A Study of the Relation of the Chemical Composition of Hens' Eggs to the Vitality of the Young Chick

A THESIS

Presented to the Faculty of the Graduate School

of

Cornell University

FOR THE

DEGREE OF DOCTOR OF PHILOSOPHY

BY

LEWIS JOSEPHUS CROSS

JUNE, 1912

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INTRODUCTION

In co-operation with the Department of Poultry Husbandry this work was begun under the direction of Professor G. W. Cavanaugh.

Poultrymen have noted that the chickens hatched from the eggs of some hens are much stronger and more vigorous than those hatched from the eggs of other hens. Even with hens apparently of the same vigor, fed and housed in the same pen, mated with the same cock, and the eggs incubated under similar conditions, we will find some hens of the pen laying eggs hatching chickens in large percentages, while other hens of the pen will give most contrary results.

This condition may be attributed to one of three different causes; namely, the inherited constitutional vigor of the hen transmitted to the chick, the influence of the cock, or a difference in the proportionate chemical composition of the egg.

To determine, if possible, the relation of the vitality of the chick to the chemical composition of the egg, and, if this relation be found, to attempt to control the composition of the egg, this work was begun.

It is evident, at once, that this problem involves an examination of the egg before incubation, and a study of the changes taking place during incubation, together with an examination of the young chick. Also in the feeding experiments, examination of the eggs must be made while the hens are in normal condition, on their normal rations, and then at intervals as the feeding is changed.

The problem of the changes in the egg during incubation were first taken up. By feeding various dyes to animals certain tissues are colored. Aniline dyes have been used by investigators to show various changes taking place in the tissue. Dyes fed to hens will color parts of the egg. This coloring of the eggs was done to study the changes taking place during the incubation of the egg. The two principal dyes used were Sudan III and Rhodamine Red. Sudan III when fed to fowls apparently colors the fat deposits only. Rhodamine Red colors the shell and albumen of the egg. Sudan III colors the yolk of the egg only, while Rhodamine Red colors the albumen strongly and the yolk but little. In the experiments, 25 milligrams of Sudan III, and 100 milligrams of Rhodamine Red were fed to a hen per day.

The eggs from the hens fed Sudan III had yolks of a bright red color. Daily feeds produced concentric layers of red alternating with yellow yolk. Even with the dye in all the food no uniformly colored yolks were produced. The eggs laid soon after the first feeding of the dye showed these concentric layers near the outer part only. These two facts show that the yolk is built up by successive layers of fat deposited on the surface of the material already present and not any intermingling of the material.

When the color was fed at stated intervals, the rate of growth within the yolk was obtained. It was possible in this way to calculate the number of days required for the development of the yolk and also to study the relative amount of material added during the stages of its formation. We find that the deposition of the yolk material is very slow at first, but very rapid at the end, the outer bands being much broader as well as greater in circumference. With the particular fowl observed it required fourteen days for the yolk to be fully formed. This observation was taken during the heavy laying season.

The germ disc, albuminous center, and connecting tubes were left uncolored, showing that either they contain little or no fat or were a part of the ovary before the dye was fed.

The Rhodamine Red dye colors the albumen of the egg principally. There is not enough protein in the yolk to make the color show very distinctly in contrast to the yellow. The albumen is colored uniformly throughout.

After two days of incubation the fertile eggs colored with Sudan III undergo a change. The outer bands of color break up and intermingle with the yellow bands of the yolk. By the fifth day of incubation, the yolk is quite well mixed, so that only a faint resemblance of the banded condition remains. By this time, also, the albumen near the developing embryo has turned pink. The bulk of the albumen, however, is still white. Upon boiling the egg, which is necessary to make the study, the white albumen becomes quite like rubber, while the pink albumen remains very soft. On the third and fourth, and often on the fifth day of incubation it was possible to get the pink albumen to coagulate. The amount of the pink albumen upon which

the embryo, to all appearances, directly feeds, remains quite constant. The white albumen gradually decreases until entirely softened and used up.

The presence of color in the albumen leads one to suspect fat, since Sudan III, colors fat only. Analysis does show its presence in large percentage. The incubated eggs were boiled and then separated into the white albumen, the pink albumen, (the albumen portion colored by the dye), and the yolk. Analyses of these parts were made. The presence of much fat in the colored albumen is shown by the results of analysis. The protein and fat in the egg before incubation is approximately as follows:

	Per Cent Protein in Dry Matter	Per Cent Fat in Dry Matter
Albumen	85–89	0.50
Yolk	30.00	65.00

ANALYSIS OF INCUBATED EGGS

The Yolk

Laboratory Number of Egg	Number of Days Incubated	Per Cent Protein (N. x 6.25)	Per Cent Fat in Dry Matter
67	3	31.43	63.82
82	5	30.44	65.67
70	6	31.87	63.54
73	6	33.75	61.47
76	6	31.31	60.50
58	7	30.62	58.91
61	7	31.43	65.25
64	7	30.56	61.13
79	8	30.87	61.70
55	11	30.56	64.78
52	12	29.87	65.24

The White Albumen

Laboratory Number of Egg	Number of Days Incubated	Per Cent Protein in Dry Matter (N. x 6.25)	Per Cent Fat in Dry Matter
67	3	85.56	.22
82	5	86.75	.25
70	6	86.12	.18
73	6	87.81	.27
76	6	86.56	.34
58	7	87.81	.09
61	7	86.81	.12
64	7	87.06	.25
79	8	87.56	.34
55	11	88.56	.15
52	12	89.18	.17

The Pink Albumen

Laboratory Number of Egg	Number of Days Incubated	Per Cent Protein in Dry Matter (N. x 6.25)	Per Cent Fat in Dry Matter
67	3	31.64	55.08
82	5	26.31	65.50
70	6	25.44	60.12
73	6	26.87	56.82
76	6	25.87	61.91
58	7	28.62	59.46
61	7	28.31	56.31
64	7	28.37	54.96
79	8	28.12	55.89
55	11	26.12	66.07
52	12	25.06	69.71

The variations shown in the analytical figures are due in part, no doubt, to incomplete separations of the different parts. It is not possible to make as complete a separation of yolk and white in the incubated egg as in the fresh egg.

By reference to the table of analyses of the yolk, it will be seen that the percentage of fat in the yolk remains practically constant throughout the twelve days of incubation. At the end of this period it also has the same approximate size and the same moisture content. This indicates that the fat found in the albumen is derived not wholly from the yolk, but mainly from another source, the albumen itself. Thus the question is raised as to whether the bulk of nourishment provided the embryo is in the form of protein or fat.

It was found that there was no change in color or composition in the infertile egg, even after five days of incubation.

Later in this paper are described experiments showing the effect in composition of the egg of a ration high in protein and also the effect of a ration high in fat, together with observations on the vitality of the chicks from these eggs.

STUDY OF THE YOUNG CHICK

To study the absorption of the yolk by the chick, young chicks were killed and examinations were made of the yolk and of the chick.

The Yolk

Number of Chick	Age of Chick from which taken	Weight of Chick from which taken Grams	Race	Per Cent of Fat in Yolk	Per Cent of Protein in Yolk
2872	1 day	33.41	Strong	35.50	48.50
2892	2 days	31.85	Weak	43.10	48.50
487	2 days	31.57	Weak	26.62	.....
498	2 days	31.26	Weak		
511	2 days	32.87	Strong	30.81	.....
M	2 days	32.80	Strong		
N	2 days	32.64	Strong	36.75	51.87
O	2 days	32.06	Strong		
499	3 days	35.59	Weak	23.22	.....
503	3 days	38.92	Strong	21.70	.....
507	3 days	42.15	Strong		

As the strong and vigorous chick is usually fatter than the weak one, we might look for more rapid absorption of the fat of the yolk by the strong chick than by the weak one. By reference to the foregoing table, it will be seen that the percentage of fat in the yolk of the weak chick is in some cases less and sometimes more than in the yolk of the strong chick.

PHOSPHORUS IN THE CHICK

There is a difference of opinion as to whether the inorganic phosphates are useful in the building up of organic phosphorus compounds in the animal body. It is has been shown by E. B. Forbes [1] that bone meal fed to pigs had the effect of strengthening the bones. The same author [2] says that the principal need of phosphorus by the body is phosphorus in the form of inorganic phosphates, and that organic phosphates can supply the bodily need for phosphorus, both organic and inorganic, provided the necessary bases are present.

The theory is advanced by some investigators that phosphorus compounds lend vigor to the young animal and that the weak animal is not obtaining sufficient phosphorized elements.

The chicks, after removal of the yolk, were examined for the content of phosphorus with the following results:

[1] Bulletin 81, Missouri Agricultural Experiment Station.
[2] Bulletin 201, Ohio Experiment Station.

Phosphorus in the Chick

Number of Chick	Age of Chick	Weight of Chick	Race	Grams of P_2O_5 in Chick	Per Cent P_2O_5 in Chick	Per Cent P_2O_5 in Dry Matter
2872	1 day	33.41	Strong	.2085	.624	2.93
2892	2 days	31.85	Weak	.2135	.670	3.17
487	2 days	31.57	Weak	.2253	.713	2.78
498	2 days	31.26	Weak	.2207	.706	2.81
511	2 days	32.87	Strong	.2468	.750	3.10
M	2 days	32.80	Strong	.2432	.741	2.82
N	2 days	32.64	Strong	.2272	.696	2.63
O	2 days	32.06	Strong	.2080	.648	2.57
499	3 days	35.59	Weak	.2618	.735	2.11
503	3 days	38.92	Strong	.3158	.811	2.65
507	3 days	42.15	Strong	.3000	.711	2.46

It will be seen that the weak chick is equally as rich in phosphorus as the strong chick. The chicks are designated "weak" and "strong," according to their ancestry. There is, of course, a possibility of the offspring of weak parents being strong and vice versa, so conclusive proof is not here shown.

Number of Hen	Number of Eggs in Sample	Date Laid
3486–29	5	July 7—14
3609–29	5	July 7—14
3486–29	6	July 21—26
3486–29	4	July 22—27

Laboratory Number	Per Cent Fat in Dry Matter	Per Cent Protein in Dry Matter	Sum of Fat and Protein Per Cent	Per Cent of Ash	Total Per Cent	Per Cent of P_2O_5
3486–29	49.97	45.00	94.97	3.67	98.64	2.03
3609–29	49.18	45.62	94.80	3.73	98.53	2.10
3486–29	45.52	49.00	94.52	3.94	98.46	2.13
3486–29	45.45	49.87	95.32	3.84	99.16	2.05

From these results it is seen that there is no difference in the phosphorus content of the eggs of the two individuals, but there is a difference in the fat content and also in the protein content.

EGGS OF UNEQUAL HATCHING POWER

Two individual hens were picked out that gave contrary results in hatching power. One individual laid eggs which invariably hatched chickens in large percentages. The other individual laid eggs, a few of which hatched. Both were fed and housed in the same pen, and the eggs were incubated under similar conditions. The average weight of the chicks from these two individuals did not indicate that one chick was more vigorous than the other. The mortality from both lots of chickens was about the same. There was practically nothing except the difference in hatching power of these eggs to indicate that one bird was stronger than the other. Two samples of eggs from each individual were examined. Number 3486-29 is the hen producing eggs that hatched well.

THE FEEDING OF INORGANIC PHOSPHORUS

From a pen of laying hens being fed the regular ration, (the Cornell Ration for Laying Hens), a sample of eggs was taken and the eggs analyzed for the total phosphorus present. The percentages of fat and protein were also determined. Then there was added to the ration some Hen-E-Ta Bone Grit. This Bone Grit was of this composition: CaO 19.04 per cent., P_2O_5 15.30 per cent. Samples of the eggs of the flock were taken from time to time and analyzed.

The Cornell Ration for Laying Hens

The following whole grain mixture is fed morning and afternoon in a straw litter:

Summer.	Winter.
60 lbs. Wheat.	60 lbs. Wheat.
60 lbs. Corn.	60 lbs. Corn.
30 lbs. Oats.	30 lbs. Oats.
	30 lbs. Buckwheat.

The following mash is fed dry in a hopper kept open during the afternoon only:

60 lbs. Cornmeal.
60 lbs. Wheat Middlings.
60 lbs. Wheat Bran.
10 lbs. Alfalfa Meal.
10 lbs. Oil Meal.
50 lbs. Beef Scrap.
1 lb. Salt.

The fowls eat about half as much mash as whole grain.

Laboratory Number	Date Laid	Number Eggs in Sample	Weight of Eggs Entire Grams	Weight of Eggs less Shells Grams	Weight of Shells Grams	Weight of Egg Powder Grams
R x 26–1	July 6–10	12	660	576.	84.0	385
R x 26–3	Aug. 16–19	12	672	590.5	81.5	395
R x 26–4	Aug. 30–Sept. 1	12	656	569.5	86.5	367
R x 26–5	Sept. 30–Oct. 7	12	689	602.5	85.5	375

Laboratory Number	Per Cent of Fat	Per Cent of Protein	Sum of Fat and Per Cent	Per Cent of Ash	Total	Per Cent of P_2O_5
R x 26–1	46.82	48.18	95.00	3.77	98.77	2.10
*R x 26–3	48.63	46.81	95.44	3.74	99.18	2.08
R x 26–4	49.35	45.62	94.97	3.76	98.73	2.14
R x 26–5	44.63	50.25	94.88	3.86	98.74	2.00

*The Bone Grit was added to the ration August 1st. Sample R x 26-3 is the first one taken after the addition of the Grit.

There was no increase in the phosphorus content of the egg and no increase in the ash, hence there was probably no increase in the lime content of the egg. The sum of the fat and the protein remained quite constant.

HENS ON RANGE

It has been noted by poultrymen that eggs from hens on ranges produced more vigorous chicks than eggs from hens kept on bare yards. In some cases, double the number of chicks were raised from the hen on range in comparison with the chicks from the hen with no range. Accordingly, samples of eggs of individuals of pens having range, and of pens having no range, were taken. Numbers 32 and 33 are from hens having range and Numbers 78 and 79 are from hens on bare yard.

Number of Hen	Number of Eggs in in Sample	Average Weight of Egg Minus Shell Grams	Per Cent of Fat	Per Cent of Protein	Grams of Fat in Egg	Grams of Protein in Egg
6062–32	4	50.6	12.91	12.07	6.53	6.11
6091–32	4	52.0	12.54	12.73	6.52	6.62
7212–33	5	52.5	12.19	12.44	6.40	6.53
7218–33	4	51.1	13.93	11.19	7.12	5.62
6095–78	2	49.5	12.66	11.64	6.27	5.76
7205–79	4	51.7	13.44	11.87	6.95	6.14
7545–79	2	50.0	12.67	11.61	6.34	5.81
7539–79	5	51.9	12.46	12.54	6.46	6.51

Number of Hen	Number of Egg in in Sample	Average Weight of Egg Minus Shell Grams	Per Cent Fat in Dry Matter	Per Cent Protein in Dry Matter	Sum of Fat and Protein Per Cent
6062–32	4	50.6	48.62	45.47	94.09
6091–32	4	52.0	47.05	47.78	94.83
7212–33	5	52.5	46.63	47.59	94.22
7218–33	4	51.1	52.45	42.69	95.14
6095–78	2	49.5	48.83	44.88	93.71
7205–79	4	51.7	50.21	44.37	94.58
7545–79	2	50.0	49.05	44.93	93.98
7539–79	5	51.9	47.14	47.41	94.55

While there is a variation of the fat content and of the protein content, this variation is not confined solely to either group. With the exception of Numbers 7539 and 7218, the hens on range produced

eggs having a higher protein content and a lower fat content than the hens on bare yard. This would seem to indicate the egg having the higher protein content, other things being equal, would produce the more vigorous chick. To determine this, if possible, an experiment was begun in feeding a ration high in protein, and, on the other hand, a ration high in fat.

The stock used was late-hatched White Leghorns. Each pen consisted of six pullets. Each pen was furnished with one cockerel. The hens were trap-nested and the eggs separately marked. The hens were first fed the Cornell ration (see page 7) and samples of the eggs of each individual taken. Then the ration was changed, one pen, 26C, being fed a ration high in fat; and the other, 26D, being fed a ration high in protein.

The Effect of High Protein Content and of High Fat Content of the Egg Upon the Development and Strength of Young Chicks.

	Ration Fed Pen 26D	Ration Fed Pen 26C
Corn Meal	120 pounds	30 pounds
Wheat Middlings	40 pounds	70 pounds
Wheat Bran	20 pounds	30 pounds
Alfalfa Meal	5 pounds	10 pounds
Oil Meal	5 pounds	10 pounds
Beef Scrap	30 pounds	70 pounds
Salt	1 pound	1 pound
	223 pounds	220 pounds
Nutritive Ratio	1 : 3.4	1 : 1.6
Corn	300 pounds	200 pounds
Wheat	200 pounds	300 pounds
Nutritive Ratio	1 : 8.5	1 : 8.0

The eggs from a third hen, 26B, were used throughout the experiment as a check. Regular weighings of the feed were made.

After being on the special ration for some weeks, some of the eggs were incubated in pedigree trays and the chicks leg-banded. The chicks were regularly brooded and their vigor and rate of growth noted.

Samples I and II were taken while all hens were on the Cornell ration.

Samples III, IV, and V were taken while hens 26C and 26D were on their respective special rations given on page 9. They were put on these rations March 7th.

Pen 26B was kept on the Cornell ration as a check.

Pen 26C was fed on the ration high in fat.

Pen 26D was fed on the ration high in protein.

Eggs were placed in the incubator April 25th.

Sample I

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Average Weight of Egg in Grams	*Average Weight of Egg Minus Shell	Average Weight of Shell	Per Cent of Fat	Per Cent of Protein
7	26 B-8004	3	J. 30; F. 1, 2	58.8	52.1	6.5	13.75	12.38
	8611		.....	....	....	...	.....	.....
2	9352	3	J. 26, 28, 30	54.0	47.0	6.8	11.08	11.00
3	9374	3	J. 25, 27, 29	55.5	48.6	6.8	13.58	12.87
10	9375	3	F. 1, 2, 4	48.5	43.1	5.2	11.23	12.00
	9385		.....	....	....	...	.....	.....
5	26 C-8408	3	J. 30; F. 1, 2	54.5	47.5	6.8	11.36	12.36
9	8659	3	J. 28, 30; F. 3	49.9	44.2	5.6	11.95	13.25
	8712		.....	....	....	...	.....	.....
6	9351	3	J. 30, 31; F. 2	52.7	46.3	6.2	11.23	13.10
	9355		.....	....	....	...	.....	.....
	9376		.....	....	....	...	.....	.....
1	26 D-8413	3	J. 25, 28, 30	55.2	48.3	6.7	10.80	12.78
8	8491	3	J. 28, 30; F. 1	49.3	43.6	6.0	11.82	12.17
12	8544	3	J. 30, 31; F. 4	53.2	47.1	6.0	12.34	13.33
11	9357	3	J. 26, 31; F. 3	51.6	44.6	6.8	11.82	12.93
4	9394	3	J. 25, 30; F. 1	58.3	50.1	7.9	9.68	13.32
13	9395	3	F. 4, 6, 8	62.5	54.5	7.8	9.96	12.23

* The weight of shell given is that obtained after thoroughly draining the contents of the egg therefrom, and is not the weight of the cleaned shell.

Sample I—Continued

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Per Cent Fat in Dry Matter	Per Cent Protein in Dry Matter	Sum of Fat and Protein in Dry Matter, %	Per Cent Moisture in the Eggs
7	26 B-8004	3	J. 30; F. 1, 2	50.38	45.34	95.72	72.69
	8611		.....	.....	.....	.....	.....
2	9352	3	J. 26, 28, 30	47.16	46.80	93.96	76.49
3	9374	3	J. 25, 27, 29	48.86	46.31	95.19	72.19
10	9375	3	F. 1, 2, 4	45.77	49.35	95.12	75.67
	9385		.....	.....	.....	.....	.....
5	26 C-8408	3	J. 30; F. 1, 2	45.20	49.16	94.36	74.85
9	8659	3	J. 28, 30; F. 3	44.77	49.63	94.40	73.30
	8712		.....	.....	.....	.....	.....
6	9351	3	J. 30, 31; F. 2	43.87	51.20	95.07	74.40
	9355		.....	.....	.....	.....	.....
	9376		.....	.....	.....	.....	.....
1	26 D-8413	3	J. 25, 28, 30	42.84	50.68	93.52	74.77
8	8491	3	J. 28, 31; F. 1	45.65	48.04	94.69	74.65
12	8544	3	J. 30, 31; F. 4	45.55	49.19	94.74	72.90
11	9357	3	J. 26, 31; F. 3	44.58	48.75	93.33	73.47
4	9394	3	J. 25, 30; F. 1	39.42	54.25	93.67	75.42
13	9395	3	F. 4, 6, 8	42.21	51.84	94.05	76.39

Sample II

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Average Weight of Egg in Grams	Average Weight of Egg Minus Shell	Average Weight of Shell	Per Cent of Fat	Per Cent of Protein
	26 B-8004		.....	....	....	...	.....	.....
21	8611	1	F. 28	54.7	47.5	6.9	11.91	12.74
28	9352	2	F. 26, 28	49.7	48.3	6.2	11.20	10.67
29	9374	2	M. 2, 4	51.8	45.9	5.8	13.81	12.94
24	9375	2	F. 19, 20	48.8	43.8	4.8	10.96	11.90
26	9385	2	F. 23, 26	48.8	42.2	6.3	11.82	12.03
25	26 C-8408	2	F. 16, 20	55.6	48.8	6.6	11.29	12.21
17	8659	2	F. 15, 17	48.7	43.1	5.4	11.74	12.47
30	8712	2	M. 1, 2	56.9	51.4	5.3	10.77	11.68
16	9351	2	F. 15, 17	54.5	49.2	5.1	10.96	12.44
18	9355	3	F. 15, 16, 18	55.7	48.9	6.6	10.74	12.70
	9376		.....	....	....	...	.....	.....
14	26 D-8413	2	F. 16, 17	57.5	50.9	6.4	10.98	12.74
15	8491	2	F. 15, 17	51.1	45.1	5.7	11.74	12.17
22	8544	2	F. 15, 17	52.8	46.6	5.9	12.02	13.00
23	9357	2	F. 15, 19	54.2	47.2	6.7	11.43	12.09
27	9394	2	F. 26, 28	58.7	51.4	7.0	9.69	12.89
19	9395	3	F. 15, 16, 18	61.7	53.2	8.2	9.93	12.24

Sample II—Continued

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Per Cent Fat in Dry Matter	Per Cent Protein in Dry Matter	Sum of Fat and Protein in Dry Matter, %	Per Cent Moisture in the Eggs
	26 B-8004		.....	.....	.....	.....	.....
21	8611	1	F. 28	46.27	49.48	95.75	74.25
28	9352	2	F. 26, 28	48.43	46.17	94.60	76.87
29	9374	2	M. 2, 4	49.39	46.25	95.64	72.09
24	9375	2	F. 19, 20	45.82	49.77	95.59	76.07
26	9385	2	F. 23, 26	46.92	47.77	94.69	74.80
25	26 C-8408	2	F. 16, 20	44.73	48.37	93.10	74.74
17	8659	2	F. 15, 17	44.07	50.00	94.07	75.11
18	9355	3	F. 15, 16, 18	43.54	51.49	95.03	75.32
	9376		.....	.....	.....	.....	.....
14	26 D-8413	2	F. 16, 17	43.71	50.68	94.39	74.86
15	8491	2	F. 15, 17	46.51	48.21	94.72	74.75
22	8544	2	F. 15, 17	46.03	49.80	95.83	73.88
23	9357	2	F. 15, 19	45.60	48.21	93.81	74.92
27	9394	2	F. 26, 28	49.44	53.81	94.25	76.03
19	9395	3	F. 15, 16, 18	42.06	51.87	93.89	76.39

Sample III

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Average Weight of Egg in Grams	Average Weight of Egg Minus Shell	Average Weight of Shell	Per Cent of Fat	Per Cent of Protein
37	26 B-8004	2	M. 26, 27	60.5	53.1	7.1	13.66	12.30
	8611		.....	.....	.....	...	....	....
32	9352	2	M. 25, 27	53.9	47.5	6.2	11.40	11.13
34	9374	2	M. 25, 27	53.6	47.4	6.1	13.19	12.43
43	9375	2	M. 25, 31	43.9	39.1	4.6	11.18	12.21
39	9385	2	M. 25, 28	52.4	46.0	6.2	12.59	12.86
33	26 C-8408	2	M. 25, 27	53.7	46.7	6.8	11.46	12.09
40	8659	2	M. 26, 29	47.2	42.0	5.0	11.83	12.31
	8712		.....	....	....	...	.....	.....
41	9351	2	M. 27, 28	49.2	43.9	5.1	11.57	11.93
42	9355	2	M. 26, 28	53.5	48.4	5.0	10.86	12.32
38	9376	2	M. 26, 27	53.7	47.8	6.7	12.03	12.54
31	26 D-8413	2	M. 25, 27	55.7	49.5	6.0	10.93	12.91
44	8491	2	M. 31; A. 1	49.7	45.1	4.4	12.13	12.03
35	8544	2	M. 25, 27	50.0	45.1	4.6	12.20	12.89
	9357		.....	....	....	...	.....	.....
	9394		.....	....	....	...	.....	.....
36	9395	2	M. 25, 26	62.6	54.4	7.9	9.59	12.78

Sample III—Continued

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Per Cent Fat in Dry Matter	Per Cent Protein in Dry Matter	Sum of Fat and Protein in Dry Matter, %	Per Cent Moisture in the Eggs
37	26 B-8004	2	M. 26, 27	49.87	44.89	94.76	72.60
	8611		.....	.....	.....	.....	.....
32	9352	2	M. 25, 27	49.97	46.83	94.80	76.23
34	9374	2	M. 25, 27	48.96	46.14	95.10	73.05
43	9375	2	M. 25, 31	45.88	50.12	96.00	75.63
39	9385	2	M. 25, 28	47.14	48.13	95.27	73.28
33	26 C-8408	2	M. 25, 27	45.60	48.09	93.69	74.85
40	8659	2	M. 26, 29	46.73	48.60	95.33	74.67
	8712		.....	.....	.....	.....	.....
41	9351	2	M. 27, 28	46.83	48.29	95.12	75.28
42	9355	2	M. 26, 28	44.29	50.23	94.52	75.46
38	9376	2	M. 26, 27	45.70	47.63	93.33	73.67
31	26 D-8413	2	M. 25, 27	43.10	50.91	94.01	74.63
44	8491	2	M. 31; A. 1	47.62	47.23	94.85	74.51
35	8544	2	M. 25, 27	46.57	49.23	96.80	73.80
	9357		.....	.....	.....	.....	.....
	9394		.....	.....	.....	.....	.....
36	9395	2	M. 25, 26	42.86	51.73	94.59	75.28

Sample IV

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Average Weight of Egg in Grams	Average Weight Egg Minus of Shell	Average Weight of Shell	Per Cent of Fat	Per Cent of Protein
51	26 B-8004	2	A. 11, 12	58.8	51.4	7.1	13.08	12.01
49	8611	2	A. 11, 13	58.3	51.2	6.8	11.14	12.40
47	9352	2	A. 10, 12	53.8	47.0	6.6	11.16	10.68
57	9374	2	A. 11, 12	50.0	43.6	6.7	13.35	12.71
48	9375	2	A. 10, 12	47.9	41.8	5.8	10.63	11.51
53	9385	2	A. 10, 12	51.9	44.9	6.7	11.97	12.07
50	26 C-8408	2	A. 10, 11	52.5	45.7	6.5	11.66	12.27
46	8659	1	A. 11	52.7	46.8	5.7	12.06	11.98
	8712		.....	....	....	...	.....	.....
56	9351	2	A. 10, 12	58.4	51.4	6.8	11.84	11.44
59	9355	2	A. 10, 12	53.0	46.4	6.4	10.97	11.86
45	9376	2	A. 12, 14	54.2	47.7	6.3	12.36	12.80
58	26 D-8413	2	A. 10, 11	53.9	47.8	6.0	10.95	13.38
52	8491	2	A. 11, 13	52.5	46.4	5.9	12.07	11.54
54	8544	2	A. 10, 12	49.7	44.0	5.5	12.33	12.94
60	9357	2	A. 10, 12	52.3	45.8	6.2	11.89	12.56
	9394		.....	.....	.....		.....	.....
55	9395	2	A. 10, 11	64.3	56.2	7.9	9.98	12.08

Sample IV—Continued

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Per Cent Fat in Dry Matter	Per Cent Protein in Dry Matter	Sum of Fat and Protein in Dry Matter, %	Per Cent Moisture in the Eggs
51	26 B-8004	2	A. 11, 12	49.16	45.12	94.28	73.38
49	8611	2	A. 11, 13	46.00	49.86	95.86	75.12
47	9352	2	A. 10, 12	48.50	46.42	94.92	76.98
57	9374	2	A. 11, 12	49.23	46.87	96.10	72.88
48	9375	2	A. 10, 12	46.08	49.88	95.96	76.91
53	9385	2	A. 10, 12	46.95	47.34	94.09	74.50
50	26 C-8408	2	A. 10, 11	46.07	48.46	94.53	74.65
46	8659	1	A. 11	47.32	47.00	94.32	74.50
	8712		.....	.....	.....	.....	.....
56	9351	2	A. 10, 12	48.19	46.58	94.77	75.43
59	9355	2	A. 10, 12	45.43	49.12	94.55	75.85
45	9376	2	A. 12, 14	46.20	47.83	94.03	73.23
58	26 D-8413	2	A. 10, 11	42.40	51.85	94.35	74.19
52	8491	2	A. 11, 13	48.10	45.98	94.08	74.90
54	8544	2	A. 10, 12	46.80	49.11	95.91	73.65
60	9357	2	A. 10, 12	46.25	48.84	95.09	74.28
	9394		.....	.....	.....	.....	.....
55	9395	2	A. 10, 11	42.25	51.10	93.35	76.36

Sample V

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Average Weight of Egg in Grams	Average Weight of Egg Minus Shell	Average Weight of Shell	Per Cent of Fat	Per Cent of Protein
75	26 B-8004	2	A. 26, 27	59.6	52.7	6.8	13.91	12.29
73	8611	2	A. 27, 29	59.6	51.6	7.7	11.65	12.58
76	9352	2	A. 27, 29	51.1	44.4	6.5	11.45	10.93
77	9374	1	A. 27	52.8	46.6	5.9	13.61	12.91
74	9375	2	A. 26, 28	46.9	40.8	5.8	11.42	12.37
72	9385	2	A. 26, 27	49.1	42.8	5.9	11.87	11.88
68	26 C-8408	2	A. 23, 25	49.1	42.5	6.4	11.86	12.50
67	8659	2	A. 24, 26	49.3	43.4	5.6	12.15	12.12
	8712		Died Apr. 16	....	....	...	.....	.....
69	9351	2	A. 24, 25	53.9	46.9	6.5	11.99	11.61
70	9355	2	A. 24, 25	50.8	44.5	6.1	11.07	11.93
62	9376	2	A. 24, 25	54.4	47.8	6.4	12.36	12.67
61	26 D-8413	2	A. 25, 26	54.7	48.2	6.3	10.85	13.31
64	8491	2	A. 24, 26	49.9	43.6	6.0	12.26	11.79
71	8544	2	A. 24, 26	53.1	46.4	6.5	12.23	12.79
65	9357	2	A. 24, 26	53.9	47.2	6.5	12.26	12.57
63	9394	2	A. 24, 25	62.4	54.0	8.1	11.13	13.17
66	9395	2	A. 24, 25	64.4	56.3	7.8	10.73	12.43

Sample V—Continued

Laboratory Number	Number of Hen	Number of Eggs in Sample	Date Laid	Per Cent Fat in Dry Matter	Per Cent Protein in Dry Matter	Sum of Fat and Protein in Dry Matter, %	Per Cent Moisture in the Eggs
75	26 B-8004	2	A. 26, 27	50.88	44.96	95.84	72.65
73	8611	2	A. 27, 29	46.10	49.78	95.88	74.72
76	9352	2	A. 27, 29	48.60	46.38	94.98	76.43
77	9374	1	A. 27	49.12	46.60	95.72	72.29
74	9375	2	A. 26, 28	46.19	50.05	96.24	75.27
72	9385	2	A. 26, 27	47.23	47.26	94.49	74.86
68	26 C-8408	2	A. 23, 25	45.98	48.48	94.36	74.20
67	8659	2	A. 24, 26	47.45	47.33	94.78	74.39
	8712		.....	....	....	.....	.....
69	9351	2	A. 24, 25	48.25	46.71	94.98	75.14
70	9355	2	A. 24, 25	45.57	49.10	94.67	75.70
62	9376	2	A. 24, 25	46.56	47.74	94.30	73.44
61	26 D-8413	2	A. 25, 26	42.39	52.01	94.40	74.40
64	8491	2	A. 24, 26	48.15	46.31	94.46	74.52
71	8544	2	A. 24, 26	46.85	49.00	95.85	73.88
65	9357	2	A. 24, 26	47.58	48.78	96.35	74.22
63	9394	2	A. 24, 25	43.39	51.33	94.72	74.34
66	9395	2	A. 24, 25	43.89	50.85	94.74	75.55

Effect of Feeding

* Number of Hen	FAT SAMPLES I Per Cent	II Per Cent	III Per Cent	IV Per Cent	V Per Cent	PROTEIN SAMPLES I Per Cent	II Per Cent	III Per Cent	IV Per Cent	V Per Cent
26 B										
8004	50.38	.....	49.87	49.16	50.88	45.34	.....	44.89	45.12	44.96
8611	.....	46.27	.....	46.00	46.10	.....	49.48	.....	49.86	49.78
9352	47.16	48.43	47.97	48.50	48.60	46.80	46.17	46.83	46.42	46.38
9374	48.86	49.39	48.96	49.23	49.12	46.31	46.25	46.14	46.87	46.60
9375	45.77	45.82	45.88	46.08	46.19	49.35	49.77	50.12	49.88	50.05
9385	.....	46.92	47.14	46.95	47.23	.....	47.77	48.13	47.34	47.26
26 C										
8408	45.20	44.73	45.60	46.07	45.98	49.16	48.37	48.09	48.46	48.48
8659	44.77	46.11	46.73	47.32	47.45	49.63	48.96	48.60	47.00	47.33
8712	.....	45.30	.....	.....	.....	.....	49.10	.....	.....	.....
9351	43.87	44.07	46.83	48.19	48.25	51.20	50.00	48.29	46.58	46.71
9355	.....	43.54	44.29	45.43	45.57	.....	51.49	50.23	49.12	49.10
9376	.....	.....	45.70	46.20	46.56	.....	.....	47.63	47.83	47.74
26 D										
8413	42.84	43.71	43.11	42.40	42.38	50.68	50.68	50.91	51.85	52.01
8491	46.65	46.51	47.62	48.10	48.15	48.04	48.21	47.23	45.98	46.31
8544	45.55	46.03	46.57	46.80	46.85	49.19	49.80	49.23	49.11	49.00
9357	44.58	45.60	.....	46.25	47.58	48.75	48.21	.....	48.84	48.78
9394	39.42	40.44	.....	.....	43.39	54.23	53.81	.....	.....	51.33
9395	42.21	42.06	42.86	42.25	43.89	51.84	51.87	51.73	51.10	50.85

* Analysis on basis of the moisture-free material.

Effect of Feeding—Continued

* Number of Hen	FT SAMPLES I Per Cent	II Per Cent	III Per Cent	IV Per Cent	V Per Cent	PROTEIN SAMPLES I Per Cent	II Per Cent	III Per Cent	IV Per Cent	V Per Cent
26 B										
8004	13.75	.....	13.66	13.08	13.91	12.38	.....	12.30	12.01	12.29
8611	.....	11.91	.....	11.44	11.65	.....	12.74	.....	10.40	12.58
9352	11.08	11.20	11.40	11.16	11.45	11.00	10.67	11.13	10.68	10.93
9374	13.58	13.81	13.19	13.35	13.61	12.87	12.94	12.43	12.71	12.91
9375	11.23	10.96	11.18	10.63	11.42	12.00	11.90	12.21	11.51	12.37
9385	.....	11.82	12.59	11.97	11.87	.....	12.03	12.86	12.07	11.88
26 C										
8408	11.36	11.29	11.46	11.66	11.86	12.36	12.21	12.09	12.27	12.50
8659	11.95	11.74	11.83	12.06	12.15	13.25	12.47	12.31	11.98	12.12
8712	.....	10.77	.....	.....	.....	.....	11.68	.....	.....	.....
9351	11.23	10.96	11.57	11.84	11.99	13.10	12.44	11.93	11.44	11.61
9355	.....	10.74	10.86	10.97	11.07	.....	12.70	12.32	11.86	11.93
9376	.....	.....	12.03	12.36	12.36	.....	.....	12.54	12.80	12.67
26 D										
8413	10.80	10.98	10.93	10.94	10.85	12.78	12.74	12.91	13.38	13.31
8491	11.82	11.74	12.13	12.07	12.26	12.17	12.17	12.03	11.54	11.79
8544	12.34	12.02	12.20	12.33	12.23	13.33	13.00	12.89	12.94	12.79
9357	11.82	11.43	.....	11.89	12.26	12.93	12.09	.....	12.56	12.57
9394	9.68	9.69	.....	.....	11.13	13.32	12.89	.....	.....	13.17
9395	9.96	9.93	9.59	9.98	10.73	12.23	12.24	12.78	12.08	12.43

* Analysis on basis of the original egg contents.

Incubation

Number of Hen	Number of Eggs Placed in Incubator	Date Laid	Number of Chicks Hatched
26 B-8004	7	Apr. 15-24	6
8611	7	Apr. 14-23	4
9352	7	Apr. 15-24	7
9374	7	Apr. 15-24	6
9375	7	Apr. 15-23	5
9385	7	Apr. 15-24	2
26 C-8408	6	Apr. 13-22	5
8659	6	Apr. 13-23	5
8712	.....	.....	.....
9351	6	Apr. 14-22	4
9355	6	Apr. 14-22	3
9376	6	Apr. 15-23	5
26 D-8413	6	Apr. 13-23	2
8491	6	Apr. 10-22	2
8544	6	Apr. 15-22	6
9357	6	Apr. 16-23	6
9394	6	Apr. 16-22	1
9395	6	Apr. 15-22	4

Pen 26 B-8004.....71.4 per cent hatched
Pen 26 C-8408.....73.3 per cent hatched
Pen 26 D-8413.....58.3 per cent hatched

METHODS USED IN THE ANALYSIS

The eggs after removal of the shells were beaten and then dried at about 40° C. They were then ground to a powder and the final determination of the moisture of the powder made in the usual way.

The fat of the egg was extracted with chloroform, the extraction of 1.5 to 2 grams of the egg powder being carried on for twenty-three hours.

The nitrogen was determined by the usual Kjeldahl method, the factor, 6.25, being used in the calculation of the amount of protein.

The total phosphorus was determined as $Mg_2P_2O_7$, using H_2SO_4 and NH_4NO_3 in the digestion.

SUMMARY

1. The work on the coloring of the parts of the egg by feeding dyes to the hen indicates that the fat found in the albumen region of the incubated egg is derived not wholly from the yolk, but from another source, the albumen itself.
2. The percentage of fat in the yolk of the weak chick is in some cases less and sometimes more than in the yolk of the strong chick.
3. The weak chick is equally as rich in phosphorus as the strong chick.
4. The phosphorus content of the egg varies but little.
5. There is no increase in the phosphorus content of the egg when the hen is fed inorganic phosphorus.
6. Hens on range do not produce eggs different in composition from those on bare yard.
7. There is a variation in the eggs of individual hens in the content of protein and in the content of fat, but the eggs produced by each individual are quite constant in composition.
8. The sum of the percentages of the fat and of the protein in eggs varies but little.
9. In feeding a ration high in fat, or a ration high in protein, there is no material change in the characteristics of the hen as regards the amount of fat and protein in the egg.
10. There seems to be no relation between the protein or fat content of the egg as regards its hatching power or the vigor of the young chick.

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