THE EFFECT OF COD LIVER OIL IN VARIOUS AMOUNTS AND FORMS ON THE GROWTH OF YOUNG CHICKENS.

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A number of experiments (1, 2, 3, 4) have shown that cod liver oil is an effective therapeutic agent for the prevention and cure of rickets (leg weakness) in young chickens. We have recently attempted to determine: (1) the minimal amount of cod liver oil necessary for the prevention of rickets in chickens, (2) the effect of one method of storage on the antirachitic potency of cod liver oil, and (3) whether there is any relation between the rate of growth of young chickens and the amount of cod liver oil fed.

EXPERIMENTAL.

Material and Apparatus.—Sixty single combed White Leghorn chickens from our inbred family No. 81 were hatched on January 8, 1924. When 24 hours old these chickens were weighed and divided into four equivalent lots. Each lot was placed in one compartment of a laboratory brooder table similar to the one illustrated in Bulletin 116 of this station. This table was rotated a quarter turn each day in order to equalize the amount of light received by the several lots. Heat was supplied by a 30 inch “Electro hatch” hover and the room was kept at about

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1 See Storrs Agric. Exp. Station, Bull. 111, for the history of this stock and plan of the inbreeding experiment.

2 For the first 3 weeks of the experiment it was necessary to use an improvised platform of boards in place of the rotating table illustrated. This platform was rotated one-quarter turn every 2nd day in order to equalize the amount of light received by the several lots. Windows were kept closed throughout the experiment.

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60°F. The table was covered with sheet zinc, on which was spread a thin layer of coarse washed sand. No other litter was provided.

**Feeding.**—When the chickens were 48 hours old they were given pasteurized skim milk (sweet) as drink and a light feeding of fine cracked white corn. From the 2nd until the 7th day they were fed sparingly with white cracked corn, and had skim milk before them at all times. When 7 days old they were again weighed after which the differential feeding of the four lots was begun.

The basic ration adopted for all lots was the formula devised by Hart, Halpin, and Steenbock (1) and found by them to be adequate for growth when supplemented with cod liver oil. It consisted of: white corn meal, 97 parts; calcium carbonate, 2 parts; and sodium chloride, 1 part. This ration may be regarded as practically free from the fat-soluble and antirachitic vitamins. To this we added, as roughage, 10 per cent of sifted pine sawdust, in place of the shavings used as litter by Hart and Steenbock. Supplements were added to this ration for the several lots as follows:

<table>
<thead>
<tr>
<th>Lot</th>
<th>Supplement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.5 per cent cod liver oil (Harris)³</td>
</tr>
<tr>
<td>2</td>
<td>1.0 per cent cod liver oil (Harris)³</td>
</tr>
<tr>
<td>3</td>
<td>2.0 per cent cod liver oil (Harris)³</td>
</tr>
<tr>
<td>4</td>
<td>3.0 per cent cod liver oil (Harris)³</td>
</tr>
</tbody>
</table>

Lot 1...0.5 per cent cod liver oil (Harris)³

Lot 2...1.0 per cent cod liver oil (Harris)³

Lot 3...2.0 per cent cod liver oil (Harris)³

Lot 4...3.0 per cent cod liver oil (Harris)³ which had been absorbed in starch, granulated, and held in corked bottles in the dark at about 50°F. for 6 months.

The proportions of supplements were calculated on the basis of the corn meal-salt mixture exclusive of the roughage. In mixing, the oil was poured thinly over the meal and rubbed in thoroughly by hand. The mixture of cod liver oil and starch was pulverized and thoroughly incorporated with the meal. These rations were mixed fresh every 3 days, and fed in small hoppers *ad libitum*. Skim milk was kept before all the lots throughout the experiment.

**Growth.**—The weekly average weights of these four lots from 0 to 7 weeks are given in Table I and shown graphically in Fig. 1.

³ The oil used had been stored in unopened corked bottles in the dark at about 50°F. for 6 months.
It will be noted that growth in all the lots was equal through the 3rd week, at which time the rate of growth of Lot 4, receiving dry stored cod liver oil, began to fall behind that of the three other lots.

Rickets.—This decrease in the rate of growth in Lot 4 coincided with and was probably the result of the onset of rickets in this lot. The first symptoms of rickets in Lot 4 were noted when the chickens were 16 days old. The symptoms of unsteady gait, lameness, apparent stiffness, and swelling of the leg joints appeared then in one chicken, but by the night of the 19th day had become so general and marked that several chickens could not walk to the feed hopper. These chickens (seven in number) were then (20th day) given cod liver oil by pipette at the rate of about 2 drops a day and improvement was noted in each one. Less severe cases were not given cod liver oil, and on the 23rd day four of the five remaining were prostrated. The four prostrated chicks were then given cod liver oil by pipette at the rate of about 2 drops a day and improvement was noted in each one.

### TABLE I.

Average weights of chickens reared in the laboratory on a basic ration of skim milk, white corn meal, and sawdust, supplemented by various amounts of cod liver oil.

<table>
<thead>
<tr>
<th>Age (wks)</th>
<th>Lot 1 (0.5 per cent cod liver oil)</th>
<th>Lot 2 (1 per cent cod liver oil)</th>
<th>Lot 3 (2 per cent cod liver oil)</th>
<th>Lot 4 (1 per cent cod liver oil stored in starch 6 mos.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weight (g)</td>
<td>No. surviving</td>
<td>Weight (g)</td>
<td>No. surviving</td>
</tr>
<tr>
<td>0</td>
<td>33.0</td>
<td>13</td>
<td>32.9</td>
<td>13</td>
</tr>
<tr>
<td>1</td>
<td>37.8</td>
<td>13</td>
<td>37.6</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>58.2</td>
<td>13</td>
<td>59.3</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>82.3</td>
<td>13</td>
<td>82.8</td>
<td>13</td>
</tr>
<tr>
<td>4</td>
<td>110.6</td>
<td>13</td>
<td>109.8</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>138.9</td>
<td>13</td>
<td>136.8</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td>176.7</td>
<td>13</td>
<td>168.4</td>
<td>12</td>
</tr>
<tr>
<td>7</td>
<td>210.2</td>
<td>13</td>
<td>207.6</td>
<td>12</td>
</tr>
<tr>
<td>7*</td>
<td>215.9</td>
<td>13</td>
<td>214.5</td>
<td>12</td>
</tr>
</tbody>
</table>

*Weights at 7 weeks reduced to male basis, according to the numbers of males and females in each lot.
trated chicks were then given 2 drops each of cod liver oil, and three of them recovered the use of their legs and were eating normally on the 25th day. One completely prostrated chicken died soon after treatment, possibly from oil which had entered the trachea. All other chickens recovered. On the 26th day administration of oil by pipette was discontinued, and cod liver oil was added to the ration as 2 per cent of the meal-salt mixture. After the 28th day, no further symptoms of rickets were noted in this lot and they continued to grow at rates approxi-

![Diagram](http://www.jbc.org/)  
**FIG. 1.** Comparison of growth of chickens on a standard ration free from the fat-soluble and antirachitic accessory factors supplemented by various amounts of cod liver oil.

mating those of the other lots, although they did not recover the weight lost during the attack of leg weakness. No symptoms of rickets were noted in any of the other lots. It is apparent then that cod liver oil absorbed in starch and stored as described had lost its antirachitic potency; while unmixed oil held for the same time and under the same conditions was both a preventive and a cure for rickets.

**Mortality.**—In addition to the one death noted in Lot 4, four other chickens died during the course of the experiment. One
chicken in each of Lots 3 (2 per cent cod liver oil) and 4 (1 per cent cod liver oil in dry mixture) died when 1 week old. This was before differential feeding of the lots began and death was probably due in each case to crowding or chilling. One chicken in Lot 2 (1 per cent cod liver oil) died in the 6th week apparently from deposition of fat in the pericardium. It showed no ante-mortem or postmortem symptoms of rickets. One chicken in Lot 3 (2 per cent cod liver oil) died in the 5th week. Cause of death could not be ascertained. All other chickens grew well and, with the exception of one death from impaction of the crop, are now alive (14 weeks old). The males have been successfully maintained in the laboratory on the ration described above, supplemented by cod liver oil in amounts of from 0.125 to 1 per cent of the ration.

Comparison of Growth on Various Amounts of Cod Liver Oil.—The rations described above were continued until the chickens were 7 weeks old. The graphs in Fig. 1 show that the growth of the chickens receiving 0.5, 1, and 2 per cent of cod liver oil was approximately equal through the 7th week. The graphs illustrating the growth of the different lots are not directly comparable one with another, because of the different proportions of male and female chickens in the several groups. It is known that male chickens gain weight at a somewhat greater rate than females.\(^5\) From other data it has been estimated that the weights of male and female White Leghorn chickens of our stock are about equal up to 3 weeks of age. Thereafter, the females gain less rapidly than the males, until at 7 weeks of age the female weight is about 90 per cent of the male weight. In order to correct for this difference all the 7th week weights have been reduced to the male basis according to the number of males and females in each group. The comparison of the weights so corrected is shown in the last line of Table I. It is evident that there are no significant differences in weight between the lots which received 0.5, 1, and 2 per cent of cod liver oil.

The corrected weight of Lot 4 which had received the starch-stored cod liver oil was significantly less than that of the other groups. Later weighings for 6 weeks showed that this group

\(^5\) Jull (5) and unpublished data at this station.
failed to make up the weight lost during the attack of leg weakness, even when transferred to a normal ration supplemented by cod liver oil.

The *Minimal amount* of cod liver oil which is necessary to prevent rickets during the first 7 weeks is shown by the above results to lie below 0.5 per cent of the food intake and additional amounts in excess of 0.5 per cent appear to yield no further antirachitic or growth-promoting effects. The actual amounts of cod liver oil consumed by the chickens which received cod liver oil as 0.5 per cent of their solid food intake are as follows:

<table>
<thead>
<tr>
<th>Age (wks.)</th>
<th>Cod liver oil per chicken per day (mg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
</tr>
<tr>
<td>3</td>
<td>43</td>
</tr>
<tr>
<td>4</td>
<td>56</td>
</tr>
<tr>
<td>5</td>
<td>57</td>
</tr>
<tr>
<td>6</td>
<td>81</td>
</tr>
<tr>
<td>7</td>
<td>89</td>
</tr>
</tbody>
</table>

The minimal amounts necessary apparently lie below the amounts as given.

We have obtained other evidence which indicates that the minimal amount lies between 0.5 and 0.25 per cent of the solid ration for chickens less than 6 weeks old. A group of fourteen chickens from the same family as those in the previous experiment was hatched on January 31, 1924, and was treated and fed like those above except that they received cod liver oil as 0.25 per cent of their meal-salt ration. Symptoms of rickets appeared in this lot on the 26th day, but were confined to half of the chickens in the group. Cod liver oil by pipette effected a cure of this condition and no mortality was experienced until the 6th week, when several chickens died although apparently not from rickets. Because of the individual variation in the occurrence of rickets and the mortality which later occurred we prefer to limit our conclusions from this group to the inference that cod liver oil as 0.25 per cent of the ration is near the minimal amount. It will probably be impossible to measure accurately...
the minimal preventive dose of cod liver oil with the methods of group feeding which we have employed because of the individual variation in food consumption and consequently in the amount of oil ingested. For practical purposes we may say that the minimal amount lies between 0.5 and 0.25 per cent of the dry ration. This means that the actual amounts of cod liver oil required by the average chicken is between 25 and 50 mg. per day at 4 weeks of age, the age of maximum incidence of rickets under the conditions outlined above. Other evidence shows that this requirement is subject to variation among individuals, and varies also with age and several factors of the environment.

Experiments designed to measure cod liver oil requirements of older chickens, and their ability to store the antirachitic substance, are now in progress.

CONCLUSIONS.

We interpret the results set forth above as showing:

1. That cod liver oil fed as 0.5 per cent of a ration which is free from the fat-soluble and antirachitic substances, but which contains proper nutrients, salts, water-soluble vitamin, and about 10 per cent of fiber, is sufficient to prevent rickets in chickens reared in strict confinement indoors. The minimal average requirement of the chickens used appears to be between 0.25 and 0.5 per cent of the ration for the first 6 weeks.

2. Addition of increments of cod liver oil above 0.5 per cent of the ration does not increase either the growth rate or protection against rickets.

3. The antirachitic potency of cod liver oil deteriorates or disappears after storage in a granulated starch mixture.⑥

The successful maintenance of a number of chickens in strict confinement in the laboratory, with growth approximating that attained by the same stock out of doors, and a mortality which is much lower than that usually encountered under range conditions, is a further demonstration of the possibility and economy of rearing chickens in confinement, both for scientific and for practical purposes.

⑥ A test of this preparation by Dr. T. B. Osborne in feeding experiments with rats showed that the antixerophthalmic potency of the oil had also disappeared under this method of storage (personal communication).
We wish to acknowledge our indebtedness to Dr. T. B. Osborne for his kindly cooperation and advice throughout these experiments, and to Dr. I. F. Harris for his advice and kindness in the preparation of some of the materials used.

BIBLIOGRAPHY.

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