Barley-meal, ad libitum.

Pen 12. Duplicate of Pen 11.

On April 26th, 1850, the pigs were allotted by weight to the different pens. They were taken from a stock of 40, all of about nine months old, which had been bought at different styes and markets, in lots respectively of four, nine, eight, eight, and eleven ; and, as before, they were on the following day changed from pen to pen, so as to disturb as little as possible the weight within each pen, and at the same time to secure greater equality as to the character of the animals between pen and pen.

Table V., which follows, shows the weights of the pigs in each pen as thus allotted.

TABLE V.

(EXPERIMENTS WITH PIGS.—SERIES II)

Showing the Weights of the Pigs (in lbs.) when Allotted to the Pens, April 26, 1850.

Nos. of the Pigs.	Pen 1	Pen 2	Pen 3	Pen 4	Pen 5	Pen 6	Pen 7	Pen 8	Pen 9	Pen 10	Pen 11	Pen 12
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	138	138	138	137	136	134	134	133	129	128	127	127
2	117	125	124	120	122	123	120	120	126	125	124	127
3	115	105	106	114	111	112	112	113	116	116	116	116
Total weights of 3 pigs	370	368	368	371	369	369	366	366	371	369	367	370

After the allotment and this first weighing, all the pens were supplied with a mixture (given ad libitum) of one part Bran, one part Bean and Lentil meal, and one part Barley-meal. Upon this food they were kept for 13 days prior to commencing the exact experiment. There was, as usual, some inconvenience during this preliminary period until the pigs became accustomed to their new situation and new companions ; and this of course accounts for some of the irregularity in increase during this period, as shown in Table VI., which follows.

TABLE VI.

(EXPERIMENTS WITH PIGS.—SERIES II)

Showing the weight (in lbs.) Gained during the 13 Days of the Preliminary Period, and also the actual Weights at the Commencement of the exact experiment. May 9, 1850.

Nos. of the Pigs.	Pen 1		Pen 2		Pen 3		Pen 4		Pen 5		Pen 6	
	Gain in 13 Days.	Weight May 9.	Gain in 13 Days.	Weight May 9.	Gain in 13 Days.	Weight May 9.	Gain in 13 Days.	Weight May 9.	Gain in 13 Days.	Weight May 9.	Gain in 13 Days.	Weight May 9.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	20	158	27	165	17	155	16	153	30	166	15	149
2	16	133	23	148	6	130	16	136	27	149	20	143
3	27	142	28	133	14	120	28	142	22	133	24	136
Totals	63	433	78	446	37	405	60	431	79	448	59	428

Nos. of the Pigs.	Pen 7		Pen 8		Pen 9		Pen 10		Pen 11		Pen 12	
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	19	153	18	151	18	147	7	135	23	150	0	127
2	23	143	19	139	17	143	14	139	12	136	10	137
3	18	130	16	129	24	140	21	137	23	139	22	138
Totals	60	426	53	419	59	430	42	411	58	425	32	402

On May 9th, then, the exact experiment was commenced ; and the pigs were now put upon the dietaries which have been already described. The management, as to the supply of food, &c., was the same as before. The pigs themselves were weighed every 14 days ; and the experiment was continued for four such periods —that is, for a total period of 8 weeks.

The following Table (VII.) gives the increase in weight per pig and per pen in this Second Series.

TABLE VII.

(EXPERIMENTS WITH PIGS.—SERIES II)

Showing the *Gain in Weight* (in lbs.) upon each of the 12 different Dietaries, of *each Pig*, and of the *Pen of Three Pigs*, during each period of 14 Days, and during the entire experimental Period of 8 Weeks.

Nos. of Pigs.	PEN 1 — Beans and Lentils (equal parts) Ad Libitum.					PEN 2 — 3 lbs. Barley Meal per Pig per Day. Beans and Lentils (equal parts) Ad Libitum.				
	1st Period 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.	Ist Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.
1	33	7	13	24	77	41	22	28	29	120
2	−3	4	Died June 9	...	1	10	14	25	16	65
3	23	34	25	35	117	25	20	27	27	99
3 pigs.	53	45	38	59	195	76	56	80	72	284

TABLE VII.—*continued.*

(EXPERIMENTS WITH PIGS.—SERIES II)—*continued.*

Nos. of Pigs.	PEN 3. 1 lb. Bran per Pig per Day. Beans and Lentils (equal parts) Ad Libitum.					PEN 4. 3 lb. Barley Meal and 1 lb. Bran per Pig per Day. Beans and Lentils (equal parts) Ad Libitum.				
	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period 8 Weeks.	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	20	16	22	25	83	23	21	24	19	87
2	25	12	25	19	81	26	16	17	Killed June 28	59
3	24	16	18	20	78	24	21	31	18	94
3 pigs.	69	44	65	64	242	73	58	72	37	240

Nos. of Pigs.	PEN 5. Barley Meal Ad Libitum.					PEN 6. 3 lbs. Bean and Lentil Meal Per Pig per Day. Barley Meal Ad Libitum.				
1	Died May 16.	24	28	10	62	35	15	11	14	75
2	37	35	41	29	142	39	23	28	23	113
3	29	19	21	18	87	28	15	20	Died June 20	63
3 pigs.	66	78	90	57	291	102	53	59	37	251

Nos. of Pigs.	PEN 7. 1 lb. Bran per Pig per Day. Barley Meal Ad Libitum.					PEN 8. 3 lbs. Bean and Lentil Meal and 1 lb. Bran per Pig per Day. Barley Meal Ad Libitum.				
1	30	20	21	24	95	35	17	29	20	101
2	35	22	17	22	96	— 3	Died May 29	...	...	—3
3	29	21	15	21	86	37	16	22	14	89
3 pigs.	94	63	53	67	277	69	33	51	34	187

TABLE VII.—*continued.*

(EXPERIMENTS WITH PIGS.—SERIES II)—*continued.*

Nos. of Pigs.	Pen 9. Mixture of 1 part Bran, " 2 parts Barley Meal, and " 3 parts Beans & Lentils Ad Libitum.					Pen 10. Duplicate of Pen 9.				
	1st Period 14 days.	2nd Period 14 Days.	3rd Period 14 Days.	4th Period 14 Days.	Total Period 8 Weeks.	1st Period 14 Days.	2nd Period 14 Days.	3rd Period 14 Days.	4th Period 14 Days.	Total Period 8 Weeks.
1	—3	20	28	Died June 20	45	28	24	19	22	93
2	32	21	22	21	96	29	14	18	18	79
3	31	30	25	26	112	31	33	20	27	111
3 pigs	60	71	75	47	253	88	71	57	67	283

Nos. of Pigs.	Pen 11. Mixture of 1 part Bran " 2 parts Bean and Lentil Meal, and " 3 parts Barley Meal, Ad Libitum.					Pen 12. Duplicate of Pen 11.				
1	32	24	22	27	105	43	22	24	21	110
2	41	27	18	24	110	31	16	25	26	98
3	27	20	24	24	95	30	17	24	28	99
3 pigs	100	71	64	75	310	104	55	73	75	307

An inspection of this Table (VII.) shows that five of the pigs of this second series died during the experiment. It would appear that we were very unfortunate in one of the purchases, for all of these five pigs belonged to one of the lots of eight, and hence the loss was most probably due to the bad constitution of the animals. The weather was, however, excessively hot during part of the period of this experiment, and therefore unfavourable to the health of pigs fattening on a very liberal diet. It was evident that many did suffer from this cause; and that some of the losses were indeed in a great measure attributable to it.

These accidents, of course render it quite impossible to form any judgment of the value of the different foods by a comparison of the *actual gross results* of pen with pen. But we shall find, that, even with this greater irregularity in the amounts of actual increase obtained per pen than in the previous series, there is still, when we come to consider this increase in relation to

These five pens were devoted to the trial, as pig-food, of *dried Newfoundland cod-fish*—an article which could be supplied in large quantities, and at a moderate price, were it found available for this purpose. The experiments were so arranged as to ascertain in what proportions it could be most advantageously mixed with other foods; the dried cod-fish containing, as will be seen in our Table of Composition, a much higher percentage of nitrogen than any other current pig-food. Hence, if it were found otherwise available, it would yield a manure of corresponding richness.

It should be stated, that during the preliminary period, the pigs in Pens 1, 2, and 3 of this Series were supplied with the same food as had been given in the 12 pens of the First Series; namely, one part Bean and Lentil mixture, one part Indian-corn, and two parts Bran. Pens 4 and 5, however, were provided, during their preliminary period, with half a pound per pig per day of the dried Cod-fish, and were allowed to take ad libitum of a mixture of one part Bean and Lentil meal, one part Barley-meal, and one part Bran. The Cod-fish was in all cases prepared by boiling in water; and a portion of the other food was then stirred in with the soup thus obtained. It is scarcely necessary to mention that in all the experiments with pigs the food was mixed with water before it was put into the troughs.

The allowance of food to the several pens of the Third Series was as follows:—

Pen 1. 2 lbs. of dried Cod-fish per pig per day; with a mixture of equal parts of Indian meal and Bran, ad libitum.

Pen 2. 2 lbs. of dried Cod-fish per pig per day; with Indian meal, ad libitum.

Pen 3. Cod-fish, and a mixture of equal parts of Indian meal and Bran, each ad libitum.

Pen 4. 1 lb. of Cod-fish per pig per day; with a mixture of 2 parts Barley-meal and 1 part Bran, ad libitum.

Pen 5. 1 lb. of Cod-fish per pig per day; with Barley-meal, ad libitum.

Table X. gives the increase of each pig, and of each pen, upon these five dietaries, during each fortnightly period, and the total periods of eight weeks.

TABLE X.

(EXPERIMENTS WITH PIGS.—SERIES III.)

Showing the *Gain in Weight* (in lbs.) upon each of the Five different Dietaries—of *each Pig*, and of the *Pen of Four Pigs*—during each Period of 14 Days—and during the entire Experimental Period of 8 Weeks.

Pig Nos.	PEN 1 — 2 lbs. Cod Fish per Pig per day. Bran and Indian-meal (equal parts) Ad Libitum.					PEN 2 — 2 lbs. Cod Fish per Pig per day. Indian-meal Ad Libitum.					PEN 3 — Bran and Indian-meal (equal parts), and Cod Fish, each Ad Libitum.				
	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	35	14	13	10	72	20	28	37	30	115	39	21	11	21	92
2	27	25	25	25	102	20	30	13	28	91	23	20	17	14	74
3	-17	31	22	21	57	39	29	32	22	122	19	17	16	16	68
4	18	26	25	23	92	-3	17	24	23	61	1	20	16	15	52
4 Pigs.	63	96	85	79	323	76	104	106	103	389	82	78	60	66	286

Pig Nos.	PEN 4 — 1 lb. Cod Fish per Pig per day. Mixture of 2 parts Barley-meal and 1 part Bran Ad Libitum.					PEN 5 — 1 lb. Cod Fish per Pig per day. Barley-meal Ad Libitum.				
	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	23	27	13	20	83	33	27	24	17	101
2	21	15	16	12	64	31	23	23	21	98
3	27	19	19	18	83	44	25	22	3	94
4	19	16	-3	39	71	30	23	21	9	83
4 Pigs.	90	77	45	89	301	138	98	90	50	376

As the experiment proceeded with Pens 1, 2, and 3, it was obvious that the fixed allowance of 2 lbs. of Cod-fish per pig per day, in the two former, was more than they would have taken had it not been so mixed with their other food as to oblige them to do so. It was evident, too, that the proportion of one part Bran to one part only of the Indian meal, in the ad libitum food of Pens 1 and 3, was also too great. In Pens 4 and 5, therefore, as the Table shows, only 1 lb. of Cod-fish per pig per day was given as the limited food; and in Pen 4, where Bran was given in the ad libitum food, the mixture was composed of only one part Bran to two parts of the Barley-meal.

The Table shows at a glance that there was throughout this Series, with Cod-fish, a very fair rate of increase per head; and we shall see further on, that the increase was also comparatively high in relation to the amount of food consumed. We observe, too, a marked superiority in Pen 2, where the Indian meal was given alone as ad libitum food, over Pen 1, where it was mixed with Bran; and the same in Pen 5 over Pen 4; the Barley-meal being mixed with Bran in the latter, and given alone in the former. This is only what we might expect, and the result is very consistent in the two cases.

The Pigs in Pens 1 and 2 of this Cod-fish Series were exceedingly fat; they indeed looked better than any, either in this or in either of the other Series. We shall have occasion to remark again on this experiment further on.

Before leaving the actual experimental results of these three Series of Pig experiments, and considering them more closely when brought by calculation to one uniform standard of comparison, or more minutely in reference to the chemical composition of the foods, it may be convenient to show the average *weekly* consumption *per head* of the unlimited, as well as of the limited, food; and also the average *weekly increase* obtained *per head* during each period, and the total period, in each of the 29 pens which the three Series of experiments comprise. These particulars are given for the several Series respectively in Tables XI., XII., and XIII., which follow.

Table XI.

(Experiments with Pigs.—Series I.)

Showing the Average Weekly Consumption of Food, and Increase in Weight per Head, during each Period, and the total Period of the Experiment.

Pen, Nos., &c.		Description, and average quantities of Food, consumed per Pig, per Week (lbs.)		Average Weekly Increase in Live Weight (lbs.) per Pig, during each Period, and the total Period of the Experiment.				
		Limited Foods.	Ad Libitum Foods.	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Average of 8 Weeks.
Pen	Pigs							
1	3	None	63 lbs. bean & lentil meal (equal parts)	12·83	13·83	12·00	11·83	12·62
2	3	14 lbs. Indian meal	52 lbs. ditto	16·00	15·66	14·00	10·33	14·00
3	3	14 lbs. bran	40¼ lbs. ditto	13·83	10·00	3·66	5·83	8·33
4	3	14 lbs. Indian meal 14 lbs. bran	31½ lbs. ditto	11·50	8·83	9·66	12·00	10·50
5	3	None	45¼ lbs. Indian meal	9·66	6·00	12·00	9·18	9·21
6	3	14 lbs. bean & lentil meal (equal parts)	44¼ lbs. ditto	15·18	12·66	9·83	12·00	12·42
7	3	14 lbs. bran	44¼ lbs. ditto	11·00	14·67	13·83	12·00	12·87
8	3	14 lbs. bean & lentil meal (equal parts), 14 lbs. bran	36¾ lbs. ditto	17·50	14·50	11·18	14·66	14·46
9	3	14 lbs. bean & lentil meal (equal parts)	18 lbs. bran	1·50	5·00	4·83	5·33	4 16
10	3	14 lbs. Indian meal	23½ lbs. ditto	0·83	6·83	5·83	5·50	4·75
11	3	14 lbs. bean & lentil meal (equal parts), and 14 lbs. Indian meal	18 lbs. ditto	9·33	6·50	6·50	7·33	7·42
12	3	None	28½ lbs. bean and lentil meal (equal parts) 25½ lbs. Indian meal 3 lbs. bran.	15·83	10·83	7·00	8·66	10·58

TABLE XII.

(EXPERIMENTS WITH PIGS.—SERIES II.)

Showing the Average weekly Consumption of Food and Increase in Weight per Head during each Period, and the Total Period of the Experiment.

Pen, Nos., &c.		Description and average quantities of Food consumed, per Pig, per Week (lbs.).		Average Weekly increase in Live Weight (lbs.) per Pig during each Period, and the Total Period of the Experiment.				
		Limited Foods.	Ad Libitum Foods.	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Average of 8 Weeks.
Pen	Pigs.							
1	3	None	44 lbs. bean & lentil meal (equal parts)	8·83	7·50	9·50	14·75	10·14
2	3	21 lbs. barley meal .	51½ lbs. ditto .	12·67	9·33	13·33	12 00	11·83
3	3	7 lbs. bran	52¾ lbs. ditto .	11·50	7·33	10·83	10 67	10 08
4	3	21 lbs. barley meal and 7 lbs. bran	33 lbs. ditto .	12·17	9·67	12·00	9·25	10·77
5	3	None	68½ lbs. barley meal	11·00	13·00	15·00	9·50	12·12
6	3	21 lbs. bean & lentil meal (equal parts)	37¾ lbs. ditto .	17·00	8·83	9·83	9·25	11·23
7	3	7 lbs. bran	57½ lbs. ditto .	15·67	10·50	8·83	11·17	11·54
8	3	21 lbs. bean & lentil meal (equal parts) and 7 lbs. bran	25 lbs. ditto .	11·50	8·25	12·75	8·50	10·25
9	3	None	61½ lbs. of mixture of 1 part bran, 2 parts barley meal, and 3 parts bean and lentil meal	10·00	11·83	12·50	7·83	10·54
10	3	None	64¾ lbs., duplicate of Pen 9	14·67	11·83	9·50	11·17	11·79
11	3	None	65 lbs. of mixture of 1 part bran, 2 parts bean and lentil meal, and 3 parts barley meal	16·67	11·83	10·67	12·50	12·92
12	3	None	64 lbs., duplicate of Pen 11	17·33	9·17	12·17	12·50	12·79

TABLE XIII.

(EXPERIMENTS WITH PIGS.—SERIES III.)

Showing the *Average weekly Consumption* of Food and Increase in Weight *per Head*, during each Period, and during the total Period of the Experiment.

Pen. Nos., &c.		Description and average quantities of Food consumed, per Pig, per Week (lbs.)		Average Weekly Increase in Live Weight (lbs.) per Pig during each Period, and the total Period of the Experiment.				
		Limited Foods.	Ad Libitum Foods.	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Average of 8 Weeks.
Pen	Pigs							
1	4	14 lbs. cod-fish .	47 lbs. of mixture of bran and Indian meal (equal parts)	7·87	12·00	10·62	9·87	10·09
2	4	14 lbs. cod-fish .	45¼ lbs. Indian meal . .	9·50	13·00	13·25	12·87	12·15
3	4	None	47 lbs. of mixture of bran and Indian meal (equal parts), and 7½ lbs. cod-fish.	10·25	9·75	7·50	8·25	8·94
4	4	7 lbs. cod-fish .	49 lbs. of mixture of 2 parts barley meal and 1 part bran.	11·25	9·62	5·62	11·12	9·40
5	5	7 lbs cod-fish .	57½ lbs. barley meal . .	17·25	12·25	11·25	6·25	11·75

From these Tables we learn the fact that the pigs consumed, on an average, about 60 lbs. of corn per head per week—or nearly 9 lbs. per head per day; and that where the quality of the food was good, they yielded from 10 lbs. to 12 lbs. of increase in live weight per head per week—or about 1½ lb. per head per day.

The amounts of food consumed per week, as given in these Tables (XI., XII., XIII.) are, it will be remembered, the averages of the whole period calculated *per head;* and those of the average weekly increase produced are also calculated per head; but the latter is given for each separate period, as well as for the total period. In the Tables which next follow, however (XIV., XV., XVI.), we have the weekly consumption of food *per* 100 *lbs. live weight of animal*, instead of per head; and calculated for each period of the experiment separately, instead of only for the total period. We have now, too, instead of the rate of increase *per head* during each separate period, the amount of increase obtained *for each* 100 *lbs. of food consumed*. In these Tables, therefore, we have the rate of *consumption* and of *increase*, during the successive periods of the experiment—each calculated to a uniform standard. And, it will be seen, that the results as thus arranged, clearly bring to view the influence of the progress of the animal, both upon the rate of consumption of food, and upon its productiveness—as already briefly alluded to, when commenting upon the results of Pen 12 of the First Series of experiments. We shall call attention to these Tables somewhat in detail.

Table XIV.

(Experiments with Pigs.—Series I.)

Showing the Average Weekly Consumption of Food per 100 lbs. Live Weight of Animal—and also the increase in Weight obtained by the Consumption of every 100 lbs. of Food, during each of the Successive Periods, and the Total Period of the Experiment.

Pen Nos.	Description and Quantities of Limited Food per Pig per Day.	Description of Ad Libitum or Complementary Food.	Division I. Average Weekly Consumption of Fresh Food, per 100 lbs. Live Weight of Animal.					Division II. Increase obtained by the Consumption of 100 lbs. Fresh Food.					Average Weekly Consumption of Food per 100 lbs. Live Weight of Animal.
			1st Period, 14 days.	2nd Period, 14 days.	3rd Period, 14 days.	4th Period, 14 days.	Total Period, 8 weeks.	1st Period, 14 days.	2nd Period, 14 days.	3rd Period, 14 days.	4th Period, 14 days.	Total Period, 8 weeks.	
1	None	Bean and lentil meal	37·2	36·7	30·0	26·6	32·0	21·6	20·8	18·8	18·9	20·0	32·0
2	2 lbs. Indian corn meal	Ditto	39·1	37·4	32·2	25·7	33·6	26·1	22·2	20·0	16·6	21·2	33·6
3	2 lbs. bran	Ditto	40·6	34·8	24·7	22·4	31·2	22·1	16·1	7·9	12·9	15·4	31·2
4	2 lbs. bran and 2 lbs. Indian corn meal	Ditto	38·3	31·2	31·7	29·9	32·3	19·5	16·3	15·8	18·7	17·6	32·3
		Means	38·8	35·0	29·6	26·1	32·3	22·3	19·0	15·6	16·8	18·5	32·3
5	None	Indian corn meal	33·7	23·3	26·9	19·0	25·1	18·7	15·2	23·8	23·1	20·3	25·1
6	2 lbs. bean and lentil meal	Ditto	40·0	32·1	27·0	20·8	29·5	23·2	20·6	17·0	24 5	21·3	29·5
7	2 lbs. bran	Ditto	37·9	32·9	30·1	25·2	30·7	19·4	25·5	22·6	20·7	22·1	30·7
8	2 lbs. bran and 2 lbs bean and lentil meal	Ditto	41·8	34·8	29·0	24·8	32·1	25·9	21·5	17·5	24·1	22·3	32·1
		Means	38·3	30·8	28·2	22·4	29·3	22·0	21·0	20·2	23·1	21·5	29·3
9	*2 lbs. bean and lentil meal	Bran	26·0	25·2	23 5	20·9	23·3	4·0	13·1	12·8	14·9	11·2	23·3
10	*2 lbs. Indian corn meal	Ditto	26·5	29·9	28·1	26·5	27·2	2·2	15·5	13·0	12·1	11·1	27·2
11	2 lbs. bean and lentil meal and 2lbs. Indian corn meal	Ditto	33·7	28·2	24·6	21·8	26·9	18·4	13·8	14·7	17·4	16·1	26·9
		Means	28·7	27·8	25·4	23·1	25·8	8·2	14·1	13·5	14·8	12·8	25·8
12	None	Bean & lentil meal, Indian corn meal, and bran	40·9	34·3	26·9	20·6	30·8	24·3	17·5	12·8	19·2	18·6	30·8
		Mean of 12 Pens	36·3	31·7	27·9	23·7	29·5	18·8	18·2	16·4	18·6	18·1	29·5

* Increased to 3 lbs. after the first period of the experiment.

Table XV.

(Experiments with Pigs.—Series II.)

Showing the Average Weekly Consumption of Food per 100 lbs. Live Weight of Animal—and also the Increase in Weight obtained by the Consumption of every 100 lbs. of Food, during each of the successive Periods. and the Total Period of the Experiment.

Pen Nos.	Description and Quantities of Limited Food per Pig per Day.	Description of Ad Libitum or Complementary Food.	Division I. Average Weekly Consumption of Fresh Food per 100 lbs. Live Weight of Animal.					Division II. Increase obtained by the Consumption of 100 lbs. Fresh Food.					Average Weekly Consumption of Food per 100 lbs. Live Weight of Animal.
			1st Period, 14 days.	2nd Period, 14 days.	3rd Period, 14 days.	4th Period, 14 days.	Total Period, 8 weeks.	1st Period, 14 days.	2nd Period, 14 days.	3rd Period, 14 days.	4th Period, 14 days.	Total Period, 8 weeks.	
1	None	Bean and lentil meal	31·2	22·9	23·9	22·7	24·9	19·4	17·5	14·4	21·8	18·4	24·9
2	3 lbs. barley meal	Ditto	43·0	39·6	36·4	31·8	37·0	18·3	12·8	17·8	16·3	16·3	37·0
3	1 lb. bran	Ditto	37·2	34·5	34·6	31·3	34·1	21·1	12·9	17·1	16·6	16·9	34·1
4	3 lbs. barley meal & 1 lb. bran	Ditto	42·4	33·7	32·9	24·3	33·2	18·4	16·1	18·3	11·7	16·4	33·2
		Means	38·4	32·7	31·9	27·5	32·3	19·3	14·8	16·9	16·6	17·0	32·3
5	None	Barley meal	39·3	38·1	34·1	28·7	34·6	17·5	18·5	20·7	14·0	17·7	34·6
6	3 lbs. bean and lentil meal	Ditto	40·3	35·2	29·9	17·0	30·9	26·4	13·5	16·1	16·4	18·4	30·9
7	1 lb. bran	Ditto	42·9	36·6	32·1	26·1	34·3	23·1	15·6	13·5	19·2	17·8	34·3
8	3 lbs. bean and lentil meal, and 1 lb. bran	Ditto	40·0	23·5	23·4	20·6	26·8	19·8	13·8	19·8	13·9	17·2	26·8
		Means	40·6	33·3	29·9	23·1	31·6	21·7	15·3	17·5	15·9	17·8	31·6
9	None	Mixture of 1 part bran, 2 parts barley meal, and 3 parts bean & lentil meal	41·0	37·4	34·1	22·5	33·1	15·9	18·1	18·4	15·8	17·1	33·1
10	None	Duplicate of Pen 9	40·8	38·3	33·7	28·2	35·2	23·7	17·3	14·1	18·0	18·2	35·2
		Means	40·9	37·8	33·9	25·3	34·1	19·8	17·7	16·2	16·9	17·6	34·1
11	None	Mixture of 1 part bran, 2 parts bean & lentil meal, and 3 parts barley meal	42·7	35·4	31·0	26·3	33·6	24·6	17·9	16·4	20·4	19·9	33·6
12	None	Duplicate of Pen 11	42·8	33·7	34·2	28·5	34·7	26·7	15·3	17·8	19·6	19·9	34·7
		Means	42·7	34·5	32·6	27·4	34·1	25·6	16·6	17·1	20·0	19·9	34·1
		Mean of the 12 Pens	40·3	34·1	31·7	25·7	32·7	21·2	15·8	17·0	17·0	17·8	32·7

Table XVI.

(Experiments with Pigs.—Series III.)

Showing the Average Weekly Consumption of Food per 100 lbs. Live Weight of Animal—and also the Increase in Weight obtained by the Consumption of every 100 lbs. of Food, during each of the successive Periods, and during the Total Period of the Experiment.

Pen Nos.	Description & Quantities of Limited Food per Pig per Day.	Description of Ad Libitum or Complementary Food.	Division I. Average Weekly Consumption of Fresh Food per 100 lbs. Live Weight of Animal.					Division II. Increase obtained by the Consumption of 100 lbs. Fresh Food.					Average Weekly Consumption of Food per 100 lbs. Live Weight of Animal.
			1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.	1st Period, 14 Days.	2nd Period, 14 Days.	3rd Period, 14 Days.	4th Period, 14 Days.	Total Period, 8 Weeks.	
1	2 lbs. cod-fish .	Bran and Indian meal (equal parts) . . .	28·9	30·3	29·7	26·8	28·6	16·4	21·3	17·2	16·1	17·7	28·6
2	2 lbs. cod-fish .	Indian meal . . .	29·3	27·7	26·0	23·8	26·1	18·9	24·2	23·2	22·0	22·1	26·1
3	None	Bran and Indian meal (equal parts). and cod fish	32·8	33·7	32·1	29·7	32·3	21·7	17·7	12·9	14 1	16·3	32·3
4	1 lb. cod-fish . .	Mixture of 2 parts barley-meal and 1 part bran	44·7	39·9	33·3	28·8	36·3	19·5	16·1	10·2	21·3	16·7	36·3
5	1 lb cod-fish . .	Barley-meal . . .	56·2	40·0	33·9	27·5	39·6	23·4	18·8	17·8	11 1	18·2	39·6
		Means of the 5 Pens . .	38·2	34·3	31·0	27·3	32·6	20·0	19·6	16·3	16·9	18·2	32 6

Looking first to Table XIV. (which refers to Series I.), it is seen, by the heading, that Division I. gives the quantity, in lbs. and tenths, of the gross or fresh food *consumed weekly by every* 100 *lbs. live-weight of animal* in each pen, during each of the four successive periods, and the total period of the experiment. A glance at the figures in this division from left to right will show, that, with scarcely an exception, there is a very considerable decrease of consumption to 100 lbs. live weight, as the experiment progresses. In several cases there is scarcely half as much food consumed to a given weight of animal in the fourth period as in the first; and, indeed, in all where the progress is known to have been good, this decrease in consumption, from the first period to the fourth, amounts to about one-third or more. On the other hand, it is as clearly seen, that in those cases in which the pigs fattened but very slowly, the decrease in the consumption of food to a given weight of animal, as the experiment proceeded, is very inconsiderable.

Looking at the figures a little more in detail, we observe too, that there is a perceptibly greater decrease in consumption to a given weight of animal, where the comparatively *non*-nitrogenous Indian corn predominated, than where the more highly nitrogenous foods were more freely given.

If we now turn to Division II. of the Table—which shows the comparative *productiveness* of a given weight of food in gross increase, as the experiment progressed—we see no such obvious general gradation in this, as the animal matured, as has been observed in the rate of the *consumption* of food; though there is perhaps, upon the whole, more of a tendency to decrease than to increase in this rate of productiveness in gross increase, as the experiment proceeded. Comparing, however, the results of pens 1 to 4 inclusive, where the nitrogenous food more predominated, with those of pens 5 to 8, where the Indian meal was given in larger quantity, there is certainly, with the more highly nitrogenous diets, more of the tendency to decrease, in the proportion of gain in live weight to food consumed, than with the more *non*-nitrogenous ones.

Turning to Table XV., which gives the same particulars for the Second Series, we see, that, notwithstanding during the course of the experiment several of the pigs in this Series were unhealthy, and some died, yet the same general facts are here brought out as in Series I. Thus, taking first Division I. (Table XV.), which shows the rate of *consumption* as the animals fattened, we find (owing, doubtless, to the generally better and more uniform balance of the constituents of the food throughout this Series than in Series I.), that the decrease in the consumption of food to 100 lbs. live weight of animal, is even more general in

this series than in the former one. And, the greater tendency to decrease in consumption of food to a given weight of animal, the more within certain limits the comparatively non-nitrogenous food predominates, is here again seen.

In Division II. (Table XV.) we observe, that the rate of *productiveness* in gross increase in weight to 100 lbs. of food consumed, fluctuates so considerably from the commencement to the conclusion of the experiment, but so irregularly, that it is impossible to decide that there is any regular gradation in either direction. There is, indeed, in this case, perhaps more of the tendency to *decrease* in the rate of productiveness of the food in *gross increase* as the experiment proceeded. It is not improbable, however, that the great heat of the weather, and the unhealthiness of some of the pigs, may have had something to do with this result. Though, as we shall have further occasion to observe, a slightly lessened proportion of *gross* increase, to food consumed, does not necessarily show that the food was really less productive in *real dry* increase.

In Division I. of Table XVI., which shows the *rate of consumption*, as the experiment proceeded, with the Third or Cod Fish Series, the influence of the composition of the food on this rate of consumption by the fattening animal, is strikingly shown. Thus, in pens 1 and 2, considerably more of the highly nitrogenous cod-fish was allotted to the pigs than they would have taken, could they have obtained other food in its stead; but, in pens 4 and 5, only half as much of the cod-fish was given, so that the pigs were enabled to take a much larger proportion of the comparatively non-nitrogenous complementary foods. The result is, that with this very much larger proportion of the more *non*-nitrogenous foods in pens 4 and 5, we have in these, a very much greater decrease in the rate of consumption to a given weight of animal than in the pens 1 and 2. There was, indeed, as we shall have occasion to notice again further on, a much less proportion of food consumed to a given weight of animal, when the large amount of the highly nitrogenous cod-fish was given, than in most other cases in our experiments—and, at the same time, a full average productiveness in gross increase of that food. But, confining ourselves just now to the question of the proportion of the food consumed to the weight of the animal as it fattens, we find, looking a little more in detail to the figures in Table XVI., that small as was the decrease in consumption in either pens 1 or 2, yet it was greater in pen 2, where the non-nitrogenous Indian meal alone constituted the complementary food, than where, as in pen 1, it was mixed with a quantity of Bran. We have a similar result, more clearly brought out, in comparing pens 4 and 5; the decrease in the rate of consumption to a given weight of animal

as the experiment proceeded, being much greater in pen 5, where Barley-meal was given alone as the ad libitum food, than in pen 4, where it was mixed with Bran.

The progressive rate of *productiveness* of a given weight of food in this Third Series (see Table XVI., Division 2) is very variable, and does not show anything like regularity of gradation. The increase obtained for a given weight of food during the whole period was, however, generally good in this Series. In pen 2 it was about as high as in any case in the three Series; and we may readily suppose, that the mixture of Cod-fish and Indian-meal given in this pen 2, would supply more digestible assimilable matter in a given weight of the food, than that in any other pen in the three Series of experiments.

Upon the whole then, the experiments show very strikingly, the rapid *decrease in the rate of consumption of food to a given weight of animal as it fattens*. The fact of such a decrease is, we believe, pretty currently admitted, though we presume that the extent of it will appear from these Tables to be much greater than is generally supposed. At the same time it is seen, that although there is this great decrease in the amount of food consumed to a given weight of animal as it matures, yet that the *productiveness*—at least in *gross* increase in live weight—of a given amount of food, is much more nearly constant throughout the fattening process. It has, however, been observed, that there is perhaps a greater tendency to an increased rate of productiveness of the food in gross increase as the animal matures, the greater, within certain limits, the proportion of the more *non*-nitrogenous constituents of the food. At any rate it is undoubted, that it was under these circumstances of a larger proportion of the non-nitrogenous constituents, that the decrease in the rate of *consumption—indicating maturity*—was by far the most rapid. And, in reference to this point it may be interesting here to observe, that it appears from an extensive series of experiments which we have made with a view of determining the probable composition of the *gross* increase in weight of the fattening animal, that the nearer it approaches to maturity the greater will be the proportion of *fat* in the gross increase obtained—and also, that the greater the proportion of fat, the greater is the proportion in the gross increase of *real dry substance*. It appears, therefore, from the results, that not only is the amount of food required to a given weight of animal, the more diminished as it fattens—the more within certain limits the food contains of the *non*-nitrogenous constituents—but likewise, that it is these more *non*-nitrogenous foods that seem to give any indication of an increased rate of productiveness in *real dry increase* as the fattening process proceeds.

It will be observed, that in our remarks upon Tables XIV., XV., and XVI., we have almost confined our attention to the

question of the *progressive* rate of the consumption, and of the productiveness, of food during the fattening process—and to the influence which the character of the foods—as generally known apart from the evidence of direct chemical analysis—may be supposed to have had, on this *progression*. The actual relationship of consumption, and of increase, to the various constituents of the food, will be more clearly brought out in Tables which will shortly follow. But, before introducing this part of the subject, it will be well to subjoin statements, both of the per centage composition of the foods employed, and of the actual quantities of the various constituents consumed, with the amounts of increase which they have yielded.

In Tables XVII. and XVIII., which now follow, we have a summary statement of the per centage composition of the foods employed in the three Series of experiments.

Table XVII.

(Experiments with Pigs.—Series I.-III.)

Summary of the Percentages of *Dry Matter, Ash, Nitrogen*, and *Fatty Matter*, in the Foods employed in the 1st Series of Experiments with Pigs.

Description.	Percentage Results.							
	Dry Matter.		Ash.		Nitrogen.		Fatty Matter.	
	Inclusive of Ash.	Organic Only.	In Fresh Substance.	In Dry Matter.	In Fresh Substance.	In Dry Matter.	In Fresh Substance.	In Dry Matter.
Egyptian beans .	88·30	83·57	4·73	5·35	4·24	4·80	2·29	2·60
Lentils, Lot 1 . .	87·30	82 43	4·87	5·58	4·52	5·18	2·23	2·55
Lentils, Lot 2 . .	86·62	81·64	4·98	5·75	4·56	5·26	2·21	2·55
Indian corn meal, Lot 1 . . .	89·70	88·33	1·37	1·53	1·72	1·92	5·10	5·68
Indian corn meal, Lot 2 . . .	89·89	88·62	1·28	1·42	1·95	2·17	5·59	6·22
Bran	84·79	78·77	6·02	7·10	2·61	3·08	4·92	5·80

Table XVIII.

(Experiments with Pigs.—Series II.-III.)

Summary of the Percentage Composition of the Foods.

Egyptian beans .	88·17	84·45	3·72	4·22	4·21	4·78	2·20	2·50
Lentils, Lot 1 . .	89·42	86·44	2·98	3·33	4·54	5·08	2·25	2·52
Do. 2 . .	89·97	85·10	4·87	5·41	4·18	4·65	1·35	1·50
Barley, Lot 1 . .	82·38	80·19	2·19	2 66	1·82	2·21	2·34	2·84
Do. 2 . .	80·95	78·77	2·18	2·69	1·83	2·26	2·33	2·88
Do. 3 . .	82·53	80·48	2·05	2·48	1·55	1·88	1·41	1·71
Bran	85·08	78·67	6·41	7·53	2·62	3·08	4·98	5·85
Dried Newfoundland cod-fish	59·26	40·60	18·66	31·49	6·60	11·13	0·90	1·52

The figures in these Tables (XVII. and XVIII.), are in all cases the means of two or more determinations agreeing well with each other. The dry matter is determined by drying in a water-bath at 212°. The ash, by burning on platinum trays, in cast-iron muffles arranged specially for that process. The per-centages of ash, as given in the Table, are, however, generally too high, as, to secure a fair sample, the whole bulk of the food was well mixed together; and, from this, somewhat large samples were taken in the first instance, from which it was impossible to remove all adventitious matters, and especially so when the samples were taken from the bulk in the state of meal. The nitrogen determinations were made by combustion with soda lime, and estimated as the double platinum salt. The fatty matter is that yielded by extraction with ether.

It is seen, that the Indian-corn and Barley-meal contained less than 2 per cent. of nitrogen; the Bran about $2\frac{3}{4}$ per cent.; the Beans and Lentils about $4\frac{1}{2}$ per cent.; and the dried Cod-fish about $6\frac{1}{2}$ per cent.

Of fatty matter, on the other hand, the dried Cod-fish contains less than 1 per cent; the Beans and Lentils only about $2\frac{1}{4}$ per cent.; the Barley-meal about the same quantity; and the Indian-corn and Bran, each about 5 per cent.

These Tables of the *per-centage* composition of the foods, are employed in the construction of all the Tables which will now follow.

In Tables XIX., XX., and XXI. there are given, for the three Series respectively—the total amount of increase in live weight obtained *in each pen*; also the total amounts consumed—of each of the different foods in the fresh state as weighed out to the pigs—and of the dry organic matter—of the mineral matter—of the nitrogen—and of the fatty matter, which those amounts of fresh food contained; also a summary of the same particulars for several of the pens classed together, as well as for all the pens of each Series, respectively.

TABLE XIX.

(EXPERIMENTS WITH PIGS.—SERIES I.)

Showing the Total amounts of Gross Food or Constituents consumed, and of Increase produced, during the Total Period of the experiment.

Nos. of Pen	Total Increase of 3 Pigs during 8 Weeks.	Description of the Foods.	Total Fresh Food consumed.	Total Dry Organic Matter consumed.	Total Mineral Matter consumed.	Total Nitrogen consumed.	Total Fatty Matter consumed.
	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.
1	303	Bean meal	756	632	35·74	32 06	17 36
		Lentil meal	756	620	37·34	34·34	16·73
		Total	1512	1252	73·08	66·40	34·09
2	336	Indian meal	336	297	4·41	6·26	18·16
		Bean meal	624	521	29·48	26·44	14·32
		Lentil meal	624	511	30·80	28·34	13·82
		Total	1584	1329	64·69	61·04	46·30
3	200	Bran	336	265	20·23	8·77	16·53
		Bean meal	484	404	22·89	20·50	11·10
		Lentil meal	484	397	23·82	21·96	10·72
		Total	1304	1066	66·94	51·23	38·35
4	252	Indian meal	336	297	4·40	6·25	18·16
		Bran	336	265	20·23	8·77	16·52
		Bean meal	378	316	17·88	16·04	8·68
		Lentil meal	378	311	18·63	17·17	8·39
		Total	1428	1189	61·14	48·23	51·75
5	221	Indian meal	1086	961	14·33	20·03	58·23
6	298	Bean meal	168	140	7·93	7·12	3·85
		Lentil meal	168	138	8·27	7·61	3·71
		Indian meal	1065	942	14·06	19·62	57·05
		Total	1401	1220	30 26	34·35	64·61
7	309	Bran	336	265	20·23	8·77	16·53
		Indian meal	1063	941	13·94	19·81	57·44
		Total	1399	1206	34·17	28·58	73·97
8	347	Bran	336	265	20·23	8·77	16·53
		Bean meal	168	140	7·93	7·12	3·85
		Lentil meal	168	138	8·27	7·61	3·71
		Indian meal	884	782	11·56	16·55	47·93
		Total	1556	1325	47·99	40·05	72·02

TABLE XIX.—EXPERIMENTS WITH PIGS.—SERIES I.—*continued.*

Nos. of Pen.	Total Increase of 3 Pigs during 8 Weeks.	Description of the Foods.	Total Fresh Food consumed.	Total Dry Organic Matter consumed.	Total Mineral Matter consumed.	Total Nitrogen consumed.	Total Fatty Matter consumed.
	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.
9	100	Bean meal	231	193	10·91	9·78	5·30
		Lentil meal	231	189	11·39	10·48	5·10
		Bran	431	339	25·95	11·25	21·19
		Total	893	721	48·25	31·51	31·59
10	114	Indian meal	462	409	6·03	8 66	25·10
		Bran	566	446	34·07	14·77	27·83
		Total	1028	855	40·10	23·43	52·93
11	178	Bean meal	168	140	7·93	7·12	3·85
		Lentil meal	168	138	8·27	7·61	3·71
		Indian meal	336	297	4·41	6·25	18·16
		Bran	431	339	25·90	11·25	21·19
		Total	1103	914	46·51	32·23	46·91
12	256	Bean meal	342	286	16·18	14·51	7·85
		Lentil meal	342	282	16·78	15·52	7·60
		Indian meal	616	545	8·07	11·50	33·30
		Bran	71	56	4·27	1·85	3·49
		Total	1371	1169	45·30	43·38	52·24

Summary of Classes of Pens.

Class I. Pens 1-4.	1091	Bran	672	530	40·46	17·54	33·06
		Indian meal	672	594	8·81	12·51	36·32
		Bean meal	2242	1873	105·99	95·04	51·46
		Lentil meal	2242	1839	110·59	101·81	49·66
		Total	5828	4836	265·85	226·90	170·50
Class II. Pens 5-8.	1175	Bran	672	530	40·46	17·54	33·06
		Bean meal	336	280	15·86	14·24	7·70
		Lentil meal	336	276	16·54	15·22	7·42
		Indian meal	4098	3626	53·89	76·01	220·65
		Total	5442	4712	126·75	123·01	268·83
Class III Pens 9 to 11.	392	Bean meal	399	333	18·84	16·90	9·15
		Lentil meal	399	327	19·66	18·09	8·81
		Indian meal	798	706	10·44	14·91	43·26
		Bran	1428	1124	85·92	37·27	70·21
		Total	3024	2490	134·86	87·17	131·43
All Pens	2914	Bean meal	3319	2772	156·87	140·69	76·16
		Lentil meal	3319	2724	163·57	150·64	73·49
		Indian meal	6184	5471	81·21	114·93	333·53
		Bran	2843	2240	171·11	74·20	139·82
		Total	15.665	13,207	572·76	480·46	623·00

TABLE XX.

(EXPERIMENTS WITH PIGS.—SERIES II.)

Showing the Total Amounts of Gross Food or Constituents consumed, and of Increase produced, during the Total period of the Experiment.

Nos. of Pen.	Total Increase of 8 Pigs during 8 Weeks.	Description of the Foods.	Total Fresh Food consumed.	Total Dry Organic Matter consumed.	Total Mineral Matter consumed.	Total Nitrogen consumed.	Total Fatty Matter consumed.
	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.
1	195	Bean meal. .	528	446	19·66	22·25	11·64
		Lentil meal .	528	453	20·78	22·80	8·93
		Total .	1056	899	40·44	45·05	20·57
2	284	Bean meal .	619	523	23·07	26·11	13·65
		Lentil meal .	619	530	26·39	26·63	10·17
		Barley meal .	504	400	11·00	9·21	11·76
		Total .	1742	1453	60·46	61·95	35·58
3	242	Bean meal .	633	535	23·59	26·70	13·96
		Lentil meal .	633	542	27·03	27·22	10·36
		Bran . . .	168	132	10·76	4·40	8·36
		Total .	1434	1209	61·38	58·32	32·68
4	240	Bean meal .	397	335	14·78	16·73	8·75
		Lentil meal .	397	340	16·50	17·14	6·71
		Barley meal .	504	400	11·00	9·21	11·76
		Bran . . .	168	132	10·76	4·40	8·36
		Total .	1466	1207	53·04	47·48	35·58
5	291	Barley meal .	1643	1306	35·64	29·50	35·97
		Total .	1643	1306	35·64	29·50	35·97
6	251	Bean meal .	231	195	8·60	9·73	5·09
		Lentil meal .	231	198	9·47	10·00	3·97
		Barley meal .	907	720	19·80	16·55	21·11
		Total .	1369	1113	37·87	36·28	30·17

TABLE XX.—(EXPERIMENTS WITH PIGS.—SERIES II.)—*continued.*

Nos. of Pen.	Total Increase of 8 Pigs during 8 Weeks.	Description of the Foods.	Total Fresh Food consumed.	Total Dry Organic Matter consumed.	Total Mineral Matter consumed.	Total Nitrogen consumed.	Total Fatty Matter consumed.
	lbs.		lbs.	lbs.	lbs.	lbs.	lbs.
7	277	Barley meal .	1383	1100	29·96	24·77	30·60
		Bran . . .	168	132	10·76	4·40	8·36
		Total .	1551	1232	40·72	29·17	38·96
8	187	Bean meal .	189	160	7·04	7·96	4·16
		Lentil meal .	189	162	7·61	8·20	3·31
		Barley meal .	600	478	13·03	10·82	13·55
		Bran . . .	126	99	8·07	3·30	6·27
		Total .	1104	899	35·75	30·28	27·29
9	253	Bean meal .	369	311	13·73	15·54	8·13
		Lentil meal .	369	317	13·66	16·06	6·55
		Barley meal .	492	391	10·70	8·92	11·28
		Bran . . .	246	193	15·76	6·44	12·24
		Total .	1476	1212	53·85	46·96	38·20
10	283	Bean meal .	389	329	14·50	16·41	8·58
		Lentil meal .	389	333	16·13	16·83	6·61
		Barley meal .	519	413	11·25	9·30	11·49
		Bran . . .	260	204	16·64	6·80	12·92
		Total .	1557	1279	58·52	49·34	39·60
11	310	Bean meal .	260	219	9·68	10·95	5·73
		Lentil meal .	260	222	10·76	11·23	4·41
		Barley meal .	779	619	16·98	14·16	17·93
		Bran . . .	260	204	16·65	6·81	12·93
		Total .	1559	1264	54·07	43·15	41·00
12	307	Bean meal. .	257	217	9·56	10·82	5·66
		Lentil meal .	257	220	10·62	11·10	4·36
		Barley meal .	770	613	16·70	13·81	17·11
		Bran . . .	257	202	16·46	6·73	12·78
		Total .	1541	1252	53·34	42·46	39·91

These Tables of the actual amounts of the increase in live weight produced, and of the fresh food or its constituents consumed, furnish a complete account of the chemical statistics of the experiments, and provide a basis for any further calculations; and it is only as serving these purposes, that we have given them in detail in these Tables. We shall find, indeed, that the influence of the composition of the food, upon its consumption, and its productiveness, will be more clearly brought out in the Tables which next follow (XXII., XXIII., XXIV., XXV., XXVI., and XXVII.), in which the actual results of Tables XIX., XX., and XXI. are brought by calculation, to a more convenient and uniform standard of comparison.

We have also endeavoured to arrange some of the more important indications of these six Tables (XXII.-XXVII, inclusive), in the form of *Diagrams;* which, with the necessary explanations, will be found at the end of the Paper; and, it is thought, that a careful inspection of them, will materially facilitate a clear conception of the general bearing of the results. A glance even at the Diagrams will show, how very much greater is the variation in the proportion of the *Nitrogenous* constituents consumed in the different pens by a given weight of animal within a given time, or which is required to produce a given amount of increase, than is that of the *Non*-nitrogenous, or of the Total Organic substance.

TABLE XXII.

(EXPERIMENTS WITH PIGS.—SERIES I.)

Division I.—Showing the *Average Weekly Consumption per* 100 lbs. *Live Weight of Animal*—of Fresh Food—of Gross Dry Matter—of Mineral Matter—of Nitrogen—and of Fatty Matter. Results calculated from direct Experimental Determinations. (Quantities stated in lbs., tenths, &c.)

Pen	Pigs	Description of Limited Food.	Description of Ad Libitum Food.	Fresh Food consumed.			Gross Dry Matter consumed.			Mineral Matter consumed.			Nitrogen consumed.			Fatty Matter consumed.		
				Limited Food.	Ad Libitum Food.	Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limitod Food.	In Ad Libitum Food.	In Total Food.
1	3	None	Bean & lentil meal	–	32·0	32·0	-	28·0	28·0	-	1·54	1·54	-	1·40	1·40	-	0·72	0·72
2	3	Indian meal	Ditto	7·1	26·4	33·5	6·4	22·9	29·3	0·09	1·28	1·37	0·13	1·16	1·29	0·38	0·60	0·98
3	3	Bran	Ditto	8·0	23·2	31·2	6·8	20·3	27·1	0·48	1·12	1·60	0·21	1·01	1·22	0·40	0·52	0·92
4	3	Indian meal & bran	Ditto	15·2	17·1	32·3	13·2	15·0	28·2	0·56	0·82	1·38	0·34	0·75	1·09	0·78	0·39	1·17
5	3	None	Indian meal	–	25·1	25·1	-	22·5	22·5	-	0·33	0·33	-	0·46	0·46	-	1·34	1·34
6	3	Bean & lentil meal	Ditto	7·1	22·4	29·5	6·2	20·1	26·3	0·34	0·30	0·64	0·31	0·41	0·72	0·16	1·20	1·36
7	3	Bran	Ditto	7·4	23·3	30·7	6·2	20·9	27·1	0·44	0·31	0·75	0·19	0·43	0·62	0·36	1·16	1·52
8	3	{Bean and lentil meal and bran}	Ditto	13·9	18·2	32·1	11·9	16·4	28·3	0·75	0·24	0·99	0·48	0·34	0·82	0·50	1·04	1·54
9	3	Bean & lentil meal	Bran	12·1	11·3	23·4	10·6	9·5	20·1	0·58	0·68	1·26	0·53	0·29	0·82	0·27	0·55	0·82
10	3	Indian meal	Ditto	12·2	14·9	27·1	11·0	12·7	23·7	0·16	0·90	1·06	0·23	0·39	0·62	0·66	0·73	1·39
11	3	{Bean and lentil meal & Indian meal}	Ditto	16·4	10·5	26·9	14·5	8·9	23·4	0·88	0·63	1·51	0·51	0·27	0·78	0·63	0·54	1·17
12	3	None	{Bean and lentil meal, Indian meal and bran, each ad libitum}	-	30·8	30·8	-	27·2	27·2	-	1·02	1·02	-	0·97	0·97	-	1·17	1·17
Mean of the 12 Pens				8·3	21·2	29·5	7·2	18·7	25·9	0·36	0·76	1·12	0·24	0·66	0·90	0 34	0·83	1·17

TABLE XXII.—*continued.*

(EXPERIMENTS WITH PIGS.—SERIES I.)

Division II.—Showing the *Average Weekly Consumption per* 100 lbs. *Live Weight of Animal*—of Dry Organic Matter—of Nitrogenous Substance—of Total *Non*-Nitrogenous Substance—of Non-Nitrogenous Substance not Fat—and of Fatty Matter. Results calculated from Division I. (Quantities stated in lbs., tenths, &c.)

Pen	Pigs	Description of Limited Food.	Description of Ad Libitum Food.	Dry *Organic* Matter consumed.			Nitrogenous Substance consumed.			Total *Non*-Nitrogenous Substance consumed.			*Non*-Nitrogenous Substance not fat consumed.			Fatty Matter consumed.		
				In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.
1	3	None	Bean & lentil meal	-	26·47	26·47	-	8·84	8·84	-	17·63	17·63	-	16·91	16·91	-	0·72	0·72
2	3	Indian meal	Ditto	6·30	21·65	27·95	0·83	7·30	8·13	5·47	14·35	19·82	5·08	13·75	18·83	0·38	0·60	0·98
3	3	Bran	Ditto	6·34	19·19	25·53	1·32	6·39	7·71	5·01	12·80	17·81	4·62	12·28	16·90	0·40	0·52	0·92
4	3	Indian meal & bran	Ditto	12·70	14·17	26·87	2·14	4·73	6·87	10·56	9·44	20·00	9·78	9·05	18·83	0·78	0·39	1·17
5	3	None	Indian meal	-	22·18	22·18	-	2·91	2·91	-	19·27	19·27	-	17·92	17·92	-	1·34	1·34
6	3	Bean & lentil meal	Ditto	5·85	19·84	25·69	1·95	2·60	4·55	3·90	17·23	21·13	3·74	16·03	19·77	0·16	1·20	1·36
7	3	Bran	Ditto	5·81	20·65	26·46	1·21	2·74	3·95	4·60	17·91	22·51	4·24	16·75	20·98	0·36	1·16	1·52
8	3	Bean and lentil meal and bran	Ditto	11·20	16·15	27·35	3·05	2·15	5·20	8·15	14·00	22·15	7·65	12·96	20·61	0·50	1·04	1·54
9	3	Bean & lentil meal	Bran	10·00	8·88	18·88	3·34	1·85	5·19	6·66	7·03	13·69	6·39	6·47	12·86	0·27	0·55	0·82
10	3	Indian meal	Ditto	10·80	11·78	22·58	1·44	2·46	3·90	9·36	9·32	18·68	8·70	8·59	17·29	0·66	0·73	1·39
11	3	Bean and lentil meal & Indian meal	Ditto	13·66	8·29	21·95	3·23	1·73	4·96	10·44	6·56	17·00	9·81	6·01	15·82	0·63	0·54	1·17
12	3	None	Bean and lentil meal, Indian meal, and bran, each ad libitum	-	26·23	26·23	-	6·12	6·12	-	20·10	20·10	-	18·93	18·93	-	1·17	1·17
Mean of the 12 Pens				6·89	17·95	24·84	1·54	4·15	5·69	5·35	13·30	19·15	5·00	12·97	17·97	0·34	0·83	1·17

TABLE XXIII.

(EXPERIMENTS WITH PIGS.—SERIES II.)

Division I.—Showing the *Average Weekly Consumption per* 100 lbs. *Live Weight of Animal*—of Fresh Food—of Gross Dry Matter—of Mineral Matter—of Nitrogen—and of Fatty Matter. Results calculated from direct Experimental Determinations. (Quantities stated in lbs., tenths, &c.)

Pen	Pigs	Description of Limited Food.	Description of Ad Libitum Food.	Fresh Food consumed.			Gross Dry Matter consumed.			Mineral Matter consumed.			Nitrogen consumed.			Fatty Matter consumed.		
				Limited Food.	Ad Libitum Food.	Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.
1	3	None	Bean & lentil meal	-	24·9	24·9	-	22·2	22·2	-	0·95	0·95	-	1·06	1·06	-	0·48	0·48
2	3	Barley meal	Ditto	10·7	26·3	37·0	8·7	23·4	32·1	0·22	1·05	1·27	0·20	1·12	1·32	0·25	0·51	0·76
3	3	Bran	Ditto	4·0	30·1	34·1	3·4	26·8	30·2	0·26	1·20	1·46	0·10	1·28	1·38	0·20	0·58	0·78
4	3	Barley meal & bran	Ditto	15·2	18·0	33·2	12·6	16·0	28·6	0·49	0·71	1·20	0·31	0·77	1·08	0·46	0·35	0·81
5	3	None	Barley meal	-	34·6	34·6	-	28·3	28·3	-	0·75	0·75	-	0·62	0·62	-	0·76	0·76
6	3	Bean & lentil meal	Ditto	10·4	20·5	30·9	9·3	16·7	26·0	0·41	0·45	0·86	0·45	0·37	0·82	0·20	0·48	0·68
7	3	Bran	Ditto	3·7	30·6	34·3	3·2	25·0	28·2	0·24	0·66	0·90	0·10	0·55	0·65	0·18	0·68	0·86
8	3	Bean and lentil meal and bran	Ditto	12·3	14·6	26·9	10·8	11·9	22·7	0·55	0·32	0·87	0·47	0·26	0·73	0·33	0·33	0·66
9	3	None	Mixture of 1 part bran, 2 parts barley meal, and 3 parts bean and lentil meal	-	33·1	33·1	-	28·4	28·4	-	1·21	1·21	-	1·05	1·05	-	0·86	0·86
10	3	None	Duplicate of Pen 9	-	35·2	35·2	-	30·3	30·3	-	1·32	1·32	-	1·12	1·12	-	0·90	0·90
11	3	None	Mixture of 1 part bran, 2 parts bean and lentil meal, and 3 parts barley meal.	-	33·6	33·6	-	28·4	28·4	-	1·16	1·16	-	0·93	0·93	-	0·88	0·88
12	3	None	Duplicate of Pen 11	-	34·7	34·7	-	29·4	29·4	-	1·20	1·20	-	0·95	0·95	-	0·90	0·90
Mean of the 12 Pens				4·7	28·0	32·7	4·0	23·9	27·9	0·18	0·91	1·09	0·13	0·84	0·97	0·13	0·64	0·77

TABLE XXIII.—*continued.*

(EXPERIMENTS WITH PIGS.—SERIES II.)

Division II.—Showing the *Average Weekly Consumption per* 100 lbs. *Live Weight of Animal*—of Dry Organic Matter—of Nitrogenous Substance—of Total *Non*-Nitrogenous Substance—of Non-Nitrogenous Substance not Fat—and of Fatty Matter. Results calculated from Division I. (Quantities stated in lbs., tenths, &c.)

Pen	Pigs.	Description of Limited Food.	Description of Ad Libitum Food.	Dry *Organic* Matter consumed.			Nitrogenous Substance consumed			Total *Non*-Nitrogenous Substance consumed.			*Non*-Nitrogenous Substance not Fat consumed			Fatty Matter consumed.		
				In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.
1	3	None	Bean & lentil meal	—	21·21	21·21	—	6·69	6·69	—	14·51	14·51	—	14·03	14·03	—	0·48	0·48
2	3	Barley-meal . .	Ditto	8·51	22·39	30·90	1·23	7·06	8·29	7·28	15·33	22·61	7·03	14·82	21·85	0·25	0·51	0·76
3	3	Bran	Ditto	3·14	25·59	28·73	0·66	8·07	8·73	2·48	17·52	20·00	2·28	16·94	19·22	0·20	0·58	0·78
4	3	Barley-meal & bran	Ditto	12·07	15·31	27·38	1·95	4·85	6·80	10·12	10·46	20·58	9·66	10·11	19·17	0·46	0·35	0·81
5	3	None	Barley-meal . .	—	27·51	27·51	—	3·91	3·91	—	23·60	23·60	—	22·84	22·84	—	0·76	0·76
6	3	Bean & lentil meal	Ditto	8·87	16·26	25·13	2·81	2·36	5·17	6·06	13·91	19·97	5·86	13·43	19·29	0·20	0·48	0·68
7	3	Bran	Ditto	2·92	24·36	27·28	0·61	3·45	4·06	2·31	20·90	23·21	2·13	20·22	22·35	0·18	0·68	0·86
8	3	{Bean and lentil meal and bran}	Ditto	10·23	11·62	21·85	2·98	1·66	4·64	7·25	9·97	17·22	6·92	9·64	16·56	0·33	0·33	0·66
9	3	None	Mixture of 1 part bran, 2 parts barley meal, and 3 parts bean and lentil meal.	—	27·24	27·24	—	6·65	6·65	—	20·59	20·59	—	19·73	19·73	—	0·86	0·86
10	3	None	Duplicate of Pen 9	—	28·96	28·96	—	7·03	7·03	—	21·92	21·92	—	21·02	21·02	—	0·90	0·90
11	3	None	Mixture of 1 part bran, 2 parts bean and lentil meal, and 3 parts barley meal.	—	27·26	27·26	—	5·86	5·86	—	21·41	21·41	—	20·53	20·53	—	0·88	0·88
12	3	None	Duplicate of Pen 11	—	28·17	28·17	—	6·02	6·02	—	22·15	22·15	—	21·25	21·25	—	0·90	0·90
		Mean of the 12 Pens		3·81	22·99	26·80	0·85	5·30	6·15	2·96	17·69	20·65	2·82	17·05	19·87	1·13	0·64	0·77

TABLE XXIV.

(EXPERIMENTS WITH PIGS.—SERIES III.)

Division I.—Showing the *Average Weekly Consumption per* 100 lbs. *Live Weight of Animal*—of Fresh Food—of Gross Dry Matter—of Mineral Matter—of Nitrogen—and of Fatty Matter. Results calculated from direct Experimental Determinations. (Quantities stated in lbs., tenths, &c.)

Pen.	Pigs.	Description of Limited Food.	Description of Ad Libitum Food.	Fresh Food consumed.			Gross Dry Matter consumed.			Mineral Matter consumed.			Nitrogen consumed.			Fatty Matter consumed.		
				Limited Food.	Ad Libitum Food.	Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.
1	4	Cod-fish .	{Bran&Indian meal (equal parts) . .}	4·8	23·8	28·6	2·9	20·8	23·7	0·91	0·87	1·78	0·32	0·54	0·86	0·04	1·23	1·27
2	4	Ditto . .	Indian meal .	4·6	21·5	26·1	2·7	19·4	22·1	0·85	0·28	1·13	0·30	0·40	0·70	0·04	1·17	1·21
3	4	None . .	{Cod-fish . .}	—	4·4	32·3	—	2·6	27·0	—	0·82	1·84	—	0·29	0·92	—	0·04	1·49
			{Bran&Indian meal (equal parts) . .}	—	27·9		—	24·4		—	1·02		—	0·63		—	1·45	
		Means		3·1	25·9	29·0	1·9	22·4	24·3	0·59	0·99	1·58	0·21	0·62	0·83	0·03	1·29	1·32
4	4	Cod-fish	{Mixture of 2 parts barley-meal, and 1 part bran . .}	4·5	31·7	36·2	2·7	26·2	28·9	0·84	1·14	1·98	0·30	0·66	0·96	0·04	1·01	1·05
5	4	Ditto . .	Barley-meal . .	4·3	35·3	39·6	2·5	30·5	33·0	0·80	0·77	1·57	0·28	0·64	0·92	0·04	0·82	0·86
		Means . . .		4·4	33·5	37·9	2·6	28·4	31·0	0·82	0·95	1·77	0·29	0·65	0·94	0·04	0·91	0·95
		Means of the 5 Pens . . .		3·6	29·0	32·6	2·2	24·8	27·0	0·68	0·98	1·66	0·24	0·63	0·87	0·03	1·14	1·17

TABLE XXIV.—*continued.*

(EXPERIMENTS WITH PIGS.—SERIES III.)

Division II.—Showing the *Average Weekly Consumption per* 100 lbs. *Live Weight of Animal*—of Dry Organic Matter—of Nitrogenous Substance—of Total *Non*-Nitrogenous Substance—of Non-Nitrogenous Substance not Fat—and of Fatty Matter. Results calculated from Division I. (Quantities stated in lbs., tenths, &c.)

Pen.	Pigs.	Description of Limited Food.	Description of Ad Libitum Food.	Dry *Organic* Matter consumed.			Nitrogenous Substance consumed.			Total *Non*-Nitrogenous Substance consumed.			*Non*-Nitrogenous Substance not fat consumed.			Fatty Matter consumed.		
				In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.
1	4	Cod-fish	Bran&Indian meal (equal parts)	1·97	19·91	21·88	1·92	3·38	5·30	0·04	16·54	16·58	0·00	15·30	15·30	0·04	1·23	1·27
2	4	Ditto	Indian meal	1·86	19·08	20·94	1·82	2·54	4·36	0·04	16·54	16·58	0·00	15·37	15·37	0·04	1·17	1·21
3	4	None	Cod-fish	—	1·79	25·18	—	1·75	5·71	—	0·04	19·47	—	0·00	17·97	—	0·04	1·49
			Bran&Indian meal (equal parts)	—	23·39		—	3·96		—	19·43		—	17·97		—	1·45	
Means				1·28	21·39	22·67	1·25	3·88	5·13	0·03	17·52	17·55	0·00	16·21	16·21	0·03	1·29	1·32
4	4	Cod-fish	Mixture of 2 parts barley-meal, and 1 part bran	1·86	25·06	26·92	1·80	4·16	5·95	0·06	20·90	20·96	0·02	19·89	19·91	0·04	1·01	1·05
5	4	Ditto	Barley-meal	1·70	29·73	31·43	1·71	4·05	5·76	0·04	25·68	25·72	0·00	24·86	24·86	0·04	0·82	0·86
Means				1·78	27·46	29·17	1·75	4·11	5·86	0·05	23·29	23·34	0·00	22·37	22·37	0·04	0·91	0·95
Means of the 5 Pens				1·48	23·79	25·27	1·45	3·97	5·42	0·04	19·82	19·86	0·004	18·68	18·68	0·03	1·14	1·17

TABLE XXV.

(EXPERIMENTS WITH PIGS.—SERIES I.)

Division I.—Showing the Average Consumption *to produce* 100 lbs. *Increase in Live Weight*—of Fresh Food—of Gross Dry Matter—of Mineral Matter—of Nitrogen—and of Fatty Matter. Results calculated from direct Experimental Determinations. (Quantities stated in lbs., tenths, &c.)

Pen.	Pigs.	Description of Limited Food.	Description of Ad Libitum Food.	Fresh Food consumed.			Gross Dry Matter consumed.			Mineral Matter consumed.			Nitrogen consumed.			Fatty Matter consumed.		
				Limited Food.	Ad Libitum Food.	Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.
1	3	None	Bean & lentil meal	—	499	499	—	437	437	—	24·12	24·12	—	21·91	21·91	—	11·25	11·25
2	3	Indian meal	Ditto	100	371	471	90	322	412	1·31	19·93	19·24	1·86	16 28	18·14	5·41	8·37	13·78
3	3	Bran	Ditto	168	484	652	142	424	566	10·09	23·31	33·40	4·38	21·20	25·58	8·26	10·91	19·17
4	3	Indian meal & bran	Ditto	267	300	567	233	263	496	7·75	14·48	24·23	5·96	13·18	19·14	13·76	6·77	20·53
5	3	None	Indian meal	—	491	491	—	441	441	—	6·48	6·48	—	9·06	9·06	—	26·35	26·35
6	3	Bean & lentil meal	Ditto	113	357	470	99	321	420	5·44	4·72	10·16	4·94	6·58	11·52	2·54	19·14	21·68
7	3	Bran	Ditto	109	344	453	92	309	401	6·53	4·51	11·04	2·84	6·41	9·25	5·35	17·15	22·50
8	3	Bean and lentil meal, and bran	Ditto	194	255	449	167	229	396	10·48	3·33	13·81	6·77	4·77	11·54	6·94	14·48	21·42
9	3	Bean & lentil meal	Bran	462	431	893	405	365	770	22·20	25·90	48·10	20·26	11·25	31·51	10·40	21·19	31·59
10	3	Indian meal	Ditto	405	496	901	364	421	785	5·29	29·90	35·19	7·60	12·96	20·56	2·20	24·41	26·61
11	3	Bean and lentil meal, & Indian meal	Ditto	377	242	619	335	205	540	20·31	14·55	34·86	11·79	6·32	18·11	14·44	11·90	26·34
12	3	None	Bean and lentil meal, Indian meal and bran, each ad libitum	—	536	536	—	474	474	—	17·72	17·72	—	16·93	16·93	—	20·40	20·40
Mean of the 12 Pens				183	400	583	160	351	511	7·62	15·58	23·20	5·53	12·24	17·77	5·77	16·03	21·80

TABLE XXV.—*continued.*

(EXPERIMENTS WITH PIGS.—SERIES I.)

Division II.—Showing the Average Consumption *to produce* 100 lbs. *Increase in Live Weight*—of Dry Organic Matter—of Nitrogenous Substance—of Total *Non*-Nitrogenous Substance—of Non-Nitrogenous Substance not Fat—and of Fatty Matter. Results calculated from Division I. (Quantities stated in lbs., tenths, &c.)

Pen.	Pigs.	Description of Limited Food.	Description of Ad Libitum Food.	Dry *Organic* Matter consumed.			Nitrogenous Substance consumed.			Total *Non*-Nitrogenous Matter consumed.			*Non*-Nitrogenous Matter not fat consumed.			Fatty Matter consumed.		
				In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.
1	3	None	Bean & lentil meal	—	413·3	413·3	—	138·0	138·0	—	275·3	275·3	—	264·0	264·0	—	11·25	11·25
2	3	Indian meal	Ditto	88·5	304·1	392·6	11·7	102·6	114·3	76·8	201·5	278·3	71·4	193·2	264·6	5·41	8·37	13·78
3	3	Bran	Ditto	132·3	400·7	533·0	27·6	133·6	161·2	104·7	267·1	371·8	96·5	256·2	252·7	8·26	10·91	19·17
4	3	Indian meal & bran	Ditto	222·9	248·7	471·6	37·5	83·0	120·5	185·4	165·7	351·1	171·6	158·9	330·5	13·76	6·77	20·53
5	3	None	Indian meal	—	434·8	434·8	—	57·1	57·1	—	377·7	377·7	—	351·4	351·4	—	26·35	26·35
6	3	Bean & lentil meal	Ditto	93·3	316·2	409·5	31·1	41·4	72·5	62·2	274·7	336·9	59·7	255·6	315·3	2·54	19·14	21·68
7	3	Bran	Ditto	85·6	304·5	390·1	17·9	40·4	58·3	67·7	264·1	331·8	62·4	247·0	309·4	5·35	17·15	22·50
8	3	Bean and lentil meal, and bran	Ditto	156·4	225·5	381·9	42·6	30·0	72·6	113·8	195·4	309·2	106·8	181·0	287·8	6·94	14·48	21·42
9	3	Bean & lentil meal	Bran	382·4	339·5	721·9	127·6	70·9	198·5	254·8	268·6	523·4	244·4	247·4	491·8	10·40	21·19	31·59
10	3	Indian meal	Ditto	358·6	391·0	749·6	47·9	81·6	129·5	310·7	309·4	620·1	308·5	274·9	583·4	2·20	24·41	26·61
11	3	Bean and lentil meal, & Indian meal	Ditto	314·5	190·7	505·2	74·3	39·8	114·1	240·2	150·9	391·1	252·8	139·0	391·8	14·44	11·90	26·34
12	3	None	Bean and lentil meal, Indian meal and bran, each ad libitum	—	456·5	456·5	—	106·7	106·7	—	349·8	349·8	—	329·4	329·4	—	20·40	20·40
		Mean of the 12 Pens		152·9	335·4	488·3	34·8	77·1	111·9	118·0	258·3	376·3	114·5	241·5	356·0	5·77	16·03	21·80

TABLE XXVI.

(EXPERIMENTS WITH PIGS.—SERIES II.)

Division I.—Showing the Average Consumption *to produce* 100 lbs. *Increase in Live Weight*—of Fresh Food—of Gross Dry Matter—of Mineral Matter—of Nitrogen—and of Fatty Matter. Results calculated from direct Experimental Determinations. (Quantities stated in lbs., tenths, &c.)

Pen.	Pigs.	Description of Limited Food.	Description of Ad Libitum Food.	Fresh Food consumed.			Gross Dry Matter consumed.			Mineral Matter consumed.			Nitrogen consumed.			Fatty Matter consumed.		
				Limited Food.	Ad Libitum Food.	Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.
1	3	None	Bean & lentil meal	—	544	544	—	484	484	—	20·84	20·84	—	23·22	23·22	—	10·55	10·55
2	3	Barley meal	Ditto	177	436	613	145	388	533	3·87	17·39	21·26	3·24	18·57	21·81	4·14	8·39	12·53
3	3	Bran	Ditto	69	523	592	59	466	525	4·45	20·92	25·37	1·82	22·28	24·10	3·45	10·05	13·50
4	3	Barley meal & bran	Ditto	280	331	611	231	294	525	9·07	13·03	22·10	5·67	14·11	19·78	8·38	6·44	14·82
5	3	None	Barley-meal	—	565	565	—	461	461	—	12·25	12·25	—	10·14	10·14	—	12·36	12·36
6	3	Bean & lentil meal	Ditto	184	361	545	164	295	459	7·20	7·89	15·09	7·87	6·59	14·46	3·61	8·41	12·02
7	3	Bran	Ditto	61	499	560	52	408	460	3·88	10·82	14·70	1·59	8·94	10·53	3·02	11·05	14·07
8	3	Bean and lentil meal and bran	Ditto	265	316	581	233	258	491	11·96	6·86	18·82	10·24	5·69	15·93	7·35	7·25	14·60
9	3	None	Mixture of 1 part bran, 2 parts barley meal, and 3 parts bean and lentil meal.	—	583	583	—	501	501	—	21·28	21·28	—	18·56	18·56	—	15·10	15·10
10	3	None	Duplicate of Pen 9	—	550	550	—	473	473	—	20·68	20·68	—	17·42	17·42	—	14·00	14·00
11	3	None	Mixture of 1 part bran, 2 parts bean and lentil meal, and 3 parts barley meal.	—	503	503	—	425	425	—	17·44	17·44	—	13·92	13·92	—	13·22	13·22
12	3	None	Duplicate of Pen 11	—	502	502	—	425	425	—	17·37	17·37	—	13·83	13·83	—	13·00	13·00
		Mean of the 12 Pens		86	476	562	74	406	480	3·37	15·56	18·93	2·54	14·44	16·98	2·49	10·82	13·31

TABLE XXVII.—*continued.*

(EXPERIMENTS WITH PIGS.—SERIES III.)

Division II.—Showing the Average Consumption *to produce* 100 lbs. *Increase in Live Weight*—of Dry Organic Matter—of Nitrogenous Substance—of Total *Non*-Nitrogenous Substance—of Non-Nitrogenous Substance not Fat—and of Fatty Matter. Results calculated from Division I. (Quantities stated in lbs., tenths, &c.)

Pen.	Pigs.	Description of Limited Food.	Description of Ad Libitum Food.	Dry *Organic* Matter consumed.			Nitrogenous Substance consumed.			Total *Non*-Nitrogenous Matter consumed.			*Non*-Nitrogenous Matter not fat consumed.			Fatty Matter consumed.		
				In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.	In Limited Food.	In Ad Libitum Food.	In Total Food.
1	4	Cod-fish . .	Bran&Indian meal (equal parts) . .	38·7	391·4	430·1	37·8	66·3	104·1	0·9	325·1	326·0	0·0	300·8	300·8	0·86	24·27	25·13
2	4	Ditto . .	Indian meal . .	32·1	329·9	362·0	31·4	44·0	75·4	0·7	285·9	286·6	0·0	265·7	265·7	0·71	20·20	20·91
3	4	None . .	Cod-fish . . .	—	33·8	476·1	—	33·0	108·0	—	0·7	368·0	—	0.0	339·9	—	0·75	28·18
			Bran&Indian meal (equal parts) . .	—	442·3		—	75·0		—	367·3		—	339·9		—	27·43	
		Means		23·6	399·1	422·7	23·0	72·8	95·8	0·5	326·3	326·8	0·0	302·1	302·1	0·52	24·22	24·74
4	4	Cod-fish . .	Mixture of 2 parts barley-meal, and 1 part bran . .	30·2	413·4	443·6	29·5	68·5	98·0	0·7	344·9	345·6	0·0	328·2	328·2	0·67	16·65	17·32
5	4	Ditto . .	Barley-meal . .	24·2	412·4	436·6	23·6	56·2	79·8	0·6	356·2	356·8	0·0	344·9	344·9	0·54	11·33	11·87
		Means		27·2	412·9	440·1	26·5	62·4	88·9	0·6	350·5	351·1	0·0	336·5	336·5	0·60	13·99	14·59
		Means of the 5 Pens .		25·0	404·7	429·7	24·5	68·6	93·1	0·6	336·0	336·6	0·0	315·9	315·9	0·56	20·12	20·68

In Tables XXII., XXIII., XXIV., XXV., XXVI., and XXVII., we have then, for each Series, the actual facts of Tables XIX., XX., and XXI., reduced by calculation to one uniform standard of comparison. That is to say, we have in Tables XXII., XXIII.. and XXIV., * for the three Series respectively, the amounts of the fresh food, and of its various constituents, consumed *weekly per* 100 *lbs. live weight of animal* in each pen, instead of, as in the previous ones, the *actual quantity* of food, or of its constituents, consumed *per pen during the whole course of the experiment.* And again, we have, in Tables XXV., XXVI., and XXVII., † the amounts of the foods, or their constituents, consumed *to produce* 100 *lbs. increase in live weight*, instead of, the *actual amounts* consumed, *to produce the actual amount of increase obtained per pen.* We have in previous papers, when adopting these methods of representing the results of feeding experiments, explained the general principle upon which such Tables are calculated, and we shall not therefore repeat those explanations here. We may, however, a little further describe the plan of the Tables as they stand—as well as the materials whence some of their contents have been derived.

It will be seen, that each of the six Tables, whether relating to the amounts of food, &c., consumed weekly per 100 lbs. live weight of animal, or the amounts consumed to produce 100 lbs. gross increase in weight, is divided into two "Divisions." *Division* 1, in every case, gives what may be called the results of direct experiment—that is to say, the amounts of fresh food consumed, or of those constituents which are calculated directly from the quantities of the latter and the Tables of their per-centage composition, as determined by actual analysis. The constituents given in this Division 1, are—the *Fresh Food*, the *Gross dry matter*, the *Mineral matter*, the *Nitrogen*, and the *Fatty matter*. In Division 2, we have—the *Dry organic matter*, the *Nitrogenous substance*, the *Total non-nitrogenous substance*, the *Non-nitrogenous substance not Fat*, and with these (which, as will be readily understood, are derived by calculation from those in Division 1), the *Fatty matter* is repeated in this Division, for the convenience of comparison with them. The dry organic matter, is obtained by deducting the mineral matter from the gross dry substance—the nitrogenous substance, by multiplying the nitrogen by 6·3, on the assumption that it existed in the foods as protein compounds—a method which we think sufficiently accurate for our present purpose. The total non-nitrogenous substance, is obtained by deducting the nitrogenous substance from the dry organic matter—and the non-nitrogenous substance not fat, by deducting the fatty matter from the total non-nitrogenous substance.

* See also Diagram I.

† See also Diagram II.

Before considering the results themselves given in these Tables, it may be as well to say a few words on some of the questions of interest upon which, we think, they are calculated to afford some useful information.

Our readers are aware, that much attention has of late years been paid to the subject of the adaptation of food, according to its composition, to the various exigencies of the animal system. And, it will be admitted, that it is to the experiments and writings of MM. Boussingault, Liebig, and Dumas, that we must attribute, either directly or indirectly, much of the progress that has been made. These writers, as well as many others, whether themselves experimenters, or more systematic writers on the subject of the Chemistry of Food, seem with few exceptions, and with some limitations, to agree on two main points, namely—as to the relationship of the *nitrogenous* constituents of food, with the formation in the animal body of compounds containing nitrogen—and as to the general connection of the non-nitrogenous constituents with respiration and the deposition of animal fat. Founded more or less upon this broad classification of the constituents of food, according to their supposed varied offices in the animal economy, a vast number of analyses of foods have of late years been made; and from the results of these analyses, numerous Tables have been constructed, professing to arrange the current articles of diet, both of man and other animals, according to their comparative values as such. In attempting to apply to practice the more generally admitted facts to which we have referred, in the construction of Tables of the comparative values of foods according to their composition, it seems to have been generally assumed, that our current food-stuffs are thus measurable rather by their *flesh-forming* than by their more specially *respiratory* and *fat-forming* capacities. Hence, with some limitations, the percentage of nitrogen has always been taken as the standard of comparison.

Founded on their per-centages of nitrogen, M. Boussingault first arranged Tables of the comparative value of different articles of food, chiefly in reference to the dieting of the animals of the farm. And, in reference to the views and experiments of M. Boussingault on this subject, Baron Liebig, at p. 369 of the Third Edition of his Chemical Letters, makes the following observations:—"The admirable experiments of Boussingault prove, that the increase in the weight of the body in the fattening or feeding of stock (just as is the case with the supply of milk obtained from milch cows), is in proportion to the amount of plastic constituents in the daily supply of fodder." In like manner various specimens of flour and of bread have been arranged by Dr. R. D. Thomson; other articles of vegetable diet by Mr. Horsford; and a large series of aliments from the animal kingdom by MM. Schlossberger and Kemp. Dr. Anderson also,

in the Report of his elaborate investigation, on the Composition of Turnips, grown under different circumstances, and in different localities, has taken their per-centage of Nitrogen as the measure of their comparative feeding values.

It has been found, however, that the indications of Tables of the comparative values of foods, founded upon their per-centages of nitrogenous compounds, were frequently discrepant with those which common usage, or direct experiments on feeding, seem to give. These discrepancies have not escaped the attention of some of the authors of the theoretical Tables; but they have attributed them, rather to erroneous interpretations of common practice or experiment, than to any defect in the theoretical method of estimation. It has been admitted on all hands, however, that further direct experiment bearing upon this important question was much needed; and it was the acknowledgement of this necessity, and the fact that the further we proceeded with our own investigations, the more we became convinced that the current views on the subject required some modification—that led us to give a paper, "On the Composition of Food in relation to Respiration and the Feeding of Animals," at the meeting of the British Association held last year at Belfast. That paper is now in print as a "Report" in the annual volume of the Association. But, as in that medium it will probably come under the notice of few but scientific readers, we have been induced, in compliance with a wish expressed by Mr. Pusey, as the editor of this Journal, to embody in this article, so far as these experiments on Pigs illustrate them, some of the views of that paper, which may be of interest more particularly in their agricultural bearings.

Recurring to the question of the adopted views on the subject of the Chemistry of Food, to which we have called attention, we may observe, that in our paper on Sheep Feeding, in vol. 10, part 1, of this Journal, we ourselves had, to a certain extent, adopted the current opinion that the increase in weight in the fattening animal will bear a pretty direct relationship to the supply in the food of the nitrogenous or plastic elements of nutrition. At that time, however, we observed in our results, some marked exceptions to this rule; and we pointed out, that it seemed to apply only so long as the nitrogenous supplies in the food did not exceed a somewhat narrow limit, frequently reached in our current fattening food-stuffs—and beyond which, the proportion of increase obtained from a given amount of nitrogenous substance consumed seemed to be considerably diminished. In that paper, we also showed, that the amount of food consumed to a given weight of animal, within a given time, bore in the experiments then brought forward, a much closer relationship to the amounts in the food of the available non-nitrogenous constituents,

than to those of the nitrogenous ones. The results of the experiments with Pigs, as given in the six Tables now about to be considered, will be found fully to bear out the same conclusions which those on Sheep seemed to indicate—namely, that, as our current fattening food-stuffs go, both the amount consumed by a given weight of animal, within a given time, and that required to produce a given amount of increase, bear a much closer relationship to the amounts in the food, of the available *non*-nitrogenous constituents, than to those of the nitrogenous ones.

Turning now to the Tables themselves (XXII., XXIII., XXIV., XXV., XXVI., and XXVII.), we shall find, that the columns of total dry organic matter, of nitrogenous substance, and of total non-nitrogenous substance, as given in Division 2 of each of them will illustrate the points in question. A glance at the total columns for these three classes of constituents, throughout the Tables for the three Series as a whole, will show, that in all comparable cases, there is very much more of uniformity, in the columns of the *total organic matter*, or of the *total non-nitrogenous* substance, than in those of the *nitrogenous* substance—both in tables XXII., XXIII., and XXIV., which give the amounts consumed *weekly per* 100 *lbs. live weight of animal*, and in Tables XXV., XXVI., and XXVII., which give the amounts consumed *to produce* 100 *lbs. of increase.**

Some of the deviations from this general regularity in the amounts of non-nitrogenous, or of total organic substance consumed, clearly show when examined into, that the uniformity would be even more strict, if the amounts, only of the really digestible or available respiratory and fat-forming constituents could have been represented, instead of, as in these Tables, that of the *gross* or *total* organic or non-nitrogenous substance consumed; and this is more particularly the case in those Tables which show the amount consumed to produce a given weight of increase.

Thus, in reading the figures of the Tables, allowance has to be made, both for those of the non-nitrogenous constituents of the food, which would probably become at once effete, and also for the different respiratory and fat-forming *capacities*, so to speak, of those portions of the food which are digestible and available for the purposes of the animal economy. For, it will be remembered—that the Bran, which was given in such large quantities in some cases, contains a large quantity of indigestible and innutritious, and consequently effete woody fibre—that it must require as much as from twice to thrice as much of the starchy series of compounds, as of the fatty

* See also the Diagrams.

ones, to afford the same equivalent of respiratory and fat-forming material—and again, that the nitrogenous constituents, if they took any part in these processes, would have also their own special equivalent or capacity, in these respects. Further, it should be borne in mind, that even after all due allowance has been made for those various sources of discrepancy in the actual figures of the Tables to which we have referred, the amounts which we may suppose to be thus corrected, would still include all those variations—whether arising from differences of external circumstances—from individual peculiarities in the animals themselves—from the different amounts stored up as increase according to the adaptation of the foods—or from the many other uncontrollable circumstances, which must always interfere with any attempt to bring within the range of accurate numerical measurement, the results of those processes, in which the subtle principle of animal life exerts its influence.

Bearing then those points in mind, which must tend to modify the indications of the actual figures in the Tables, it will appear, we think, that the coincidences in the amounts of available respiratory and fat-forming constituents, consumed by a given weight of animal within a given time, or to produce a given amount of gross increase, are much more strikingly shown throughout the numerous results represented in these Tables, than *à priori* we could have expected to find them. With this general uniformity, however, as to the amounts of non-nitrogenous substance, consumed under given circumstances, or to produce a given result, those of the nitrogenous constituents are found to vary in the proportion of from *one* to *two*, or even *three*; very much more indeed, than is consistent with the idea that the supply of these had regulated either the amounts of food consumed, or of increase produced. There may, indeed, be some individual discrepancy in the figures, not easily accounted for by any of the circumstances to which we have referred; and which might perhaps appear to lead to opposite conclusions to those which we would draw from the Tables as a whole. But, we think it will be much more reasonable to attempt to explain—or, considering the nature of the subject, even to admit as inexplicable—a few discrepant cases, than to reject on their account, the general testimony of much more numerous, consistent, and otherwise sufficiently conclusive results.

Looking first to Table XXII, which gives the amounts consumed *weekly per* 100 *lbs. live weight in Series* I., we find, that there is a generally less amount of the *non*-nitrogenous constituents consumed in the first set of four pens than in the second. This somewhat less amount of non-nitrogenous constituents consumed per 100 lbs. live weight per week in the first set, is, how-

ever, more than compensated by the amount of nitrogenous matter consumed; and there is, with this larger amount of nitrogenous matter in the food, upon the whole a somewhat larger amount of total organic substance consumed in the first set of four pens than in the second. If we now look down these columns, either of total dry organic matter, or of non-nitrogenous substance, and exclude, as we may, pens 9, 10, and 11 (in which there was given the excessive amounts of bran, and the foods could not be considered as of fattening quality), we cannot fail to see, a very close uniformity in the amounts consumed of both these classes of constituents throughout the nine pens. Thus, taking first the non-nitrogenous substance, the range throughout these nine comparable pens is between the two extremes of 17½ lbs. and 22½ lbs. Again, in the column of total organic substance, the range in these nine pens is from 22 lbs. to nearly 28 lbs.; but among eight of them, it is only from 24½ lbs. to not quite 28 lbs. The column of nitrogenous substance, on the other hand, shows a range in the amount of weekly consumption per 100 lbs. live weight of animal, in these nine pens, of from 2·9 lbs. in pen 5, to 8·8 lbs. in pen 1. The range of difference, therefore, in the amounts of nitrogenous substance consumed, instead of being, as with the other two constituents, in the highest only about 25 per cent. above the lowest, is more than 200 per cent.

Turning now to Table XXIII, which gives the same particulars for the Second Series of experiments, owing to the generally better balance of the constituents of the foods throughout this Series, we need not exclude any of the 12 pens from our comparison. Looking first at the column of total *non*-nitrogenous substance (see Division 2), we find the range of weekly consumption per 100 lbs. live weight of animal, to be from 14½ lbs. to 23½ lbs. This is, it is true, a considerably greater range in the amounts of non-nitrogenous matter consumed, than in the pens we compared in Series 1. If, however, we were to exclude pens 1 and 8 from the comparison in this Second Series, we should find, that the amounts of non-nitrogenous matter consumed in the remaining ten pens range only from 19·9 lbs., or say 20 lbs., to 23½ lbs.; and again, the range in the amounts of the total organic substance, consumed in these ten pens, is only from about 25 lbs. to 31 lbs. The difference in the amounts of nitrogenous matter consumed, however, is from 3·9 lbs. to 8·7 lbs.—the highest being therefore, more than 120 per cent. above the lowest.

Comparing the Second Series with the First, the amounts of non-nitrogenous substance consumed weekly per 100 lbs. live weight, are more uniform throughout the former than the latter. They are, however, rather higher in the Second Series with the

Barley-meal, than in the first with the Indian corn. But, if we refer to the columns of fatty matter for the two Series respectively, we see, that there is always a somewhat larger amount consumed of this substance, with its high respiratory and fat-forming capacity, in the food of the First Series, than in that of the Second; and, the due allowance for this, would in several cases make the differences in the amounts of non-nitrogenous matter consumed in the two Series, even somewhat more inconsiderable.

In the Third Series (see Division 2, Table XXIV.), we have the range in the non-nitrogenous matter consumed, from about 16½ lbs. to about 25½ lbs.; and in the total dry organic substance, from about 21 lbs. to about 31½ lbs. On the other hand, in this Series, with the highly nitrogenous Cod-fish, we have, in the amounts of nitrogenous matter consumed, a very small range throughout these five pens compared with that in the other Series—it being only from 4·3 lbs. to 5·9 lbs. We shall see presently, however, that although there was in this Third Series, a less range in the amounts of nitrogenous substance consumed weekly per 100 lbs. live weight, than in those either of the pure non-nitrogenous, or of the total organic constituents—yet, there was, in the amounts consumed *to produce a given weight of increase* in this Series, a wider range in the column of nitrogenous than in that of the other constituents.

Throughout these experiments, then—in which the animals were allowed to fix for themselves the limit of their consumption, according to the composition of the foods within their reach—we have, as shown in the Tables XXII., XXIII., and XXIV., a very striking coincidence in the amounts of pure non-nitrogenous, or of total dry organic matter, consumed weekly for 100 lbs. live weight of animal; and, with the slight exception in Series 3, a very much greater diversity in the amount of the *nitrogenous* constituents so consumed. There are, indeed, some exceptions to the regularity in the amounts of non-nitrogenous, and of gross organic substance consumed; most of which are found, however, on examination, to prove no exceptions to the conclusion—that, other things being equal, it was the respiratory and fat-forming exigencies of the animals, and not the supplies of the nitrogenous substances in the food, that regulated the amounts of it consumed. Thus, in Series 1., we have in pens 9, 10, and 11, a generally less amount of non-nitrogenous and total organic substance, but especially of the latter consumed to a given weight of animal, than in the other pens. But, the difference in the amounts of these substances available for the purposes of the animal economy, in these pens as compared with the rest, is in fact much greater than the figures in the table seem to indicate; for, it will be remembered, that in these a very large proportion of the food was Bran, containing

a very large percentage of bulky and innutritious woody fibre, which appears to have put a limit to consumption, scarcely beyond the point required for the mere maintenance of the respiratory process; and, in these three pens, the animals gave scarcely half as much increase for a given amount of gross food consumed as the average of the Series. Hence, as is obvious, the amounts consumed weekly per 100 lbs. live weight, as given in the Table, include but a small amount devoted to the purposes of increase; and represent, therefore, besides that which was only innutritious woody fibre, little more than was demanded by the respiratory requirements of the animal. There was, it is true, in pen 5, a comparatively small amount of total organic matter consumed per 100 lbs. of live weight; but a reference to the columns of nitrogenous and of non-nitrogenous substances respectively, will show, that the deficiency in this case was rather in that of the amount of the nitrogenous, than of the non-nitrogenous constituents. It must be remembered too, that the food in this pen 5, which was Indian meal exclusively, would possess a higher respiratory and fat-forming capacity, than that in any other pen in the Series—and, unlike pens 9, 10, and 11, a very small amount of innutritious woody fibre. Still, the amount of non-nitrogenous substance consumed weekly per 100 lbs. live weight, was comparatively small in this pen; but we shall presently find, that notwithstanding this comparatively small amount of the non-nitrogenous matter consumed to a given weight of animal within a given time, and also, that we had in this pen three well fattened pigs—yet, in fact, *in proportion to the amount of increase produced*, the amount of non-nitrogenous matter consumed, was as large here as in any case in the Series. In pens 1 and 3 again, we have a somewhat low amount of non-nitrogenous substance consumed, considering that there was in both pens a good rate of increase. In both these pens, however, the amounts of nitrogenous substance consumed were very high; and, owing to this, the amounts of total organic matter consumed are also somewhat high. It would appear, therefore, that in these cases, the somewhat small amounts of non-nitrogenous substance consumed were compensated by the larger amounts of nitrogenous substance. Part of the larger amounts of the non-nitrogenous substances taken in the other pens, would seem therefore to have been substituted, in these cases, by the nitrogenous substances.

In Series II. there are very few notable exceptions to the rule of regularity in the amounts of non-nitrogenous, or total organic matter, consumed by a given weight of animal within a given time. There is, however, certainly one such exception; which, indeed, might seem to lead to very opposite conclusions to those which

we have formed from the experiments as a whole. Thus, in Pen 1 of Series II., with Beans and Lentils as the only food—which contained a larger proportion of the nitrogenous constituents than any of the other dietaries of the Series—we have little more than two-thirds as much of non-nitrogenous substance, and only four-fifths as much total dry organic matter consumed as the average of the Series. In this pen, however, a larger amount of total dry organic substance, was consumed *to produce a given amount of gross increase*, than in many of the pens in the Series where the proportion it contained of nitrogenous substance was very much less. And, when we further consider, that with an excessive proportion of nitrogenous substance in the food of the fattening pig, we have found there was more of a tendency to grow in frame and flesh than in other cases—and again, that the larger the proportion of flesh in the increase, the less will be the proportion in it of real dry substance—it will be seen, that if there were a smaller amount of food consumed, there would also at the same time, be a smaller amount of increase produced by it—especially of that formed from the non-nitrogenous constituents of the food, and which would contain the largest proportion of real dry substance. Hence there would be, though a small amount of non-nitrogenous constituents consumed, a larger proportion of them available for the respiratory process. This apparent exception, is not then necessarily adverse to the view, that the respiratory process was the gauge of consumption.

In Series III. again, where we have, in Pens 1 and 2, a comparatively small amount of non-nitrogenous matter consumed, the food consisted, in a large proportion, of the highly nitrogenous Cod-fish; and in both of these cases, we had not only a very good proportion of increase to food consumed, but the pigs in these pens were very fat and well ripened; and hence, a large proportion of their increase would be real dry substance. It is then, again when the proportion of nitrogenous constituents in the food was large, that a small amount both of non-nitrogenous substance and of gross dry organic matter, seemed to have sufficed for the wants of the animal. This result is in itself interesting; and it may perhaps point to a comparatively greater efficiency in the already animalized protein compounds supplied in the Cod-fish, than in those derived, as in the other cases, from the purely vegetable diets. Whether or not there may be any truth in such an explanation of the great efficiency of this highly nitrogenous food, we presume that this result with the unusual, or at least only very locally adopted food, of *fish*, can scarcely be taken as contradicting the indications of the natural requirements of the fattening pig, such as we have found them to be so consistently brought out, in so large a series of experiments, in which he was fed upon his more usual and appropriate food.

Reviewing then, as a whole, the results of these Three Series of experiments with Pigs, and carefully considering the bearing of the various circumstances which must influence our reading of the actual figures of the Tables relating to them—we think it cannot be doubted, that here, as we have already shown in the case of our Sheep experiments, the evidence is very clear, that it is the *non*-nitrogenous rather than the *nitrogenous* constituents of the foods, that have been the gauge of, or fixed the limit to—*consumption*.

We now come to the question of the relationship respectively, of the nitrogenous and of the non-nitrogenous constituents of the food, to the amount of *increase in live weight* obtained in the fattening Pig. This point is illustrated in Tables XXV., XXVI., and XXVII., which give the amounts of fresh food, or of its various constituents, which were consumed to *produce* 100 *lbs. increase in live weight of animal.** In considering these Tables, we must of course, as before, read the indications of the actual figures, as modified by the obviously different *capacities* for the purposes of the animal economy, of the substances the amounts of which they in each case represent. We must remember too, that as in the Tables showing the relationship of *consumption* to *respiration*, the figures included also the amounts which served to increase the weight of the animal—so now, in these Tables professing to show the relationship of the *increase* to the *constituents consumed*, the figures at the same time include the amounts which have been expended in the respiratory process. And further, we should recall to mind the fact, that even the increase itself, will represent different amounts of total dry or of *non*-nitrogenous substance, expended to produce it, according to the amounts respectively, of fat or of flesh, which it may contain.

If we cast the eye down the columns of non-nitrogenous substance consumed, and more particularly those of the total organic matter, in these Tables (see Division 2, Tables XXV., XXVI., and XXVII.), we see, with but few exceptions, a very strikingly close coincidence in the amounts of these, required *to produce* 100 *lbs. gross increase* throughout these three Series of experiments with Pigs. Some of the exceptions, such as those where a large quantity of Bran was used, are at once explained by a consideration of the more obvious qualities of that food; and some of the minor differences, by that of the different respiratory and fat-forming capacities of those portions of the foods which would be digestible and available for the purposes of the animal economy. Turning now to the adjoining columns in these Tables, those of the *nitrogenous* substance consumed to produce a given weight of increase throughout these three Series, we find the amount of it as strikingly various as that of the non-nitrogenous

* See also Diagram II.

matter had been otherwise; and certainly, in no way consistent with the view, that the increase of the fattening animal bears any direct relationship to the supplies in its food of the nitrogenous or plastic constituents.

Taking the results of each Series separately;—we may first call attention to Table XXV., which refers to the first Series of 12 pens. If we again exclude pens 9, 10, and 11 from the comparison—and certainly the foods in those pens could not be called fattening foods—we see, that amongst the other nine, the amounts of non-nitrogenous substance consumed to produce 100 lbs. increase in live weight, ranged from 275½ lbs. to 377½ lbs.; and that in seven of the pens the range was only from 309 lbs. to 377½ lbs. In pens 1 and 2, where the food contained so large a proportion of nitrogenous substance, we see that the amounts of non-nitrogenous substance consumed to produce a given amount of increase, was indeed comparatively very small. But, if we look to the column of *total* dry organic matter, we shall find that the amount of this required to produce a given amount of increase was greater in these two pens than in several cases in the Series where the food contained little more than half as much nitrogenous substance. The large proportions of nitrogenous substance in the foods of pens 1 and 2, would seem, therefore, not to have really economised material in the production of gross increase—but only to have *substituted* an even somewhat smaller amount of non-nitrogenous constituents in that process; whilst, as we have said, there is reason to believe, that a given amount of increase obtained from the more non-nitrogenous diets, contains more fat, and with this a larger proportion of real dry substance.

Again, if we look down the column of total dry organic substance consumed to produce a given amount of increase, we find, that the range for the nine pens is from 382 lbs. in pen 8, to 533 lbs. in pen 3; but of this comparatively large amount of total organic substance consumed in pen 3, to produce 100 lbs. of increase, a larger proportion was nitrogenous substance than in any other case of the nine pens. In this pen too, with this very large amount of *nitrogenous* substance, consumed *to produce a given amount of increase*, there was indeed the minimum amount in the Series of *non*-nitrogenous substance, consumed *weekly per* 100 *lbs. live weight*. Hence, it would seem, that the pigs had been pushed to the consumption of a larger amount of nitrogenous substance than they required, or could turn to any useful account, in order to secure a sufficiency of the *non*-nitrogenous substances, which existed in the food in such comparatively small proportion.

Again, in the pen in which there was the next largest amount of total organic substance, consumed to produce a given amount

of increase, namely, pen 4, the food contained both Bran and a very large proportion of the highly nitrogenous Bean and Lentil meal. There is, indeed, throughout this Series, scarcely an instance of deviation from the regularity in the amounts of non-nitrogenous or dry organic substance, consumed to produce a given amount of increase, which is not so accounted for by the character of the food, or by the known progress of the animals, as consistently to indicate a very close relationship between the available *non*-nitrogenous constituents of the food and the increase of the so-called "*fattening*" animal. In the column of the amounts of *nitrogenous* constituents, consumed to produce a given weight of increase, we have, however, no indication whatever of any direct numerical relationship of the one to the other. In one of the pens which we have excluded from our calculation —since the food in it could not be considered of good fattening quality—there was indeed three and a half times as much nitrogenous substance, consumed to produce a given amount of increase, as in one or two of the other pens. But, excluding as before, pens 9, 10, and 11, from the estimate, we even then find that the range in the amounts of nitrogenous substance, consumed to produce 100 lbs. of increase, is from 57 lbs., as in pen 5, or 58¼ lbs., as in pen 7, to 138 lbs., as in pen 1, and even to 161 lbs., as in pen 3. We have, then, among the nine pens with fattening foods, a variation in the quantities of nitrogenous substance, consumed to produce a given amount of increase, in the proportion of from 1 to nearly 3.

In the First Series then, taking the nine pens, we have, even in the actual figures of the Table (XXV.), a very much closer relationship between the increase produced, and the amounts consumed—of non-nitrogenous, or total organic—than of nitrogenous substance. Whilst, as we have pointed out, the variations in the amounts of the non-nitrogenous substance consumed are generally such as to show, even more clearly, that, beyond a narrow limit of nitrogenous supply, the proportion of increase obtained to a given quantity of this consumed, is in a very rapidly decreasing ratio. There is evidence, however, in the results, that probably in one or two cases in the Series, the nitrogenous supply in the food was at the minimum, if not even somewhat below the amount best adapted as the food of the fattening pig.

Looking to the same points in Series II. (Table XXVI.), we see, that there is a very much closer relationship in the amounts of non-nitrogenous or total dry organic substance, consumed to produce a given amount of increase, than in Series I.; and there is at the same time, a variation in the amounts of nitrogenous substance consumed, but little less than in the nine pens of the

former Series. Thus, among the whole twelve pens, with their as many different dietaries, the range in the amounts of the non-nitrogenous matter, consumed to produce 100 lbs. of gross increase, is only from 317 lbs. to 385 lbs.; and, that of the total organic substance, from 408 lbs. to 511 lbs.; but, that of the nitrogenous substance, is from 64 lbs. to 152 lbs. In the non-nitrogenous, or total organic substance, required to produce a given amount of increase, the range of variation in the highest amount is, therefore, only about 25 per cent. above the lowest; but in the amounts of the nitrogenous substance, the range of the highest above the lowest is nearly 140 per cent. Looking to the figures a little more closely, we see, that in the second set of four pens in this Second Series, where the amount of nitrogenous substance in the food was on the average only about half as much as in the first set of four pens, there was at the same time, on the average, a little more non-nitrogenous substance, consumed to produce a given result. In these four pens of the second set, however—with their comparatively low amount of nitrogenous substance—we have an average of about 50 lbs. *less*, of total dry organic matter, consumed to produce 100 lbs. of increase, than in the pens 1 to 4, where it consisted in so much larger a proportion of nitrogenous substance. Nor, will any one practically acquainted with pig feeding doubt, that the pigs in pens 5 to 8, where the food consisted in such very large proportion of Barley-meal, would progress more favourably as to the quality of their increase, or, that they would contain a larger proportion of fat, and, consequently, more of dry substance, than those upon the chiefly Bean and Lentil dietaries of pens 1 to 4. The coincidence, too, in the amount of total dry organic matter, consumed to produce 100 lbs. of increase, in the four pens where the Barley-meal, with its low supply of nitrogenous substance predominated, is very striking; and especially in three of them, it being in these respectively 449 lbs., 443½ lbs., and 444¾ lbs.; and, it was in these three pens, that the supply of nitrogenous substance was about the lowest in the Series. Again, in three of the pens in the first set of four, with the nitrogenous substance generally double that of the three last alluded to, we have also nearly as close a coincidence in the amounts of total dry substance consumed; though, as we have before noticed, it was here about 50 lbs. more than in the former. Thus, the amounts consumed to produce 100 lbs. of increase in the three pens with the highly nitrogenous food, are respectively 511½ lbs., 499¾ lbs., and 503 lbs.; instead of, as in the three former, only about 345 lbs.

The fact, that a generally larger amount of total dry organic matter, is required to produce a given amount of increase, the

more beyond a certain narrow limit, this organic substance abounds in nitrogenous compounds, is again seen, on comparing the pens 9 and 10 of this Second Series, with pens 11 and 12. In pens 11 and 12, we have a larger proportion of Barley-meal, and less of Beans and Lentils, and therefore, less of nitrogenous substance consumed, than in pens 9 and 10; and with this larger proportion of nitrogenous substance in the food of pens 9 and 10, we have from 50 lbs. to 70 lbs, more of gross dry organic substance required to produce 100 lbs. of increase, than in the former. In pens 9 and 10, the food was the same in both cases. But the amounts of total organic substance consumed to produce 100 lbs. of increase, vary in the two from 452 lbs. to 479 lbs. In pens 11 and 12, again, the foods were also duplicates. They contained, as we have said, less nitrogenous substance than those of pens 9 and 10; and we have in them, the lowest amounts of total organic substance, consumed to produce a given amount of increase, of any in the Series; nor is there in these two cases, a variation of half a pound in the amount of total organic substance consumed to produce 100 lbs. of increase; it being in pen 11, 408·1 lbs., and in pen 12, 407·7 lbs.

Notwithstanding, however, the very clear indications which this Second Series affords, of the much closer connection between the amount of increase produced, and that of the non-nitrogenous or total organic substance of the food, than that of the nitrogenous constituents, it must not be overlooked, that it was in pen 1, where the proportion of nitrogenous substance in the food was higher than in any other pen, that we have even a slightly less amount of *non*-nitrogenous substance, consumed to produce a given amount of increase, than in any other case in the Series. The amount of *total organic substance*, consumed for the same result in this pen 1, was, however, somewhat greater than the average of the twelve pens, and greater also than in six of the individual pens, in several of which the amount of nitrogenous substance was only about half as great as in this pen 1. It would seem, therefore, that this large proportion of nitrogenous substance in the food of pen 1, had yielded a comparatively low rate of gross increase; whilst this increase, the result of the highly-nitrogenous diet, would probably consist in a less proportion of solid fat, and, therefore, in a less proportion also, of real dry substance.

The results of Series II., then, very clearly show, the very close connection, between the amount of increase produced and the supply in the food of the non-nitrogenous constituents, or of total organic substance—independently of its nitrogen, when this exceeds a somewhat narrow limit; and again, as in Series I., that the amount of *nitrogenous* substance, on the other hand, consumed

to produce a given amount of gross increase, may vary very greatly, the range being, in fact, in this Series II., in the proportion of from 1 to nearly 2¼.

Turning now to a consideration of the same particulars for the Third Series, as given in Table XXVII.—it will be remembered, that the food in this Series contained a large amount of the highly nitrogenous Cod-fish; and also, that in this Series there was, in the *weekly consumption by a given weight of animal*, a less range from the minimum, of either class of constituents, but especially of the nitrogenous ones, than in either of the other Series. In this Table XXVII., too, showing the amounts of constituents consumed in this Series, *to produce a given amount of increase*, we have also a less range in both classes of constituents than in the Series I. and II. Still, even here, the range in the amounts of nitrogenous substance, consumed to produce a given amount of increase, is somewhat greater, than that of either the pure non-nitrogenous, or the total organic substance. The smallest amounts, both of *non*-nitrogenous and of total organic substance, consumed to produce a given amount of increase, in this Series, are in pen 2; in which the amounts of the *nitrogenous* substance also was the least. And again, the *largest* amount of non-nitrogenous, or of total organic substance required, were in pen 3, where there was, at the same time, the largest supply of the nitrogenous substances. The smallest amount of total dry organic substance, required to produce a given amount of increase, *throughout the three Series* indeed, was in the pen 2 of this Third Series; and it was here, that the food contained a less proportion of indigestible effete matter, than in any other pen in the three Series; whilst, at the same time, it had a higher respiratory and fat-forming capacity, and a large proportion of previously animalized protein compounds. With the exception of this pen 2, in which the food was of such concentrated flesh-forming, fat-forming, and respiratory capacity, the amounts of non-nitrogenous and of total organic substance, consumed to produce a given amount of increase throughout the Third Series, agree very closely; and the amounts in this Series also correspond very closely with those in the Series I. and II. Whilst, however, in the four pens of Series III., now compared together, the amounts of non-nitrogenous, or of total organic substance, consumed to produce a given result, vary only about 10 per cent. in the highest above the lowest—those of the nitrogenous substance in the same pens, varied about 30 per cent.

Upon the whole, then, although the results of this Series, with the unusual food of Cod-fish, show less strikingly than those of the former ones, the closer connection of the non-nitrogenous, than of the nitrogenous constituents consumed, with the amount

of gross increase produced—yet still, so far as they go, they are consistent in their indications.

Reviewing, as a whole, the results of the Three Series of experiments with Pigs—if we consider, that it is the results obtained under the subtle agency of animal life, that we are seeking to measure and express in figures—and if we also bear in mind, the various sources of modification to which our actual figures must be submitted, in order to attain their true indications, we think it cannot be doubted, that beyond a limit, below which few of our current fattening Pig foods are found to go, it is rather their supplies of available *non*-nitrogenous constituents, than those of their nitrogenous ones, that measure, both the *amount consumed to a given weight of animal within a given time*, and *the increase in weight obtained*. This result with Pigs, is too, perfectly consistent with that obtained in our experiments with Sheep.

It will be noticed, that wherever the amount of nitrogenous constituents consumed, either by a given weight of the animal within a given time, or to produce a given amount of gross increase, was in these pig-feeding experiments comparatively large, it was where a large proportion of the Leguminous seeds was employed. Some writers who have taken the per centage of the nitrogenous compounds of food, as the measure of its feeding value, have recognised, and endeavoured to explain in various ways, the fact, that the records of feeding experiments, do not award to the Leguminous seeds, a feeding value in proportion to their richness in these compounds; and they have supposed, that it is the accepted deductions from the practical feeding experiments, and not the theoretical conclusions, that are in error.* Thus it has been objected against the teachings of such experiments—that the variations in the composition of foods of ostensibly the same description used in different cases, has not been determined; that the test has been the *gross* increase or loss in weight; that the increase may be only *fat* formed from starch, &c.; that loss in weight, if any, may be the result of activity, and not of defective diet; that the food in the different cases compared, has been employed in different states, that is, coarse or fine, raw or cooked; that the animals have been variously circumstanced as to temperature, exposure, and activity; that individual animals have very various tendencies to increase, and so on. Now, we believe, that not one of all these objections can vitiate the comparisons which we have made; unless indeed, in some degree, the one which refers to the difficulty of determining whether the *gross* increase obtained be composed chiefly of *fat* formed from the starch and oily series of compounds, or whether of *flesh*

* See Postscript at the end of the Paper.

from the nitrogenous ones. We believe, indeed, from direct experiments which we have made, that, in fact, the composition of our domestic animals generally—but especially that of the gross increase of the so-called "*fattening*" animals—consists of a much larger proportion of fat, and a much less one of nitrogenous compounds, than is usually supposed. The whole question of *Animal Composition*, however, as illustrated by the experiments referred to, we hope to treat of separately, on some other occasion. But, apart from the considerations involved in the question of the varying composition of the Increase, or from the fact that our own feeding experiments (which, so far as we are aware, are the largest comparable series bearing upon the point), afford testimony in the same direction, we think, that there is evidence of another kind, of the general correctness and truth of the indications of practical experiments which have thus been objected to. Thus, the comparative prices of the Leguminous seeds and the Cereal grains, may be taken as some condemnation of the measurement of their comparative feeding value, according to their percentage of nitrogenous constituents. In matters of this kind, indeed, especially when staple and generally-used articles of food are concerned, the *market* is one of our shrewdest judges.

While speaking of the comparative feeding values of the Leguminous seeds and the Cereal grains, we may here casually allude to some other points of much interest bearing upon this question, and which are suggested by a consideration of the general results of our feeding experiments, taken in connection with those on the manuring and growth of our Leguminous and Graminaceous corn and fodder crops.

As a general rule it may be said, that, weight for weight, the Leguminous seeds contain about twice as much of nitrogenous compounds as the Cereal grains. We have elsewhere stated, that, speaking generally, an acre of land, under equal circumstances of soil and season, will frequently yield twice or thrice as much nitrogenous constituents in a Leguminous crop, as in a Cereal grain; and again, that in the latter, an *increase* of produce is not obtained by the use of nitrogenous manures, except at the cost of more nitrogen so supplied in manure, than is contained in the increase thus produced. How is it, we would ask, if this be the case, and if really foods are valuable, at least for the fattening of stock, in proportion to their richness in nitrogenous constituents—how is it, we would ask, if this be the case, that according to the usual state of the market, we could obtain for a given sum about twice as much nitrogenous substance in the Leguminous seeds as in the Cereal grains?—or how is it, on the other hand, that the Leguminous crop does not, much more than is in fact the case, supersede the Cereal grain in the field, the

frequently found to give a very rapid increase. But pork so fed, is found to sink rapidly in the salting process, and to waste considerably when boiled. And, although the first batch of pigs so fed may fetch a good price, their character is at once detected, and the market closed against a second sale. On the other hand, when pigs are fattened upon the highly nitrogenized Leguminous seeds—peas being, however, if not an exception, at any rate much less objectionable than some others—the lean is said to be very hard, and the fat also to waste in cooking. And again, when fish, flesh, and some strong flavoured oleaginous matters are given, the pork is found to be rank in flavour, or otherwise disagreeably tainted. Common practice, indeed, has settled, that the Cereal grains with their low per centage of nitrogenous compounds, constitute in the long run the staple food of the fattening pig; and the whole of the results of the experiments detailed in this paper bear testimony in favour of the correctness of this decision. Considering, however, not only the price at which a given weight of Leguminous seeds can be purchased, compared with that of the Cereal grains, but also the increased value of the manure from the former, and their probably greater tendency to give increase in frame and flesh —it is obviously the interest of the farmer, to use the highly nitrogenous Leguminous seeds, and perhaps even refuse flesh and other such matters, if at command, during the earlier and more growing stages. But it is certain, that if a constant good market for the pork is to be secured, these must greatly diminish, or cease entirely, and the supply of barley-meal, or other Cereal grain, be substituted for them as the period of fattening proceeds.

But not only do the principles involved in these suggestions, apply to the fattening of pigs, but, *mutatis mutandis*, they are applicable also to the fattening of other animals for the butcher; though—since in the case of fattening oxen and sheep, the Leguminous seeds, or other highly nitrogenous foods, constitute but a small proportion of the total food consumed—any deleterious influence which an excess of them might have upon the quality of the flesh, is less likely to occur. Indeed, all our feeding results consistently show, that the theory which assigns to the different substances used as fattening foods, a value in proportion to their per centage of nitrogenous compounds, is fallacious. It is probably a consideration of the obviously vast importance of the functions exercised by the nitrogenous structures and fluids of the animal body, which has given rise, in the scientific mind, to the notion of the relatively higher value of foods according to their richness in nitrogenous constituents. The economical or commercial estimate, is, however, founded upon

very different principles; and simply takes cognizance of the relations of supply and demand. Thus, air, water, and other natural agents, from their vast importance in sustaining animal and vegetable life, have a high value in a physiological or scientific point of view; but, from the relations of supply and demand, they are of little accounted money value. And so it is with the nitrogenous compounds of food; the functions which they alone can fulfil in the animal body are of the utmost importance; but in relation to the demand for them, it would seem, that our current food stuffs are much more likely to be deficient in certain other elements. Indeed, it would be difficult adequately to account for the comparatively high commercial value of the foods which contain a comparatively large proportion of certain *non*-nitrogenous compounds, except by supposing, that these, compared with the nitrogenous ones, were in less abundance in relation to the demands of the animal system for them.

It is not indeed, only in our current *fattening foods*, that the amount of certain elaborated and digestible non-nitrogenous constituents, rather than that of the nitrogenous ones, chiefly determines their relative value; for, a careful consideration of many human dietaries has led us to similar conclusions. When we remember too, that in using sugar, we do so at the cost of the rejection of all the nitrogenous compounds of the sugar-cane—and, in addition, of heavy money charges—it would seem improbable that it would become an article of diet of such growing necessity in all ranks of society, if our own home-produced foods were chiefly deficient in the nitrogenous constituents. Again, in the much higher price of butter than cheese, and of those cheeses which contain a large proportion of butter than those which are richer in nitrogen, it would seem to be further illustrated, that the demands of the body in relation to the supplies within its reach, are measured more by the amounts in the food, of the non-nitrogenous, than of the nitrogenous constituents. It would perhaps not be difficult to trace the undue estimates which, from scientific considerations merely, have been made as to the relative value of nitrogen and of mineral substances in manures, to a source somewhat similar to that which has given to the nitrogenous compounds of food, such a high theoretical value. For, as it is the mutual relationship of supply and demand of the nitrogenous and non-nitrogenous constituents of food, which must chiefly determine their relative values—so it is the relationship of supply and demand of the nitrogenous and mineral constituents of manures, that must give to them also their respective comparative values.

In conclusion, whilst we must not be understood, as in any way depreciating the value of a somewhat liberal supply of the

feeding-shed, or even on the table? We have, it is true, much yet to learn, of those minor differences of composition, to which are due the greater or less adaptation to the instinctive wants of the system, of the various constituents of which our staple articles of food are made up. But we think, that in no considerations of this kind, could we seek an adequate solution of our question. On the other hand, we believe, that in the Leguminous seeds the due proportion of the nitrogenous to the non-nitrogenous constituents is not observed. If this be true, it is obvious, that in the use of the Leguminous seeds instead of the Cereal grains, more than is requisite of the nitrogenous constituents will be taken into the system, before the adequate supply be attained, of the *non*-nitrogenous or respiratory and fat-forming materials. Nor, as our markets go, would the relative prices of these seeds and grains be found to interfere with a somewhat lavish use and expenditure of nitrogenous compounds in the former.

In the facts which are here briefly stated, we have surely very curious and interesting matter for reflection; and we have brought to our view, a striking instance of the mutual adaptations which are everywhere traceable in the practical application of natural laws. Thus, we have said, that under given circumstances, the Leguminous crop will give a much larger acreage yield of nitrogen than the Cereal grain; and that an increase of produce of the latter is not obtained by the use of nitrogenous manures, except at the cost of more nitrogen in the manure than is contained in such increased produce; whilst, in point of fact, in the ordinary practice of rotation in this country, the growth of a Leguminous corn or fodder crop, with its high percentage and actual amount of nitrogen, is itself, frequently either the direct or indirect source of the nitrogenous manure by which the increased Cereal is obtained. And, again, this Cereal, obtained at the *cost* of, but with its lessened *produce* of—nitrogen, is found in practice to be, weight for weight, of equal, or of a more highly feeding value, than the more highly nitrogenized Leguminous product, which perhaps has been expended to produce it. It would thus appear, that the demands of the respiratory function, which have been seen more than any other to regulate the consumption of food, would, in point of fact, not be satisfied in the use of the Leguminous diet, unless by a consumption or expenditure of an amount of nitrogen beyond that which the due balance of the constituents of food would seem to require; whilst, on the other hand, in the use of the Cereal grain, its better proportion of the *non*-nitrogenous to the nitrogenous constituents, has only been attained, by the sacrifice of nitrogen expended in its growth. It would seem, then, that whether we would seek our supplies of food in the direct use of the highly

nitrogenous products, or in the better balanced diet of the Cereals—in either case the end is attained, only at the cost or expenditure of nitrogen; in the one case, by the consumption of a larger amount of it in the food, than the due balance of its constituents would seem to require; whilst, in the other, this due balance has not been attained, without the loss of nitrogen during growth. The claims of health and natural instinct generally, leave little doubt which alternative should be adopted, at least in the case of human food. It becomes us, therefore, to investigate and understand, the practical bearings of these curious and interesting facts; for, upon the principles they involve, depend much for their success, those fundamental practices of the farm—the feeding of our stock for their double produce of meat and manure, and the adaptation of our rotations.

Apart from considerations of a more general and extended bearing, we may conclude our observations, with a few words on the more direct application of the results of our experiments to the practice of Pig-feeding.

It has been seen, that the larger the proportion of nitrogenous compounds in the food, the greater was the tendency to increase in frame and flesh; but, that the *maturing* or *ripening* of the animal—in fact, its "*fattening*"—depended very much more on the amount in the food, of certain digestible non-nitrogenous constituents. It also appears, however, when the price at which the more highly nitrogenous pig foods could be purchased, is taken into account, that a given amount of gross increase could be obtained, at a less cost with some of the highly nitrogenous foods, than with the more expensive ones, which have an undoubted character of superiority as pork producers. Were we, indeed, merely to take into consideration the amount of *gross* increase obtained for a given amount of food, of a given money value, there is no doubt, that in addition to the roots, or wash, or other matters, which generally form a greater or less proportion of the food of the pig, it would be the most advantageous, to rely almost exclusively to the end of the fattening process, upon the highly nitrogenous foods, dried fish, or animal refuse, and the Leguminous seeds, beans, lentils, and the like; for, in their use, not only could a given amount of gross increase be obtained at a less cost, than by the use of the Cereal grains, but the manure—the value of which must never be lost sight of in calculating the economy of the feeding process—would be much richer in nitrogen than if the latter were employed.

Unfortunately, however, it is not only a large amount of *gross increase* that secures to the farmer a good profit upon his styes. When pigs are fed freely upon highly succulent food, such as cooked roots, the refuse of starch-works, and the like, they are

frequently found to give a very rapid increase. But pork so fed, is found to sink rapidly in the salting process, and to waste considerably when boiled. And, although the first batch of pigs so fed may fetch a good price, their character is at once detected, and the market closed against a second sale. On the other hand, when pigs are fattened upon the highly nitrogenized Leguminous seeds—peas being, however, if not an exception, at any rate much less objectionable than some others—the lean is said to be very hard, and the fat also to waste in cooking. And again, when fish, flesh, and some strong flavoured oleaginous matters are given, the pork is found to be rank in flavour, or otherwise disagreeably tainted. Common practice, indeed, has settled, that the Cereal grains with their low per centage of nitrogenous compounds, constitute in the long run the staple food of the fattening pig; and the whole of the results of the experiments detailed in this paper bear testimony in favour of the correctness of this decision. Considering, however, not only the price at which a given weight of Leguminous seeds can be purchased, compared with that of the Cereal grains, but also the increased value of the manure from the former, and their probably greater tendency to give increase in frame and flesh —it is obviously the interest of the farmer, to use the highly nitrogenous Leguminous seeds, and perhaps even refuse flesh and other such matters, if at command, during the earlier and more growing stages. But it is certain, that if a constant good market for the pork is to be secured, these must greatly diminish, or cease entirely, and the supply of barley-meal, or other Cereal grain, be substituted for them as the period of fattening proceeds.

But not only do the principles involved in these suggestions, apply to the fattening of pigs, but, *mutatis mutandis*, they are applicable also to the fattening of other animals for the butcher; though—since in the case of fattening oxen and sheep, the Leguminous seeds, or other highly nitrogenous foods, constitute but a small proportion of the total food consumed—any deleterious influence which an excess of them might have upon the quality of the flesh, is less likely to occur. Indeed, all our feeding results consistently show, that the theory which assigns to the different substances used as fattening foods, a value in proportion to their per centage of nitrogenous compounds, is fallacious. It is probably a consideration of the obviously vast importance of the functions exercised by the nitrogenous structures and fluids of the animal body, which has given rise, in the scientific mind, to the notion of the relatively higher value of foods according to their richness in nitrogenous constituents. The economical or commercial estimate, is, however, founded upon

very different principles; and simply takes cognizance of the relations of supply and demand. Thus, air, water, and other natural agents, from their vast importance in sustaining animal and vegetable life, have a high value in a physiological or scientific point of view; but, from the relations of supply and demand, they are of little accounted money value. And so it is with the nitrogenous compounds of food; the functions which they alone can fulfil in the animal body are of the utmost importance; but in relation to the demand for them, it would seem, that our current food stuffs are much more likely to be deficient in certain other elements. Indeed, it would be difficult adequately to account for the comparatively high commercial value of the foods which contain a comparatively large proportion of certain *non*-nitrogenous compounds, except by supposing, that these, compared with the nitrogenous ones, were in less abundance in relation to the demands of the animal system for them.

It is not indeed, only in our current *fattening foods*, that the amount of certain elaborated and digestible non-nitrogenous constituents, rather than that of the nitrogenous ones, chiefly determines their relative value; for, a careful consideration of many human dietaries has led us to similar conclusions. When we remember too, that in using sugar, we do so at the cost of the rejection of all the nitrogenous compounds of the sugar-cane—and, in addition, of heavy money charges—it would seem improbable that it would become an article of diet of such growing necessity in all ranks of society, if our own home-produced foods were chiefly deficient in the nitrogenous constituents. Again, in the much higher price of butter than cheese, and of those cheeses which contain a large proportion of butter than those which are richer in nitrogen, it would seem to be further illustrated, that the demands of the body in relation to the supplies within its reach, are measured more by the amounts in the food, of the non-nitrogenous, than of the nitrogenous constituents. It would perhaps not be difficult to trace the undue estimates which, from scientific considerations merely, have been made as to the relative value of nitrogen and of mineral substances in manures, to a source somewhat similar to that which has given to the nitrogenous compounds of food, such a high theoretical value. For, as it is the mutual relationship of supply and demand of the nitrogenous and non-nitrogenous constituents of food, which must chiefly determine their relative values—so it is the relationship of supply and demand of the nitrogenous and mineral constituents of manures, that must give to them also their respective comparative values.

In conclusion, whilst we must not be understood, as in any way depreciating the value of a somewhat liberal supply of the

nitrogenous constituents of food, we would at the same time repeat, that by the concurrent testimony of all our feeding experiments, we are led to believe, that on the prevailing views, too high a relative importance is attributed to them. We have thought, therefore, that it would conduce to further progress in this most important field of inquiry, if the current opinions on the subject were somewhat modified. So general indeed has been the adoption, both on the Continent and in this country, of opinions on this subject, for which we have been unable to discern a sufficient basis of facts, and which at the same time, seem to be at variance with the indications of direct experiment, that we suppose little apology will be needed, for entering at the length we have done, into questions, which—involving as they do, the very fundamental principles of scientific feeding—appeared to us, to be some of the most interesting and important lessons which our experiments were calculated to teach.

Postscript. December, 1853.—Since this Paper was in type, we have had the pleasure of intercourse on some of the points to which it relates, with both Professors Liebig and Boussingault, and we are glad to gather, that they would perhaps somewhat modify the opinions which have generally been attributed to them. M. Boussingault indeed, referred us to the last edition of his 'Economie Rurale' (Paris 1851), in which both the text and the tables relating to this subject of feeding, have, compared with the edition published some years ago in this country, undergone considerable alteration and enlargement. In this new edition, M. Boussingault has clearly pointed out, that the true source of the discrepancy between the practical and theoretical feeding equivalents of the Leguminous seeds, depends upon their relatively too small amount of respiratory to nitrogenous constituents. Yet, he still supposes, that the theoretical estimate (*i.e.*, according to the percentage of nitrogen), must be considered as entirely satisfactory, when only comparing together foods within the same description or class; the following being the classes he enumerates:—

"1. Hays and Straws."
"2. Roots and Tubers."
"3. Oleaginous Grains."
"4. The Cereal Grains, the Leguminous Seeds, Oilcakes."

But, it will be seen, that neither the facts, nor the opinions, given in this Paper, are in accordance with this Rule.

EXPLANATION OF THE DIAGRAMS.

DIAGRAM I.—Shows the *proportions*, respectively, of *Nitrogenous*, of *Non-nitrogenous*, and of *Total Organic substance*, consumed WEEKLY PER 100 LBS. LIVE WEIGHT OF ANIMAL, in the different pens throughout the Three Series of experiments with Pigs.*

Nitrogenous substance is represented by . . . . . Black.
Non-nitrogenous substance . . . . . Yellow.
Total organic substance . . . . . Red.

For each constituent, the lowest amount of it consumed in any pen throughout the Three Series (see Tables XXII., XXIII., XXIV.), is taken as = 100; and the proportions of it in each of the other pens, in relation to this minimum amount taken as 100, is calculated by Rule of Three.

EXAMPLE—Showing the calculations for the three columns of *Pen* 1, *Series* 1.—The lowest amount of NITROGENOUS SUBSTANCE consumed weekly, &c., in any pen throughout the Three Series, was 2·91 lbs. in *Pen* 5, *Series* 1. This, therefore, is taken as the standard by which to compare the amounts of Nitrogenous substance, consumed in each of the other pens, and it is represented as 100; and as seen in the Diagram, the column of *Nitrogenous* substance for Pen 5, Series 1, is coloured (black) only, up to the standard or base line, 100. In *Pen* 1, *Series* 1, the amount of *Nitrogenous substance* consumed weekly, &c., was 8·84 lbs. Therefore, we say —

2·91 : 8·84 : : 100 : 304;

and, consequently, the column of *Nitrogenous substance*, for *Pen* 1, *Series* 1, is coloured (black), up to 304.

The lowest amount of NON-NITROGENOUS SUBSTANCE, consumed weekly, &c., was in *Pen* 1, *Series* 2—namely, 14·51 lbs. This, then, is the standard of comparison for all the other pens, as to *Non-nitrogenous substance;* and the column for that substance, in this *Pen* 1, *Series* 2, is coloured (yellow), only up to the base line, 100. In *Pen* 1, *Series* 1, the amount of *Non-nitrogenous substance* consumed, was 17·63 lbs.; and to get the proportion of this to the amount in the standard pen, we say:—

14·51 : 17·63 : : 100 : 122;

and hence, the column for *Non-nitrogenous substance*, in *Pen* 1, *Series* 1, is coloured (yellow), up to 122.

Lastly:—the lowest amount of TOTAL ORGANIC SUBSTANCE consumed, was 20·94 in *Pen* 2, *Series* 3; and, therefore, the column for this substance, for this *Pen* 2, *Series* 3, is coloured (red), only up to 100. The amount of

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* Pens 9, 10, and 11 of Series 1, being however excluded, for the reasons which will be understood from the text referring to those Pens.