THE NUTRITIONAL REQUIREMENTS OF BABY CHICKS.

IV. THE CHICKS' REQUIREMENT FOR VITAMIN A.*

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When Sugiura and Benedict (1) concluded from their work with pigeons and squabs that vitamin A was not required for avian nutrition, a fundamental distinction, if true, in the nutritional requirement of birds and mammals was made. It would seem, of course, that such an observation could not go unchallenged for any length of time, especially when the entire gamut of avian life was included. Consequently, it was no surprise when a little later Emmett and Peacock (2) reinvestigated this point and produced evidence unfavorable to the sweeping conclusion of Sugiura and Benedict, but in support of the view that vitamin A is required by the chicken, which is as distinctly avian as is the pigeon.

In our experiments on the nutritional requirements of baby chicks we have had occasion to accumulate considerable data bearing on this same point and in this paper we desire to present such data, all of which is in support of the early conclusion of Emmett and Peacock that the chick does require vitamin A for its existence.

In early work with baby chicks on the use of synthetic diets (3) such as are employed with success in rat nutrition we experienced varying degrees of success. A diet carrying 37 per cent of

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dextrin, 5 per cent of a salt mixture (3), 18 per cent of purified casein, 15 per cent of dried yeast, 15 per cent of butter fat, and 10 per cent of paper did prove successful in a single trial, but in other experiments where the paper was displaced by charcoal, agar, or dirt no such success in growth followed. With increasing knowledge of the liberal demands by this species of the fat-soluble vitamins such as are contained in cod liver oil (4) it was altogether probable that our many failures and rare successes in the growth of baby chicks under confinement and on synthetic diets was to be related to the low and variable supply of the fat-soluble vitamins in the butter fats used. Further, we had no knowledge of the relation of light to the growth of this species (5) at the time of these earlier experiments, although these experiments were conducted in the basement of the poultry building where the windows were often left open and with the possibility that sufficient illumination had influenced the results in some of our more successful growth experiments. All of which serves to emphasize how slow was our progress in the development of specific knowledge of the factors operating in chicken nutrition.

With more complete knowledge of the requirements of the baby chick for growth, synthetic rations were again attempted, but in which the butter fat was displaced by cod liver oil in the proportion of 5 per cent and also with saponified cod liver oil equivalent in cod liver oil to 5 per cent of the ration. Earlier observations from this laboratory had shown the stability of vitamin A to saponification (6) and later observations (7) showed the stability of the antirachitic vitamin to this same treatment. In addition, observations in this laboratory by Steenbock and Nelson (8) had disclosed the importance of the antirachitic vitamin or its equivalent in light as a necessary factor in growth. This important observation lead to the use of ultra-violet light as an adjunct to the synthetic ration with the thought in mind that possibly growth could be secured. Ultra-violet light in 10 minute exposures per day, except Sunday, was used.

Chart I shows the results secured with these four rations; namely, the basal synthetic ration; the basal synthetic ration plus cod liver oil; the basal synthetic ration plus saponified cod liver oil; and the basal synthetic ration plus radiation. The chicks used were Barred Rocks taken at 1 day old and kept in pens
CHART I. The results secured with the basal synthetic ration; the synthetic ration plus 5 per cent of cod liver oil; the synthetic ration plus 5 per cent of saponified cod liver oil equivalent to 5 per cent of the raw oil; and the synthetic ration plus 10 minutes daily exposure (except Sunday) to the radiations from a quartz mercury lamp. The cod liver oil used displaced an equivalent quantity of dextrin in the ration.
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provided with shavings litter and artificial heat in the attic of our laboratory where no direct sunlight enters. They were fed the ration as dry mash and weighed weekly.

There was little or no growth on the basal synthetic ration; with the addition of 5 per cent of cod liver oil practically no better growth was secured. The cod liver oil was mixed directly into the ration which was made up weekly in order to minimize the effect of aging upon the vitamins of the oil. We have successfully prevented and cured rickets in chickens by the administration of cod liver oil, but it has usually been done by direct feeding with a pipette. Where the oil is mixed in the ration the appetite is adversely affected and consumption of the ration lags. Some individuals will consume such a ration, but in a group the results are likely to be distinctly variable. With saponified cod liver oil the results are generally much more uniform. The fatsoluble vitamins are introduced by its use, but certain obnoxious smelling and tasting substances are avoided. In this group by the use of saponified cod liver oil good growth was secured as shown in Chart I, but the results are certainly not optimum for the species. The data do, however, demonstrate the favorable effect on growth in this species of the fat-soluble vitamins. Where ultra-violet light was used with the basal synthetic ration little growth was secured which indicated that this species did require vitamin A which was practically absent from the ration. With the baby chick, as with other animals, there is always a variable reserve of nutritive factors at the time of hatching which can account for some of the variations in growth secured.

The problem still confronting us was how to provide vitamin A and not provide the antirachitic vitamin in the ration of the chick; thereby securing more convincing evidence of the vitamin needs of this species than we had secured up to this time. In some preliminary experiments on the use of plant tissue, either green or dried, as a source of the antirachitic vitamin in the growth of the chick it was observed that leg weakness or rickets could not be prevented in this species by the incorporation of green plant tissue (clover) equivalent to 5 per cent of the ration or as dried plant tissue (clover) in amounts varying from 0.5 to 5 per cent of the ration. The clover used was fresh green material which had been dried in a dark attic with an electric fan. Preliminary observa-
tions on the use of green plant tissue in baby chick growth have already been published (5).

HAM II. The results secured with the basal synthetic ration plus radiation; the synthetic ration plus 1.5 per cent of dried clover; and the synthetic ration plus 1.5 per cent of dried clover plus 10 minutes daily exposure (except Sunday) to the radiations from a quartz mercury lamp. The clover displaced 1.5 per cent of dextrin.

With our further knowledge that carefully dried clover contains an abundance of vitamin A (9), but in the proportion used did not
contain sufficient of the antirachitic vitamin to protect the chick from leg weakness, it seemed possible that through the use of dried clover and ultra-violet light the problem of the vitamin A requirement of the chick could be definitely settled. Consequently, groups of 1 day old chicks (Barred Rocks) were placed upon our synthetic ration plus radiation; the synthetic ration plus 1.5 per cent of dried clover; and the synthetic ration plus 1.5 per cent of dried clover plus 10 minutes of ultra-violet light daily. The records of this experiment are shown in Chart II. According to present theory the first ration should provide all the factors of nutrition except vitamin A. Vitamin C has not been demonstrated as a requirement of the chicken; the second ration should provide all the nutritional factors except the antirachitic vitamin; and the third ration should provide all the factors and allow normal growth.

The records show that in the absence of vitamin A there was complete or early failure in the nutrition of the chick. Emmett and Peacock have reported the occurrence of ophthalmias in their chicks suffering from vitamin A deficiency, but in our many trials where vitamin A has been deficient and where death has resulted when the chick was 3 to 5 weeks of age no ophthalmias have been observed. With vitamin A deficiency in the case of the chicks we have had under observation there has been loss of appetite, extreme lethargy, and sudden death. Post-mortems have not revealed anything especially distinct although occasionally there were white streaks on the surface of the liver. Such streaks have already been observed and described by Beach (10) as occurring on the surface of the heart, liver, and spleen of chickens suffering from what he has called a "nutritional roup" and which he has attributed to a deficiency of vitamin A. Emmett and Peacock have also observed similar pathological conditions in chicks suffering from vitamin A deficiency. These white streaks have been characterized as salts of uric acid. On the other hand, Osborne and Mendel have correlated vitamin A deficiency in the diet of the rat with the occurrence of phosphatic renal calculi (11).

We do not wish to be understood as entertaining the view that vitamin A deficiency never occasions ophthalmias in the chicken. Only we have not observed it in chicks on our diets at early ages.
Possibly death intervened too early. We have seen distinct ophthalmias in older birds on rations low in their content of vitamin A, but whether it was "nutritional roup" or a roup produced by specific primary infection was not determined.

FIG. 1. No. 4654 on the left. The result of no vitamin A in the ration. The ration consisted of our basal synthetic ration composed as follows: purified casein 18, salt mixture 5, agar 2, dextrin 60, dried brewers' yeast 15, and 10 minutes exposure to ultra-violet light daily except Sunday. Weight at 5 weeks of age was 62 gm. Note the sleepy appearance of this bird.

No. 4644 on the right. The result of adding the fat-soluble vitamins (saponified cod liver oil equivalent to 5 per cent of raw oil) to the synthetic ration. Weight at 5 weeks of age was 142 gm. Good growth was secured in this group. Note the alertness of this specimen. Photographed at same age as No. 4654.

On the synthetic ration containing the 1.5 per cent of dried clover and, consequently, vitamin A, but not sufficient of the antirachitic factor for this species, the animals lingered somewhat longer than in the first group. They suffered from leg weakness and died early. With both 1.5 per cent of clover (vitamin A)
and ultra-violet light (antirachitic vitamin) imposed on the basal synthetic ration growth was very successful. Some of the birds reached weights of over 300 gm. in 8 weeks.

Fig. 2. The result of adding vitamin A to the synthetic ration by the use of 1.5 per cent of dried clover and in addition raying the animals 10 minutes daily, except Sunday, with the radiations from a quartz mercury lamp. Very successful growth was secured in this group. Weight at 9 weeks of age was 425 gm. This chick is one from a group of ten specimens.

In addition to the charts, pictures of three of the chicks are presented (Figs. 1 and 2). No. 4654 received the basal synthetic ration and ultra-violet light 10 minutes daily except Sunday. Vitamin A was deficient in this ration. No. 4644 received the basal ration plus saponified cod liver oil equivalent in raw oil to
5 per cent of the ration. Both vitamin A and the antirachitic vitamin were provided in this ration and good growth was secured. No. 6030 received the basal ration plus 1.5 per cent of dried clover

plus 10 minutes radiation from a quartz mercury lamp daily, except Sunday. This ration provided vitamin A from the clover and the antirachitic factor from light and in consequence growth followed.
Chart IV. This chart illustrates the results with yellow corn plus skimmed milk. On a ration of yellow corn 97, calcium carbonate 2, sodium chloride 1, skimmed milk ad libitum, and sunlight all day, continued growth and excellent condition were secured.
While the above experiments demonstrated fully the needs of vitamin A in the nutrition of the chick, additional evidence was secured through experiments involving yellow and white corn and sunlight. Some of these experiments on the influence of light on the growth of chicks and the cure of leg weakness (rickets) have already been reported (5). It was demonstrated in 1920 by Steenbock and Poutwell (12) that yellow corn was richer in its content of vitamin A than was white corn. Although at that time there had been no differentiation between vitamin A and the antirachitic vitamin and the relation of the latter to growth, yet the distinction between the two corns in respect to their vitamin A content still remains a fact (unpublished data from this laboratory).

In July, 1923, several groups of 1 day old chicks (White Leghorns) were placed upon white corn 97, calcium carbonate 2,
sodium chloride 1, and skimmed milk *ad libitum*. Other groups were placed upon yellow corn 97, calcium carbonate 2, sodium chloride 1, and skimmed milk *ad libitum*. The environment of the several groups differed in respect to the amount and kind of light each received. In this paper consideration is given only to those two groups receiving sunlight all day, one of which was on the white corn ration while the other received the yellow corn ration.

Fig. 4. The result of feeding a ration well supplied with vitamin A. This group of nine birds was started when 1 day old on a ration consisting of yellow corn 97, calcium carbonate 2, sodium chloride 1, and skimmed milk *ad libitum*. They were exposed to sunlight the entire day. All the birds grew normally and were splendid specimens. Three of the group had been used in x-ray work and consequently only six remained for this photograph.

On the white corn ration this nutritional factor was small although some of it was contributed by the skimmed milk. On the yellow corn ration this factor was certainly more liberally provided. The birds were in screened outdoor pens with access to heat and sunlight all day, but no extraneous sources of food. The growth records of the two groups are shown in Charts III and IV.
Those receiving the white corn ration grew considerably for a time in remarkable contrast to a group on this same ration, but not receiving sunlight. This fact has already been pointed out (5). In fact, three of the group receiving sunlight continued to grow for 14 weeks, reaching weights of over 600 gm. at which point a decline in weight set in. Nutritional failure followed and finally death. Toward the end of their lives these birds were listless and sleepy in appearance with feathers slightly ruffled and soiled. There were no distinct ophthalmias in this group although an edematous condition of the eyes was seen in certain cases. The variations in growth observed in this group possibly were due to variations in the stores of reserves of vitamin A at hatching or to a difference in their ability to assimilate this factor.

Those receiving the yellow corn ration grew continuously to the termination of the experiment and the birds were judged as normal.
specimens. In fact, this simple ration, supplied under summer conditions, seemed to meet the needs of this species most adequately, especially for growth. Egg production was not involved in the inquiry. We interpret the differences in growth between the two groups as due to a difference in the supply of vitamin A in the two rations. Figs. 3 and 4 illustrate in a striking manner the condition of these groups at 14 weeks of age.

Chart V is added, illustrating the failure in growth of a companion group of chicks receiving the yellow corn ration described above, but kept in the basement of the poultry building and out of the influence of direct light. In this case although there was a supply of vitamin A, the anti-rachitic factor was inadequately supplied and, consequently, failure of complete nutrition ultimately resulted.

SUMMARY.

In this paper experiments with growing chicks are presented showing the needs of this species for vitamin A. These results are in agreement with the observations of Emmett and Peacock and contrary to the sweeping statement of Sugiura and Benedict that "fat-soluble vitamin is not essential in any stage of avian nutrition."

BIBLIOGRAPHY.

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