IV. THE REARING OF CHICKENS ON THE INTENSIVE SYSTEM. PART II. THE EFFECT OF "GOOD" PROTEIN.

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OSBORNE and MENDEL [1912, 1914] have shown that the growth of rats depends upon the presence of the amino acid, lysine, in the protein of the diet and that normal or average growth follows if 2 or 3 % of this compound be present in the protein. They have shown further [1916, 1] that proteins vary greatly in their capacity for promoting growth. Lactalbumin was superior to caseinogen and caseinogen to edestin; cereal proteins were not of "good" quality¹. Buckner, Nollau and Kastle [1915] found that a mixed grain diet of high lysine content produced more rapid growth than one of low lysine content in the case of chicks and this was confirmed by Osborne and Mendel [1916, 2]. Buckner, Peter, Wilkins and Hooper [1919] repeated the experiments with a larger number of birds kept under better conditions at a poultry farm and again noted the effect of a high lysine content. In all these experiments there was a considerable mortality amongst the birds, probably to be accounted for by an insufficient supply of vitamins. In Part I [Plimmer and Rosedale, 1922] it was shown that chickens could be reared in confinement if an adequate quantity of each of the three vitamins were added to the diet. It seemed that the B factor must be present in proportion to the amount of carbohydrate and fat in the diet.

The present experiment was designed partly to confirm the previous one and partly to ascertain the effect of "good" protein upon the rate of growth. A mixture of lactalbumin and caseinogen was chosen; both these proteins contain a high amount of lysine; the main deficiency is that of cystine in caseinogen. Vitamins, additional to those in the commercial foods, were added and oatmeal formed the basis of the diet. The effect of the "good" protein produced the expected result of rapid growth. The cocks reached the average weight of 1828 g. in 122 days; after this time they increased more slowly reaching the average weight of 2002 g. in 144 days; they were really suitable for marketing at the former age. The hens started laying at the age of 139 days.

¹ A summary on "Quality of Protein in Nutrition" is given by Plimmer [1921].

EXPERIMENTAL.

The group (No. III) consisted of nine white Leghorn chicks of the same strains as those in the previous experiment hatched under hens on Aug. 21st, 1920. They were housed for the first three weeks in the foster mother and then in one of the poultry houses in the ground floor room of the Institute, except for a period of 21 days from Sept. 23rd to Oct. 13th, during which time they were kept in a house on the roof of the building. This change made no difference to their rate of growth, which was rapid throughout the experiment.

The diet, except for the first five days, was composed of a mixture of equal parts of caseinogen¹ and secwa² or dried whey, mixed with oatmeal. This choice was made so as to give some comparison with the milk used previously. No allowance was made for vitamins in these foods: B factor would be present in the lactalbumin preparation, and both A and B factors in the caseinogen. To ensure an adequate supply they were added in the form of cod liver oil, marmite and lemon or orange juice. The cod liver oil and lemon juice were given, except for a short time at the beginning and again later, in constant daily amounts, but the marmite was increased with the increase of oatmeal required as the birds grew bigger. It was always added in the proportion of 0.25 g. to 30 g. of oatmeal. The food was prepared daily in the same way: the required amounts of oatmeal, caseinogen and secwa were weighed out; marmite was measured from a freshly prepared 25 % solution and mixed with the lemon or orange juice and cod liver oil; some extra water was added and the three ingredients shaken together and well stirred into the food mixture. A wet mash was thus the only food provided; dry food only consisted of the dried surface of the mixture. No extra salts were given and no grit, but on one day the birds were given by mistake some broken pieces of porcelain. The examination of the gizzards of the surplus cocks, after they were killed, revealed the presence of small black stones; they were presumably picked up from the peat moss litter used to cover the floor of the cage.

The quantity of food eaten, protein ratio, average weight and average daily increase are shown in the following table:

	No. of days	Oatmeal g.	Casein- ogen g.	Secwa g.	Cod liver oil cc.	Marmite g.	Lemon juice cc.	Protein ratio	Average weight g.	Average daily Increase g.
Aug. 21-25	5	30	0	30	2.5	0.25	15	1 : 6	39-69	6
" 26-29	4	30	15	15	2.5	0.25	15	1 : 2.5	69-80	3
" 30-Sept. 3	5	60	30	30	5.0	0.5	30	1 : 2.5	80-111	6
Sept. 4-11	8	90	45	45	7.5	0.75	45	1 : 2.5	111-181	9
" 12-21	10	120	45	45	7.5	1.0	45	1 : 2.5	181-299	12
" 22-30	9	180	60	60	7.5	1.5	45	1 : 2.2	299-322	3
Oct. 1-5	6	210	60	60	7.5	1.75	45	1 : 2.5	322-443	20
" 6-15	10	240	60	60	7.5	2.0	45	1 : 2.4	443-714	27
" 16-26	11	300	60	60	7.5	2.5	45	1 : 3	714-904	17
" 27-Nov. 18	23	180	36	36	7.5	1.5	45	1 : 3	904-1233	14
Nov. 19-Dec. 6	18	240	48	48	7.5	2.0	45	1 : 3	1233-1445	12
Dec. 7-26	20	360	72	72	11.0	3.0	67	1 : 3	1445-1668	11
" 27-Jan. 13	18	360	36	36	7.5	3.0	45	1 : 4	1668-1767	5.5

The diminution in the daily food supply on Oct. 27th was due to the fact that the group consisted of five cocks and four hens and that it was necessary

¹ Caseinogen: moisture 9.9, ash 6.5, fat 0.8, protein 82.7 %.

² Secwa: moisture 1.2, ash 9.8, fat 0.3, lactose 74.5, sol. lactalbumin 14.2 %.

to separate off the surplus four cocks (groups III *A* and *B*, below). The figures from this date thus refer to one cock and four hens.

The birds in three weeks reached the weight of the birds in groups I and II [Part I] at the age of six weeks. The cocks in this group began to crow about Oct. 9th at the age of 49 days. The hens began to lay at the age of 139 days on Jan. 7th, 1921. It is recorded that Leghorns have started to lay at 122 days, but these birds were hatched in the spring and had a free existence.

Throughout the period the health of the birds was excellent and they moulted rapidly during October. As might be expected from the work of Palmer and Kempster [1919], the legs and beaks were not pigmented. These investigators showed that the yellow pigmentation depended on the presence of yellow pigments in the food. The food here supplied was almost colourless and the result is a confirmation of their work.

Groups III A and III B. The four cocks after removal from the main group were kept in four separate small cages and were arranged in two groups of two birds as regards food. Both groups were supplied with the same food items as the main group, but with a higher proportion of caseinogen and secwa; this proportion was reduced on Dec. 3rd, so that the protein at first 1 : 1.8 became 1 : 1.3. They were also given more cod liver oil and orange juice per bird than the main group, group III *B* more than III *A*. The marmite was always kept at 0.25 g. per 30 g. of oatmeal. The food consumption, average weight and daily average increase were as follows:

Group III A, each bird.

	No. of days	Oatmeal g.	Casein- ogen g.	Secwa g.	Cod liver oil cc.	Marmite g.	Lemon juice cc.	Protein ratio	Average weight g.	Average daily Increase g.
Oct. 27-Dec. 3	39	60	30	30	2.5	0.5	15	1 : 1.8	1053-1730	17
Dec. 4-Jan. 11	39	60	15	30	2.5	0.5	15	1 : 2.9	1730-2202	15

Group III B, each bird.

Oct. 27-Dec. 3	39	60	30	30	5.0	0.5	30	1 : 1.8	1015-1587	15
Dec. 4-Jan. 11	39	60	15	30	5.0	0.5	30	1 : 2.9	1587-1804	6

Sometimes the cocks would eat an extra daily allowance during the course of one or more days.

The housing in the smaller cages made no appreciable difference to the daily weight increase, though it was slightly higher than that of the main group. In the first part of the period the greater amount of cod liver oil given to group III *B* had a lessening rather than the augmenting effect which might have been expected. This effect was very marked in the second part. It would support the suggestion made in Part I that the amount of B factor required in the food bears a definite ratio to the consumption of carbohydrate and fat. Cod liver oil was not given for the last few days as the birds were to be killed on Jan. 11th for the purpose of examining the flesh. The flesh of the breast was pale, that of the legs about the colour usual with Leghorns. The flesh was also lacking in flavour, evidently due to the "tasteless" food.

Group III, egg laying period. The hens began to lay on Jan. 7th, 1921; seven eggs weighing 286.5 g. or 40.9 g. per egg were produced up to Jan. 13th.

On Jan. 14th a comparison of egg laying on this diet was made with the same number of hens and a cock (group IV) from the birds of groups I and II. Their diet contained blood meal as protein in exactly the same protein ratio of 1 : 4. Group IV was given less lemon juice, and marmite was omitted from their diet, since it was possible that sufficient of this B vitamin was present in the blood meal. The following tables show the diets, weights etc.:

Group III.

Oatmeal	Caseinogen	Seewa	Cod liver oil	Marmite	Lemon juice	Average weight	Increase
g.	g.	g.	cc.	g.	cc.	g.	g.
360	36	36	7.5	3.0	45	1767-1815	48

Group IV.

Oatmeal	Blood meal	Cod liver oil	Lemon juice	Average weight	Decrease
g.	g.	cc.	cc.	g.	g.
360	87	7.5	45	1537-1456	81

A hen of group III suddenly died on Feb. 4th apparently from choking. No signs of ill-health were noticed beforehand nor could any reason be found at post mortem examination. The other birds were perfectly well throughout.

Group IV did not relish the blood meal; on several occasions it was not necessary to prepare the daily food for them.

Grit was not supplied to either group; the eggs had always a sound shell.

Group III gave	6 eggs during	January	weighing	253.5 g. or 42.5 g. per egg.
" "	17 "	February	"	702.5 g. " 41.3 g. "
" IV "	7 "	January	"	316.5 g. " 45.2 g. "
" " "	3 "	February	"	134.4 g. " 44.8 g. "

The very great difference in the number of eggs from the two groups may have been due to the blood meal in the food of group IV, but from the results recorded in Part I, it is more probably due to absence of B factor. Unfortunately it was not possible to test this supposition, as the experiment had to be discontinued.

CONCLUSIONS.

On a diet containing sufficient of each of the three vitamins, chickens can be raised in confinement. This confirms the results of Part I.

Rapid growth results on a diet having an albuminoid ratio of 1 : 3 and containing "good" proteins, caseinogen and lactalbumin. Cock birds began to crow in 49 days and hens to lay in 139 days; the cocks had an average weight of 1853 g. and hens of 1815 g.

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