A NUTRITIONAL DISEASE OF CHICKS CAUSED BY FEEDING DRIED EGGS

by

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A Thesis Submitted to the Graduate Faculty
for the Degree of

DOCTOR OF PHILOSOPHY

Major Subject Poultry Nutrition

Approved:

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In charge of Major work

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Head of Major Department

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Dean of Graduate College

Iowa State College
1936
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INTRODUCTION
REVIEW OF LITERATURE

Linossier (24) studied the toxicity of eggs as early as 1905, having published an article on the subject in that year. He concluded in 1918 that there is some substance in eggs which has a toxic action on some predisposed human individuals. The toxic substance is destroyed by heat sufficient to coagulate all the albumin in the egg, in the yolk as well as in the white. He remarked that the reason cooked egg appeared harder to digest than raw egg was because it was digested in the stomach, while the raw egg is not hydrolyzed until it reaches the intestines.

References concerning the feeding of eggs, usually in the form of egg white or egg albumin, to experimental animals are numerous and cover a period of many years. Osborne and Mendel (29, 30, 31) reported that ovalbumin gave adequate growth in rats when it made up eighteen per cent of the total diet. In the first experiment however, ovalbumin was fed apparently to only two rats.

Bond (7) obtained somewhat similar results when twenty or thirty per cent of egg white was the chief source of protein. She admitted however, that "the results of feeding the lactating rat and her growing young on the egg white diet are not very conclusive" as the results were not satisfactory.

Boas (4) fed rats dried Chinese egg white at the rate of twenty per cent of the diet and found that it gave satisfactory growth for from four to six weeks, but later did not supply adequate nitrogen. Even though marmite was a part of the ration used, loss of hair occurred in the rats,
growth ceased for awhile, and then the weight fell. She concluded that egg white was inadequate as the sole source of nitrogen for rats, even when it amounted to twenty per cent of the total ration.

Later the same year Boas (5) reported that "rats fed on the whites from fresh English eggs grew normally and had good coats."

Considerably later Boas (6) reported rather extensive tests using 12.5 per cent egg white in various forms as the chief source of protein for young growing rats. Dried egg white produced severe lesions in the experimental rats unless the ration was supplemented with potato starch or arrowroot as sources of carbohydrate. Crude boiled egg white as the chief source of protein gave satisfactory results. When the egg white was coagulated by boiling before desiccation, it gave good growth results. Several feeds and supplements as raw potato, potato starch, dried yeast, fresh egg white, etc., when used in the diet with dried egg white prevented the appearance of the lesions and other characteristics of the pellagra-like symptoms encountered. The presence of a protective factor X in the above substances was postulated.

As early as 1918 Maignon (25) fed rats albumin in pellet form with sufficient bone ash, NaCl and FeCO₃ added to supply minerals, and NaHCO₃ to keep the urine faintly alkaline. He concluded that egg albumin would not sustain the life of, nor maintain a constant weight in white rats. In addition he studied the effect of egg albumin when it was fed at various seasons.

Goldberger and Lillie (16) also described a pellagra-like condition in experimental rats caused by a lack of his "P-P solid" prepared from auto-
elavex yeast. None of the symptoms appeared until a varying time follow-
ing the arrest of growth. The reader is referred to the original report
for a complete description of the pellagra symptoms but some of these were
as follows: A tendency for eyelids to adhere together, loss of fur vary-
ing from patches to "almost complete denudation of the head, neck, and
trunk. With or without such loss of fur some of the animals have develop-
ed a dermatitis at one or more of the following sites: ears, front of
neck and upper part of chest, forearms, backs of forepaws, shins, and the
backs of the hindpaws." One symptom of particular interest, because it
appears also in chicks with the pellagra syndrome is the linear fissuring
or ulceration at the angles of the mouth. Goldberger and co-workers ob-
erved this in only a few of their experimental rats. Six per cent of
their "P-P solid" included in the diet was followed, if the animals were
still able to eat, by a clearing up of this condition and resumption of
growth.

Later Goldberger and co-workers (17) as the result of extensive tests
on the blacktongue preventive value of sixteen foodstuffs, found that hard
boiled dried egg yolk did not exercise adequate blacktongue preventive ac-
tion. However, it did seem to have a delaying or partially protective ac-
tion as only two of the five experimental dogs developed definite signs of
the disease, the third dog "presented very suggestive but transient indica-
tions of blacktongue," while the remaining two showed no signs of the di-
sease. They found the cooked yolk was inferior in blacktongue preventive
action to fresh beef, pork liver, and wheat germ.

Baglioni (5) fed white rats exclusively on egg albumin in unrestricted
amounts also supplying them daily 0.2 grams butter, 9 drops of lemon juice, and 0.2 grams of yeast. The animals were weighed regularly and chemical determinations, including nitrogen, urea, and ammonia, made on the urine and feces. The animals survived weeks and months although they showed noticeable disturbances consisting especially of hepatic and renal hyperfunction.

References concerning the effect of cooking or boiling on the toxicity of egg white are confused and contradictory. Scheunert and Wagner (39) have shown that the usual mode of cooking eggs does not diminish their nutritional value. They used rats as experimental animals.

On the other hand Friedberger and Seidenberg (14) studied the effect of a diet consisting solely of hens' eggs on the growth of rats and found that when whole eggs were used raw the rats gained 198 per cent in thirty days but with cooked whole eggs the gain was only 109 per cent. Stenqvist (42) made similar studies and came to an exactly opposite conclusion.

Findlay (15) has also reported the pellagra-like lesions in rats, ascribing these to a deficiency of vitamin B₂.

Guehs (19) summarized the results of several workers on pellagra and showed that in spite of much work on the subject, it was not yet entirely acceptable that pellagra was the uncomplicated result of vitamin B₂ deficiency. In addition he found improbable the theory that pellagra was the result of a simple iron deficiency as vitamin B₂ in certain preparations could be inactivated by autoclaving in an alkaline medium. However, he recognized the possibility that pellagra might be associated with an iron deficiency. He further stated that "it is considered probable that pella-
I found these EEG waves to be quite in contradiction to the expected results. I then proceeded to record the same as a control group for comparison. Later, I recorded the waveforms associated with the EEG waves of the control group. There were significant differences in the results, which have been due to the use of waveforms in addition to the control of the process. Results were also displayed on improved equipment for the study of the waveforms.


differentiate the growth factor

through the process of the remaining control group. I then proceeded to record in 1976 that these waveforms were


each and every process of 8. In 1978, each provided further evidence to the data of the growth factor.


less good but richer than cereals." They further noted that the distribution of B₃, Goldberger's P-P factor, and the factor preventing black-tongue in dogs was identical.

Chick, Gopping, and Roscoe (10) studied the egg white of hens' eggs and found that while this product was a relatively rich source of the antidermatitis vitamin B₂, it was lacking in vitamin B₁, and in this respect is unique among the foodstuffs hitherto examined. The egg white used was a concentrate made after the removal of the approximate ten per cent of the coagulable protein which the original contained. They found this concentrate would cure the dermatitis in rats associated with vitamin B₂ deficiency, as well as restore growth. The restoration of growth was not permanent however, which they believed due to a deficiency in the egg white of an unknown factor. They stated that "a daily dose of 2.5 to 5 grams of fresh, cooked, egg white (dry weight 0.3 to 0.6 grams), or of an extract -- equivalent to 5 to 10 grams -- will restore normal growth."

Hoagland and Snider (22) have studied vitamin C and found that beef, pork, and lamb contained approximately the same amounts. Beef and pork liver and beef kidney contained five to eight times as much as beef muscle. Approximately three per cent of any of the former provided ample vitamin C for growth in rats.

Apparently the vitamin B complex is well named as several references show that it is composed of even more than two factors. Reiner (52) described a second heat labile factor in yeast which she named vitamin B₃. It was not possible to get a supply of B₃ free from B₁. In a later paper
the same author (33) supplied additional evidence of this heat labile vitamin B₂. She was able to concentrate this as it appeared in the mercuric sulphate precipitate of the Kinneraley and Peters (28) process for vitamin B₁. She considered vitamin B₂ to be the anti-pellagra vitamin of Goldberger et al (15) as interpreted by Hassan and Drummond (20), and the factor present in alkaline autoclaved yeast extract. "The term "anti-dermatitis" is probably preferable for vitamin B₂ since some evidence in this laboratory suggests that "pellagra" is due to a combined deficiency of vitamins B₂ and B₃." Later work by Roscoe (35) was not in agreement with this. She found in feeding rats daily doses of yeast extract, egg white filtrate or meat necessary to cure the dermatitis associated in young rats with vitamin B₂ deficiency no support for the theory that separate dietary factors were necessary to prevent and cure dermatitis and to promote growth.

Less work than on other phases has been done on the physiology of pellagra in experimental animals. Turner and Blanchard (43) working with pellagrins have reported that "there is a tendency to low serum albumin, which persists after symptoms of the disease have disappeared. The abnormality is one of disturbed digestion, resulting from difficulty in protein absorption and injury of the digestive system." They suggest that the low serum albumin which persists after external "diagnostic evidences of the disease have disappeared and in spite of adequate diet" may be due to a permanent injury to the digestive system. Since, Kik, and Smith (43) have observed a distinct lowering of the red blood cell count in vitamin B₂ deficiency. The same observation has been made by Guha (19).
Sebrell (40) has studied the pellagra preventive value of many common foodstuffs and has prepared a table giving the results of his work, classing the materials as good, fair, slight, and of no value.

In addition to the work that has been done on dermatitis or pellagra in rats and which has been reported above, considerable other experimental work has been completed. Recently Salmon and Goodman (38) have reported extensive experiments on the raw egg white syndrome in rats. Additional references to the literature will be found in their work. They reported a positive harmful factor in raw egg white the results of which "are apparently not due to an anti-vitamin G action of the harmful factor although many of the symptoms are similar to those produced on certain vitamin G deficient diets and even more similar to those of pellagra."

Because the scope of the present planned experiments was confined to chicks, further reference to the work on rats seems unnecessary. Concerning the latter however, the many conflicting results are at times extremely difficult to understand and the suggestion may be made that the trouble, in part at least, may be due to the use of too few experimental animals.

Norris and Ringrose (27) and Ringrose, Norris, and Heusser (34) gave a detailed description of a pellagra-like syndrome in chicks where powdered egg albumin was the chief source of animal protein in the ration. However, they also encountered a similar condition when purified casein, commercial casein, and purified casein plus two and a half per cent of autoclaved yeast were the principal sources of animal protein. This would tend to indicate that vitamin G was involved. North (28) reported feeding boiled egg yolks to chicks which at six weeks of age averaged as much as a
check lot receiving a protein supplement of 12 per cent dried skim milk
plus six per cent of meat scrap. "Those receiving boiled egg white grew
more slowly, but no indications of disease were visible." However, "chicks
fed a ration in which 66 per cent of the dry matter was in the form of
raw egg white developed a pellagra-like condition."

Tully and Franke (44) have described the same pellagra-like syndrome
in chicks when 15 per cent of dried whole egg plus five per cent of dried
buttermilk were the animal protein supplements used in a ration believed
otherwise complete. Three or five per cent of Yeast-Foam Tablet Powder
(dehydrated yeast cells not autoclaved), or five per cent similar yeast
plus three per cent of meat and bone scraps did not prevent this trouble
when used with the above ration. No signs of the trouble were found when
the dried whole egg was replaced with meat and bone scraps.

It is evident from this review of the literature on the subject of
the toxicity of or deficiency in dried eggs that the data are incomplete
and some of them contradictory. Therefore additional work on this subject
is justified.
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EXPERIMENTAL

Objectives

The objectives of the experiments described herein were as follows:

1. To determine if the pellagra-like syndrome was due to a deficiency or toxicity in the eggs.

2. To determine whether the toxicity or deficiency was located in the yolk or in the albumen.

3. To discover methods of supplementing and treating the egg products to isolate the nature of the trouble.

4. To discover associated symptoms, including growth, mortality, appearance of the syndrome, blood hemoglobin, and serum albumin and globulin, in normal and affected chicks.

Method of Procedure

For the first three experiments day-old chicks were carefully sorted into lots of equal average weight at the beginning of each experiment, and banded at the time of weighing. Chicks were usually weighed at two week intervals throughout the six or eight weeks of the experiments. Feed was weighed in at the beginning of each experiment and carefully weighed back on each weigh-day; from these figures average feed consumption could be computed on a chick-day basis. Careful observations of growth conditions were made regularly and detailed results recorded on weigh-days. Particular care was taken to observe the incidence, severity, and duration of any
The page contains text that appears to be a scientific or technical report. It includes various symbols, numbers, and possibly chemical formulas or equations. The content is not clearly legible due to the quality of the image. It seems to discuss experimental results, possibly in a biological or chemical context, given the context clues and symbols present.
27 chicks to each lot.

MIXED HEAVY CHICKS.

**Lot 1**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ground yellow corn</td>
<td>51</td>
</tr>
<tr>
<td>wheat bran</td>
<td>10</td>
</tr>
<tr>
<td>wheat middlings (standard)</td>
<td>20</td>
</tr>
<tr>
<td>dried whole egg (commercial)</td>
<td>10</td>
</tr>
<tr>
<td>dried buttermilk</td>
<td>10</td>
</tr>
<tr>
<td>meat and bone scraps</td>
<td>5</td>
</tr>
<tr>
<td>ground limestone</td>
<td>2</td>
</tr>
<tr>
<td>salt</td>
<td>1</td>
</tr>
<tr>
<td>cod liver oil</td>
<td>1</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

**Lot 2**

<table>
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<th>%</th>
</tr>
</thead>
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<td>ground yellow corn</td>
<td>36</td>
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<tr>
<td>wheat bran</td>
<td>10</td>
</tr>
<tr>
<td>wheat middlings (standard)</td>
<td>20</td>
</tr>
<tr>
<td>dried whole egg (commercial)</td>
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</tr>
<tr>
<td>dried buttermilk</td>
<td>10</td>
</tr>
<tr>
<td>meat and bone scraps</td>
<td>5</td>
</tr>
<tr>
<td>ground limestone</td>
<td>2</td>
</tr>
<tr>
<td>salt</td>
<td>1</td>
</tr>
<tr>
<td>cod liver oil</td>
<td>1</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

per cent crude protein 13.46 18.00

Ca:P 1.41:94 1.55:9

**Chart I. Rations, growth curves, and mortalities in Experiment I.**

Z09 refers to number of chicks, male and female, living through the seven weeks of the experiment; 3 in lot 1 and 2 in lot 2 had severe slipped tendons.
supplements were used, and such a ration produced the pellagra-like syndrome in a very severe form. In this experiment twice as much dried buttermilk and five per cent of meat scraps were used. At four weeks of age all chicks showed only very slight indications of the syndrome, as evidenced by trifling scabbiness at the beak junctions and some roughening of the bottoms of the feet. In some cases only one toe on each foot would be affected and in no case were feet cracked or bleeding. At six weeks only four chicks showed noticeable though very slight indications of trouble.

It would seem from this one trial that this method of increasing the milk to ten per cent and adding five per cent of meat scraps almost completely prevented the appearance of the syndrome, even though 15 per cent of dried whole egg was used. This seems to indicate a deficiency rather than a toxicity in the eggs.

Growth in this trial was of great interest. At seven weeks the males in Lot 1 averaged 355 ± 13 grams and in Lot 2, 375 ± 20. The mean difference was 220 grams while the standard deviation of this was 36. There was therefore a highly significant difference between the males of the two lots. At the same time the females in Lot 1 averaged 315 ± 15 grams and those in Lot 2 310 ± 15. The mean difference was 50 grams and the SMD 27 grams. This is also a highly significant difference. This demonstrated the efficiency of the proteins or some other factor in the dried egg. As it was thought that in two lots of chicks showing such a mean difference in weight at seven weeks, differences in hemoglobin might be found, this was determined on all of the chicks which finished the experiment. Hemoglobin was determined in chicks of Lot 1 when these were 48 days of age, and in Lot 2
when they were 49 days old. It was not thought that the one day difference in time of determination would affect results although this has not been studied in chicks. Determinations were made with the "Improved Newcomer Model" hemoglobinometer using the Newcomer (26) method, but making corrections for excess turbidity of acid hematin solutions of birds' blood first described by Dukes and Schwarte (11).

The mean hemoglobin content of blood of chicks from Lot 1 was 7.8 ± 0.109 and in Lot 2, 8.48 ± 0.131 grams per 100 c.c. When the results were analyzed by variance (41) the difference was found to be significant but not highly significant.

Experiment 2

Further Studies with Dried Egg, With and Without Supplements

This trial consisting of five pens of 25 Single Comb White Leghorn chicks each was started December 10, 1934. Lot 3 was a check lot in which 20 per cent of dried buttermilk was the only animal protein supplement used. The crude protein in this ration was 15.78 per cent, rather low for optimum growth. Lots 4 and 5 were fed combinations of animal protein, the only animal protein variant being the commercial dried egg. This was to study the effect of two different levels of egg and its effect on the chicks where it was used in combination with equal amounts of dried buttermilk and meat scraps. Lot 6 was fed 12.5 per cent of dried egg as the sole source of animal protein, this percentage being used to give the same total crude protein in this ration as in Lot 3. Lot 7 was the same as Lot 6, ex-
cept that six per cent of dried yeast (not autoclaved) was added at the expense of an equal amount of ground yellow corn to study the value of added vitamin G. Reference to Chart II gives rations in more detail, growth curves, and numbers of chicks living through the experiment. Table 1 gives additional information concerning this experiment.

Table 1*

Protein and minerals in rations, and growth in Experiment 3

<table>
<thead>
<tr>
<th>Lot Number</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
<td>Percent</td>
</tr>
<tr>
<td>Protein in ration</td>
<td>18.78</td>
<td>15.6</td>
<td>17.76</td>
<td>13.94</td>
<td>16.58</td>
</tr>
<tr>
<td>Ca in ration</td>
<td>2.07</td>
<td>1.8</td>
<td>1.77</td>
<td>2.08</td>
<td>1.83</td>
</tr>
<tr>
<td>P in ration</td>
<td>0.96</td>
<td>0.86</td>
<td>0.88</td>
<td>0.86</td>
<td>0.95</td>
</tr>
<tr>
<td>Ca:P</td>
<td>2.15:1</td>
<td>2.05:1</td>
<td>2.01:1</td>
<td>2.42:1</td>
<td>1.95:1</td>
</tr>
</tbody>
</table>

Mean weight of males
at 6 weeks
277 (10)** 369 (11) 447 (14) 360 (14) 451 (14)

Mean weight of females
261 (14) 380 (14) 418 (8) 365 (7) 453 (8)

**Refers to numbers of chicks averaged. (and Nutrition Subsection. *Analyses done under supervision of B. H. Thomas, Head, Animal Chemistry.

In this experiment there were no evidences whatever of the pellagra syndrome in any of the lots fed commercial dried egg. Whether this was due to the Leghorn chicks used, to the brand of dried egg as it was different from that used in our previous work (44), or to some other factor, could not be determined from these experiments.

As the total crude protein was the same in Lots 3 and 6, growth could be compared on an equal protein basis only in these two lots. When the
25 chicks to a lot started 12/10/1934.  

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Lot 3</th>
<th>Lot 4</th>
<th>Lot 5</th>
<th>Lot 6</th>
<th>Lot 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>ground yellow corn</td>
<td>44%</td>
<td>46%</td>
<td>41%</td>
<td>51%</td>
<td>45%</td>
</tr>
<tr>
<td>wheat bran</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>wheat middlings</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>dried buttermilk</td>
<td>20%</td>
<td>10%</td>
<td>10%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>dried egg (commercial)</td>
<td>--</td>
<td>5%</td>
<td>10%</td>
<td>12.5%</td>
<td>12.5%</td>
</tr>
<tr>
<td>meat and bone scrap</td>
<td>--</td>
<td>5%</td>
<td>5%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>dried yeast</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>steamed bone meal</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
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</tr>
<tr>
<td>ground limestone</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
<td>2.5%</td>
<td>2.5%</td>
</tr>
<tr>
<td>salt</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>cod liver oil</td>
<td>1%</td>
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<tr>
<td>totals</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

per cent crude protein 15.78 15.6 17.76 15.64 16.58

Chart II. Rations, growth curves, and mortalities in Experiment 2.
weights at six weeks of males, and of females, in these two lots were compared by analysis of variance a highly significant difference was found. Based on this one experiment the protein of dried egg is superior to that of dried buttermilk.

In Lot 7 the growth was better than in Lot 6, as there was a highly significant difference between the two lots. However, as this experiment does not show what factor in the yeast was responsible for this great difference, opportunity exists here for further study.

Individual hemoglobin determinations were made on five representative males and females in each lot when the chicks were 44 days old. The mean hemoglobin values of the ten chicks in each lot from Lot 3 to Lot 7 were respectively as follows: 4.9, 4.9, 5.1, 5.3, and 5.4 grams per 100 c.c. By analysis of variance there was no significant difference among the lots. While the results of hemoglobin determinations in this experiment were considerably lower than the 7.8 and 8.9 grams found in Experiment 1, the results are not comparable as the chicks were of slightly different ages and also not of the same variety.

Owing to the paucity of work on the serum albumin and globulin of chicks' blood, and also its relationship to the pellagra-like syndrome, it was decided to make a study of this. Anding and Sinani (1) have shown among other things that in pellagra there is a tendency to a slight decrease in the serum or plasma proteins. The work reported here was done on chick blood serum following the method of Greenberg (18) with the slight modification that it was necessary to use only 0.4 mgms. of standard tyrosine solution instead of 0.8. This was because of the lower serum albumin
and globulin in the first chicks used for this work as compared to the same proteins of dog blood.

Blood analyses in this work were made with blood from four chicks, one male and three females. The mean percentage albumin was 1.65 and globulin 0.6. As these results were so decidedly different from those reported by other workers for dog blood it was thought at first our procedure was faulty. Consequently one sample of dog blood serum was divided and seven determinations were made for serum albumin and globulin using the same method except that the standard tyrosine solution contained the usual 0.8 mgs. for both analyses. The mean of these seven determinations was 3.97 per cent albumin and 1.55 per cent globulin; these results agreed with those of other workers closely enough to show that our analytical procedure was not at fault.

The results of analysis of chicks' blood serum in Experiment 2 are given in Table 2.

Table 2
Percentages of serum albumin and globulin in blood from Single Comb White Leghorn chicks in Experiment 2

<table>
<thead>
<tr>
<th>Lot No.</th>
<th>Mean percent albumin</th>
<th>Mean percent globulin</th>
<th>Number of Chicks</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.0</td>
<td>0.7</td>
<td>6</td>
</tr>
<tr>
<td>4</td>
<td>2.1</td>
<td>0.7</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>2.1</td>
<td>0.6</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>2.5</td>
<td>0.5</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>2.2</td>
<td>0.8</td>
<td>5</td>
</tr>
</tbody>
</table>

Due to the labor involved it was not possible in this first study to analyze all the samples the first day. Lots 5 and 7 were analyzed when the
chicks were 45 days old; Lots 4 and 6 at 52 days, and Lot 5 at 55 days. The lots were kept on their experimental rations until after blood samples were taken by the heart probe method.

When the results were interpreted by analysis of variance there were no significant differences in either serum albumin or globulin among the lots.

**Experiment 3**

In neither trials 1 nor 2 could the severe pellagra-like syndrome found in our previous experiments (44) be duplicated. While it was true the rations used in this present study were not exactly the same as those of our former work, it was thought the source of dried egg might be responsible. Accordingly this subject was investigated.

In most of our previous work (44) the eggs used for drying were strictly fresh and dried in incubators in the Poultry Department. For later experiments there, a commercial dried egg was used. According to the manufacturers this was dried whole egg. It may have been made from second grade eggs where the yolk and white could not be separated. Very little of this product is manufactured. In trials 1 and 2 it was found that the product used was likely a Chinese reconstituted whole egg. Reconstituted egg is made up, according to the manufacturers, of 75 per cent dried egg yolk and 25 per cent dried egg albumen. On the basis of egg analyses the mixture should be made up to consist of 65.6 per cent dried yolk and the rest albumen. As the method of making up the commercial dried egg used in our former work, as well as the different commercial dried egg used in Experiments
...
Chart III. Rations, growth curves, and mortalities, in Experiment 3.

25 chicks to a lot started 1/26/35. White Rock chicks.

<table>
<thead>
<tr>
<th>Lot</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>ground yellow corn</td>
<td>27</td>
<td>27</td>
<td>33.4</td>
<td>27.4</td>
<td>32</td>
</tr>
<tr>
<td>wheat bran</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>wheat middlings</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>pulverised whole oats</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>dried whole egg sample 1</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>dried whole egg sample 2</td>
<td>--</td>
<td>15</td>
<td>--</td>
<td>--</td>
<td>15</td>
</tr>
<tr>
<td>dried egg albumen</td>
<td>--</td>
<td>--</td>
<td>8.6</td>
<td>8.6</td>
<td>--</td>
</tr>
<tr>
<td>dried buttermilk</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>--</td>
</tr>
<tr>
<td>ground limestone</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>salt</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>cod liver oil</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>6</td>
<td>--</td>
</tr>
</tbody>
</table>

2 Refers to number of chicks, male and female together, living through the six weeks of the experiment.
chicks, the sexes were grouped together in computing the growth means.

Table 3

Partial data of Experiment 3, chicks 6 weeks of age

<table>
<thead>
<tr>
<th>Lot Number</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean weight at six weeks</td>
<td>289</td>
<td>322</td>
<td>128</td>
<td>121</td>
<td>288</td>
<td>105</td>
</tr>
<tr>
<td>Per cent mortality</td>
<td>48</td>
<td>38</td>
<td>54</td>
<td>55</td>
<td>20</td>
<td>72</td>
</tr>
<tr>
<td>No pellagra syndrome, number of chicks</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Slightly rough feet, number of chicks</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Slight pellagra syndrome, number of chicks</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Severe pellagra syndrome, number of chicks</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>5</td>
<td>2</td>
<td>7</td>
</tr>
</tbody>
</table>

A glance at Chart III shows that the crude protein from 8.6 per cent dried egg albumen, even when supplemented with dried buttermilk, or with milk and yeast, produced markedly inferior growth to that secured from the same amount of protein from dried egg. Egg yolk not only contains better protein or some growth factor which markedly accelerates growth, but also a factor tending to prevent the pellagra syndrome. When analysed by variance there were no significant differences in the growth of Lots 10, 11, and 13.

Weights of Lots 8, 9, and 12 when analyzed by variance showed a significant difference. There was no significant difference between Lots 8 and 12, or between Lots 9 and 12. The significant difference was found to be between Lots 8 and 9. The better growth of the latter lot, which was fed
reconstituted dried egg and dried buttermilk, probably was due to the larger percentage of dried egg yolk in the reconstituted egg as compared to the whole dried egg or Sample 1.

The pellagra syndrome in Lots 8 and 9 was less severe than in our previous experiments (44) even though the ration fed Lot 8 was the same as used in that work.

Serum albumin and globulin were determined in five chicks in Lot 11 and four in Lot 15 when they were 44 days of age; and in nine chicks in Lot 9 when they were 47 days old. Due to the labor involved it was impossible to run all the chemical determinations of the three lots on the same day, but chicks were always kept on their proper experimental rations until after the blood samples were taken. Table 4 gives the results of these determinations. The chicks in Lots 11 and 15 were so small that it was necessary to pool blood in some few cases to get the required quantity. In Lot 11 two chicks were used for one pooled sample and a duplicate of this determined. This meant that while five chicks were used two of the samples were pooled and duplicates. In Lot 15 three chicks were used for one pooled sample, this procedure was duplicated for a second. From only one chick was sufficient blood obtained to yield another blood sample of sufficient size. While too few chicks were used in Lots 11 and 15 for dependable results as measured by blood determinations, such results offer suggestions for further study. When Lots 9, 11, and 15 were analyzed statistically there were no significant differences in the albumins. In the globulins differences were all significant except between Lots 9 and 15.
Table 4
Serum albumin and globulin in three lots of Experiment 3

<table>
<thead>
<tr>
<th>Lot Number</th>
<th>9</th>
<th>11</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of chicks</td>
<td>9</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Number of samples</td>
<td>9</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Mean percent albumin</td>
<td>5.5</td>
<td>5.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Mean percent globulin</td>
<td>0.7</td>
<td>0.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>

The percentages of globulin found in this experiment were close to those of Experiment 2, but the albumin was considerably higher. As up to this time serum albumin and globulin had not been determined on any "normal" chicks, except possibly those of Lot 3, no comparisons could be made except with blood from chicks in the second trial.

Experiment 4

This experiment was primarily to secure "normal" chicks for serum albumin and globulin determinations. However, as 110 Single Comb White Leghorn chicks were available, it was decided to divide them into two lots to study the value of adding two per cent of sea sand to one of the rations, as both of these were relatively high in fibre. Reference to Chart IV shows rations, growth curves, and mortalities for the six weeks of the experiment.

Lot 14 was made up of 56 chicks at the start and Lot 15, 54 chicks. As Upp (46) has shown that day-old chick weight is an unreliable index of
56 chicks in Lot N: 54 chicks in Lot O. started 2/14/35. S.C.W.L. chicks.

Chart IV

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Lot 14N</th>
<th>Lot 15-0</th>
</tr>
</thead>
<tbody>
<tr>
<td>ground yellow corn</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>wheat bran</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>wheat middlings</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>ground whole oats</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>meat and bone scrap</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>dried buttermilk</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>salt</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>white sea sand</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>cod liver oil</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

As well as supplying "normal" chicks for serum albumin and globulin determinations, this trial is a study of the effect of sand for grit in rations containing large amounts of fibre (20% ground oats, etc.) for battery brooded chicks.

Chart IV. Rations, growth curves, and mortalities, in Experiment 4.
weight at two, four, or twelve weeks, the chicks in this experiment were not weighed at the start, but sorted at random into two lots. The chicks were weighed at two weeks of age and wing-banded then. They were weighed only once more, at six weeks of age. At this time males in Lot 14 averaged 418 grams and those in Lot 15, 415 grams. There was of course, no significant difference between these two means. Females in Lot 14 averaged 362 grams and those in Lot 15, 400 grams. There was a statistically significant difference between the means of the females. Additional work would be necessary before conclusions could be drawn as to the value of adding sand to such a ration. This was not followed up as it was not primarily a part of this study.

To get so-called normal serum albumin and globulin values in Single Comb White Leghorn chicks at eight weeks of age determinations for these proteins were made on ten chicks from Lot 14. These results were needed to compare with blood proteins from chicks affected with the pellagra syndrome. By using the ratio of the standard deviation to the significant mean difference it had been found that ten chicks supplied an ample number of observations. While growth records of Lot 14 were not kept after the chicks were six weeks old, the chicks were fed their usual ration until after blood samples had been taken. Table 5 shows results of this work.

These results are decidedly different from those obtained in Experiment 2, where the means of the albumin in the five lots tested ranged from 2 to 2.3 per cent. While the results are not strictly comparable due to the slightly different ages of the chicks from which blood samples were
Table 5
Serum albumin and globulin in normal eight week Leghorn chicks from Lot 14

<table>
<thead>
<tr>
<th>Chick Number</th>
<th>Percent Albumin</th>
<th>Percent Globulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>3.28</td>
<td>0.33</td>
</tr>
<tr>
<td>4</td>
<td>3.41</td>
<td>0.34</td>
</tr>
<tr>
<td>4</td>
<td>3.75</td>
<td>0.34</td>
</tr>
<tr>
<td>14</td>
<td>3.64</td>
<td>0.54</td>
</tr>
<tr>
<td>22</td>
<td>4.58</td>
<td>0.49</td>
</tr>
<tr>
<td>13</td>
<td>4.43</td>
<td>0.39</td>
</tr>
<tr>
<td>5</td>
<td>5.90</td>
<td>0.99</td>
</tr>
<tr>
<td>16</td>
<td>4.28</td>
<td>0.54</td>
</tr>
<tr>
<td>23</td>
<td>4.28</td>
<td>0.24</td>
</tr>
<tr>
<td>30</td>
<td>4.21</td>
<td>0.45</td>
</tr>
</tbody>
</table>

Mean + P.E. 4.18 ± 0.5  0.44 ± 0.14

obtained they are suggestive that the ration does have a marked effect in altering the blood serum albumin.

To compare the serum albumin and globulin of blood of eight week Leghorn chicks with that of Leghorn hens, the globulin was determined in the serum of nine hens, and the albumin in eight of these. The hens used were all one or more years old and probably not laying. The mean percentage albumin was 2.2 and the globulin 1.7. From these results it is obvious that great changes occur in these two blood proteins due to age as well as to feed and this subject might be investigated much further.

Experiment 5

This experiment was a brief trial based on the results of Sabry (36, 37) as applied to chicks. He has reported pellagra in human beings as a toxemia due to his theorized dihydroxyphenylalanine. Ten e.e. daily of a ten
per cent solution of sodium thiosulphate when given to pellagrins intra-
venously for from 20 to 60 days showed remarkable results in treating
this disease.

Sixteen Single Comb White Leghorn chicks were started February 23,
and were fed the ration given to Lot 13 which had produced such poor
growth and severe pellagra. In addition to this ration chicks were fed
sodium thiosulphate, $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$, throughout the experiment in their
drinking water. The thiosulphate was fed on a body weight basis, using
one-tenth as much as had been injected in man, in an attempt to prevent
pellagra or the pellagra syndrome in the chicks. One c.c. of the ten
per cent solution was fed daily per chick. While measurements were accu-
rate, intake varied to some extent due to variation in the amount of the
drink used.

Reference to Chart V gives the rations used and shows the growth re-
results of the six chicks which were all that lived to six weeks, as com-
pared to normal Leghorn growth. All of the surviving six chicks showed
the pellagra syndrome in severe form so the method of using sodium thio-
sulphate as practiced in this brief trial had no effect in preventing this
trouble. None of the heavy mortality occurred before the seventeenth day
so that it was probably all due to the ration.

Experiment 6

Studies with Dried, Dried Heated, and Liquid Egg Albumen

This experiment in which 21 White Rock chicks were used in each of
four lots was a further study of the feeding value of commercial dried
13 chicks to this lot, started 2/23/35. S.C.W.L. chicks.

Lot P 16

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>ground yellow corn</td>
<td>30.4</td>
</tr>
<tr>
<td>wheat bran</td>
<td>10</td>
</tr>
<tr>
<td>wheat middlings</td>
<td>15</td>
</tr>
<tr>
<td>pulverized oats</td>
<td>20</td>
</tr>
<tr>
<td>dried egg albumen</td>
<td>8.0</td>
</tr>
<tr>
<td>ground limestone</td>
<td>1</td>
</tr>
<tr>
<td>salt</td>
<td>1</td>
</tr>
<tr>
<td>cod liver oil</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

1 c.c. of 10% solution of sodium thiosulphate daily per chick was fed in the drinking water throughout the experiment.

Chart V. Ration and mortality of Experiment 5. Growth in this Lot 16 as compared to growth of "average" Leghorn chicks.
egg albumen as well as of liquid egg albumen.

Lot 17 was a repetition of Lot 15 where 8.6 per cent dried egg albumen was the sole source of animal protein. As the total calcium and phosphorus was low in these rations, for Lot 18 two per cent of steamed bone meal was added, at the expense of yellow corn, to see if this addition would be of any value.

Lot 19 was fed liquid egg albumen from strictly fresh eggs. In separating the yolks from the whites extreme care was taken that the albumen was never contaminated by even the slightest amount of yolk. Sixty-two per cent of liquid albumen supplied the same protein as that obtained from 8.6 per cent of the dried product. The liquid albumen was mixed fresh twice daily with 38 per cent of the basal ration. The latter was the same as that fed to Lot 18 except that the dried egg albumen had been omitted.

Lot 20 was fed the same ration as Lot 18 except that the commercial dried egg albumen used had been heated for 16 hours at 106 degrees C.

Reference to Chart VI shows rations used, computed calcium and phosphorus in the rations, growth curves, and mortalities for the experiment.

At six weeks of age the mean weights of the very limited number of chicks which survived the experiment did not differ significantly. Merely a glance at Chart VI shows the markedly inferior growth of all lots. Growth was so poor it was impossible to distinguish the sex of the chicks at six weeks without making post mortem examinations.

In Lot 17 the seven surviving chicks all had severe to very severe pellagra-like symptoms. Often the chicks' feet showed such severe emaciation that it appeared as though nothing but skin and bones were present. This
Chart VI. Rations used, computed calcium and phosphorus in the rations, growth curves, and mortalities in Experiment 6.
hand an exercise with the CRF.

one or the other by the patients and the week
see more of the symptoms, but none of the cases
was shown on the symptoms of the syndrome
are very severe, but only the CRF. They were never reported on the combination, because it was shown that weeks of the ages
when they showed no symptoms whatever, to verify some information on the
and the patients were never reported on the combination of weeks of the ages
and the patients were never reported on the combination of weeks of the ages,
and the patients were never reported on the combination of weeks of the ages.

To determine if others from the above experiment were performed.

Geoffrey Tacker

needed was said. It was deepened in the combination of weeks of the ages,

It is believed that these and previous experiments that may

In the experiment, the measurements are not

these combination of weeks of the ages, were very

In lot 13, of the CRF. The CRF symptoms were very

would be necessary to check these as do few others reported

mismarked on the paper, we examined so lot 17, plus additivity work

without contact of the patients, as examined so lot 17, plus additivity work

the CRF symptoms. The men have been due to the change in the

bottom of the feet. In lot 16, the cells symmetrically altered and show

manifestation was seen opposite within any area of excision of the
It seems evident judging from this one trial that chicks affected
with the pellagra syndrome can recover when they are fed a complete ration
and that they are not permanently injured as evidenced by growth and
external appearances.

Experiment 7

Trials with Coagulated and with Coagulated Dried Albumen

As several investigators previously referred to have shown that coag-
ing egg albumen reduced its toxicity as measured by rat feeding experiments
it was decided to try to duplicate these results using chicks as experi-
mental animals.

Fifteen Single Comb White Leghorn chicks were used in each of two
lots for this experiment which was started April 5, 1935. Lot 21 was fed
62 per cent of coagulated egg albumen, made by boiling either fresh eggs,
or infertile eggs from incubators. The coagulated albumen was carefully
separated from the yolk and mixed with 38 per cent of the basal ration.
This ration was the same as used for Lot 19. Sixty-two parts of such al-
bumen were designed to supply the same protein as 8.6 parts of dried albu-
men. The ration fed to Lot 21 was mixed twice daily for the first four
weeks of the experiment, and three times daily for the remaining two weeks.

The coagulated dried albumen fed as the only animal protein to Lot 22
was prepared as follows: Fresh or infertile eggs were boiled hard and the
albumen very carefully separated from the yolk. The coagulated albumen,
after it was minced into rather small pieces, was then thoroughly dried at
150 degrees C. This resulted in a dark brown very hard product. Only with
some difficulty was this finely powdered for use. Eight and six-tenths parts of this coagulated, dried, powdered albumen were made up to 100 with basal ration 19. This ration was kept in front of the chicks of Lot 22 at all times.

In Lot 21, 62 parts of coagulated albumen, which contained 53.4 parts of water, were made up to 100 with the basal ration. This resulted in a ration containing 8.6 per cent of coagulated dried albumen, exclusive of water. Both Lots 21 and 22 therefore contained 8.6 per cent of coagulated egg albumen, on a dry weight basis.

Reference to Chart VII shows rations, growth results, and mortalities for this trial. At six weeks males in Lot 21 averaged 194 grams while those in Lot 22 had a mean of 339 grams. There was a highly significant difference between the two lots of males. Similarly where the average weights of females at six weeks in Lots 21 and 22 were 127 and 311 grams respectively, there was a highly significant difference between these means. Based on the protein content of the two rations the superior growth of chicks in Lot 22 cannot be explained from this experiment although it is possible that Lot 21 did not get sufficient feed, particularly for the first four weeks. While an effort was made to have feed in front of these chicks at all times this was not always possible because of the unusually great feed wastage. In addition the high moisture content of this ration possibly precluded optimum feed consumption.

The chief interest in this trial, however, was the occurrence of the pellagra syndrome. None of the chicks in either of the lots showed any evidence of this trouble whatever. This substantiated the work of others with
15 chicks to a lot, started 4/3/35.

<table>
<thead>
<tr>
<th></th>
<th>Lot 21</th>
<th>Lot 22</th>
</tr>
</thead>
<tbody>
<tr>
<td>ground yellow corn</td>
<td>36.4</td>
<td>36.4</td>
</tr>
<tr>
<td>wheat bran</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>wheat middlings</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>pulverized oats</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>coagulated egg albumen</td>
<td>62</td>
<td>8.6 dried at 100 deg. C.</td>
</tr>
<tr>
<td>ground limestone</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>steamed bone meal</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>salt</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>cod liver oil</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

62 gr. coagulated egg albumen contained the same protein as 8.6 gr. coagulated dried egg albumen.

Chart VII. Rations, growth curves, and mortalities, for Experiment 7.
rats, that coagulating the egg albumen before feeding destroyed some toxic
property which undoubtedly exists in raw egg albumen, either fresh or dried.
DISCUSSION

This experimental work opens up a new field in that it shows the need for a much more detailed study of the nutritional value of eggs. Previous work has been confined for the most part to a study of the albumen. While a study of the albumen is important because of the increasing use of this product, as well as dried yolk, in bakeries, a study of the whole egg should be more extensively pursued.

As only a very small part of the eggs produced in this country are used for drying it does not seem reasonable to emphasize too much the deficiency of only one part, namely the albumen. This study definitely shows that dried egg is nutritionally a much more complete product than dried albumen and therefore the suggestion is made that dried eggs should be used as an entity and not separately in the form of dried yolk and dried albumen.

However, this involves a problem concerned in the manufacture of dried eggs. The dried egg business in this country is relatively new, consequently changes have been made and are to be expected. Egg yolk is usually dried by the spray process at a temperature of 160 degrees Fahrenheit. Egg albumen is dried in shallow pans at 150 degrees, as this product has not yet been dried successfully by the spray process. When an order for dried egg is obtained, because little of this is used as compared to yolk and albumen separately, it is reconstituted by mixing 75 per cent of yolk and 25 per cent albumen. As mentioned before these proportions are not correct to represent whole dried egg. It may be that later eggs can be dried successfully without separation of the two constituents and the resulting product
more generally used.

Some of the results obtained in this work may be masked due to the use of different varieties of chicks in some of the experiments. Undoubtedly it would have been better to use the same variety for all trials but at certain seasons of the year, because of the scarcity of hatching eggs, this is often difficult.

In these experiments two different lots of dried egg were used and it is probable that they were prepared by different methods. However, it was only because of unforseen results in some of the work herein reported that the two different samples were used. This procedure, which might be questioned, in this case resulted in findings of value that might not have been otherwise uncovered.

The value of hemoglobin determinations in a study of this kind possibly might be questioned due to the many factors which are believed to affect the results. Only very meager data are available concerning this blood constituent in chicks and as yet some of the results may be questioned due to the methods which have been used. That there is opportunity for much further work here is demonstrated by the markedly different results obtained in Experiments 1 and 2 of this study. However, it was not felt that further work on this subject was justified in this thesis as no significant differences had been found among the different lots of Experiment 2.

No studies of the values for serum albumin and globulin in chicks' blood were found. While Dyer and Roe (12) have made a detailed study of the blood of hens, their work on albumin and globulin was done on blood plasma. It was not possible therefore, to compare our findings with theirs.
Results secured in the work herein reported indicate that the ration has a marked effect on these two blood proteins. It is suggested that for further work plenty of assistance should be available so that the necessary blood samples from all lots of any experiment can be obtained and the determinations made the same day. One of the difficulties which will need to be overcome is that of obtaining sufficient blood from some chicks which exhibit the syndrome in a severe form and which are much below normal in size.
CONCLUSIONS

1. Fifteen per cent of dried egg added to a ration containing ten per cent of dried milk and five per cent of meat scraps markedly increased growth in chicks and produced only very slight indications of a pellagra syndrome.

2. While no significant differences were found among the means of the hemoglobin in Experiment 2, these results were quite different from those of the first trial.

3. Based on one experiment a ration containing dried egg as the only source of animal protein gave highly significantly better growth than one containing dried buttermilk fed at the same protein level.

4. Six per cent of dried yeast increased growth highly significantly when used to supplement a ration containing 12.5 per cent dried egg as the principal source of animal protein.

5. There is a possibility that Leghorn chicks may not exhibit the pellagra syndrome as do other varieties of chicks.

6. Different samples of dried egg gave significantly different results.

7. The crude protein from 8.6 per cent dried egg albumen, even when supplemented with dried buttermilk, or with milk and yeast, produced markedly inferior results, measured by growth and mortality, in comparison with those produced by the same amount of protein from dried egg.

8. Egg yolk not only contains some factor which markedly accelerates growth, but also a factor tending to prevent the pellagra syndrome.

9. Serum albumin and globulin in chicks and hens varied with the age of
the birds and the rations used. The relation between the pellagra syndrome and these blood constituents was not conclusive.

10. The mean percentage serum albumin of normal eight week Leghorn chicks was 4.15 - 0.5, the serum globulin 0.44 - 0.14.

11. Sodium thiosulphate as used in this experiment was of no value in preventing the pellagra syndrome.

12. Raw egg albumen from fresh eggs was just as deficient or toxic as commercial dried egg albumen whether the latter was used as sold or after heat treatment.

13. Egg albumen coagulated by boiling, either without or with additional heat treatment, when fed to chicks possessed no toxic properties.

14. Chicks showing the pellagra syndrome and stunted in growth showed complete recovery in from two to four weeks when they were fed a complete ration.
SUMMARY

A review of the literature on the feeding values of dried egg* and of egg albumen is given.

Experiments are reported with 23 lots of chicks fed commercial dried egg, and egg albumen or egg white, where these products were used both as the only source of animal protein and with various supplements. The effects of egg feeding were measured by growth, the appearance of the pellagra syndrome, and in some of the experiments by hemoglobin and blood serum albumin and globulin determinations.

When a ration containing 15 per cent of commercial dried egg is supplemented with ten per cent of dried buttermilk and five per cent of meal scraps the incidence of the pellagra syndrome is very slight and growth is excellent.

Dried egg fed to growing chicks as the only source of animal protein resulted in highly significantly better growth than a ration containing the same amount of protein from dried buttermilk. It is probable that this increased growth was not due altogether to the protein; however, the addition of yeast to the dried egg protein ration still further increased growth to a highly significant extent.

Commercial dried egg is not all prepared by the same method and different samples give different results in feeding experiments.

Dried egg albumen even when supplemented with yeast, milk, or combinations of these, in rations believed otherwise complete failed to produce

*Dried egg is used to mean whole eggs, without shell and shell membranes, dried.
The work of other investigators has substantiated the nutritional value of the.jpg
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