same experiment, and since the only difference between these two media lies in the fact that the latter contains less phosphate, it seems probable that if the medium variables of No. 6 were to be used in presence of C.S.L. and with nitrate at its lowest level, results would be obtained equal to the best shown in Table III. This point was not tested experimentally, however, since, for obvious reasons, there had to be a limit set to the number of arbitrary treatments which could be devised and undertaken within a reasonable period of time.

It is of interest to compare the favourable influence of C.S.L. on cultures of *P. soppii* with the effects which followed the use of C.S.L. in media employed by Gad & Walker[4] for cultivation of *Penicillium spinulosum* and of *Penicillium javanicum*. In cultures of *P. spinulosum*, C.S.L. promoted fat synthesis; in cultures of *P. javanicum*, C.S.L. either depressed the yield of fat or was without sensible influence upon it. The present authors have observed (unpublished data) that C.S.L. is detrimental to the production of fat by *Fusarium lini*.

Acknowledgments

One of the authors (S. M.) desires to thank the Medical Research Council for a personal grant to enable her to participate in this work, which forms part of a programme of research undertaken at the suggestion of the Committee on Chemical Microbiology.

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Received 14 September, 1955

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FAT IN POULTRY NUTRITION. I.—The Chick from Hatching to Five Weeks of Age

By A. L. DAVIDSON

Although it has been generally agreed that the use of fat in poultry rations has some value, the scientific papers which have been published so far provide quite a number of contradictory results. This paper shows that where a proper balance is maintained between the various nutrients in the ration, particularly in the protein/total digestible nutrient ratio, high levels of fat consistently improve efficiency of feed conversion and growth rate.

Introduction

Previous research into the use of fat in poultry rations has developed roughly along two lines. Firstly, natural fats have been considered simply as natural sources of growth-promoting factors such as vitamins A, D, E, and certain essential unsaturated fatty acids. Along the second avenue of research, fats have been treated as a concentrated source of energy in the diet, but here results have been somewhat inconclusive.

Carver & Johnson[1] have shown that chicks maintain normal health and viability on a ration containing as little as 0·04% of fat. In this study, the fat was acting as a source of essential growth factors in the form of unsaturated fatty acids. The fat contributed a negligible amount to the energy value of the feed. Russell, Taylor, Walker & Polskin[2] in their studies on the absorption and retention of carotene and vitamin A in rations of low and normal fat content showed that the absorption of carotene was improved by the presence of fat in the ration, and that the retention of vitamin A in the liver was less in birds which received the low fat ration.

The use of fat to increase the energy value of feeds with the intention of improving feed efficiency and growth rate has been studied by many workers. A method of assessing the value of fat from nutritional studies has been published by Rice *et al.*[3] Henderson & Irwin[4] published a report on the tolerance of chickens for the rations containing levels of soya-bean oil up to 22%. They found that levels above 10% had a marked depressing effect on growth rate. The tolerance of chicks and hens for very high levels of fat in their diet has been reported by several workers—Cruickshank[5] and Buckner *et al.*[6] An excellent review of work done on fat nutrition has been given by Wilcke.[7]

The reason for the conflicting evidence published appears to depend on whether or not attention has been given to maintaining a proper balance between energy and protein. If the fat is used in wrongly constructed rations, lower food intake may result in insufficient assimilation of other growth factors. In a few cases only, have protein levels been amended when fat has been added to the ration.

In the series of experiments described in this paper, the first necessity was to establish the proportion of total digestible nutrients (T.D.N.) which had to be present as protein in order to obtain maximum rate of live-weight gain. The result obtained in this experiment was then used in balancing rations for further experiments. By using rations constructed with optimum T.D.N./protein ratios, it was possible to establish that the addition of fat to poultry rations leads to successive increases in growth rates and improvements in feed conversion.

Experimental

Heavy-cross (R.I.R. × L.S.) cockerels obtained from local hatcheries have been used throughout these experiments. Twenty-five cockerels were used in each treatment and allocated to the test groups by standard procedure. Electrically heated wire floor brooders were used to house the birds, food and water being supplied *ad lib.*

Experiment 1

The object of this experiment was to determine the effect that altering the ratio of total digestible nutrient to crude protein had on the growth rate and feed efficiency of young chicks. The basal ration used in this test is shown in Table I.

Table I

	Parts
Ground wheat	60·0
Ground barley	20·0
Ground oats	20·0
Mineral mixture	3·0
Cod liver oil	2·0
Vitamin B supplement	0·125

The basal ration comprised 80% of each of the four test rations which were designed as shown in Table II. The protein content of the ration was varied, using good quality white fish meal.

Table II

Ration No.	Parts: Basal ration	Parts: White fish meal	Parts: Ground wheat
1	80	5	15
2	80	10	10
3	80	15	5
4	80	20	0

The results obtained after feeding for 5 weeks are shown in Table III. This Table also shows total digestible nutrients (T.D.N.) and crude protein (C.P.) content (determined by Kjeldahl method) and the ratio of these two figures (R) in the test ration. [T.D.N. = sum of digestible protein, carbohydrate, fibre and 2·25 × % digestible oil, values being taken from the literature.]

Table III

Ration No.	Weight increase g.	Food conversion	T.D.N. of ration	C.P. of ration	$R = \frac{T.D.N.}{C.P.}$
1	184	4·2	75·9	12·94	5·9
2	275	3·8	75·5	16·59	4·6
3	325	3·3	75·0	19·24	3·9
4	304	3·4	74·6	21·88	3·4

From these results it is seen that no advantage could be obtained by adding more than 15% of white fish meal to a ration of this type, and that maximum growth rate therefore resulted when the ration contained 1 unit of protein in every 4 units of total digestible nutrients (R = 4).

Experiment 2

Using the results obtained in the first experiment, rations were designed containing fat and protein in varying amounts so as to have R values in the range from 3·4 to 4·5. The basal ration used in this test was similar to that of experiment 1 except that the cod liver oil was omitted, as synthetic vitamins A and D were used in the non-fat diets and cod liver oil was part of the fat mixture in the high fat rations.

The test rations are given in Table IV.

Table IV

Ration No.	Parts				
	Basal ration	White fish meal	Ground wheat	Vitamins A and D	Fat mix*
5	80	15	5	Synthetic	—
6	80	20	—	,,	—
7	80	15	—	—	5*
8	80	20	—	—	4·5*

* Fat mix—Blend of cod liver oil and vegetable oil to give 1% cod liver oil in the ration and the same vitamin potency as the synthetic vitamins used in rations 5 and 6. The cod liver oil contained 750 i.u. of vitamin A/g. and 75 i.u. of vitamin D/g. Synthetic vitamins were added to give the same potency in the blend as in the cod liver oil.

From the balance of these rations and the results obtained in the first experiment, it would be expected that rations No. 5 and No. 8 would give the best growth rate and feed efficiency; that ration No. 6 being too low in T.D.N. would give a poorer growth rate and that ration No. 7 with 5% added fat would be the poorest of all, as the replacement of wheat by fat unbalances even more a ration with this T.D.N./C.P. relationship.

The results obtained are shown in Table V.

Table V

Ration No.	Weight increase g.	Food conversion	T.D.N. of ration	C.P. of ration	$R = \frac{T.D.N.}{C.P.}$
5	351	3·26	75·9	19·24	4·0
6	351	3·26	74·6	21·88	3·4
7	328	3·40	87·0	19·30	4·5
8	366	3·00	83·8	20·95	4·0

The results obtained in this test were more or less those that were envisaged. Ration No. 6 did not give the poorer results expected, but nevertheless the use of a higher protein feed did not give the improved results which are often associated with increased protein content of the diet. The experiment demonstrated how contradictory results can be obtained by adding fat to rations, as Ration No. 7 with added fat gave the worst results in the test, whereas Ration No. 8, also with added fat, gave the best, showing good growth rate and feed efficiency. The necessity of maintaining a correct T.D.N. to C.P. balance is of the utmost importance in obtaining the maximum benefit from added fat, and in designing a high production ration.

Experiment 3

This experiment was designed along the same lines as Experiment 2, but here a higher level of fat was used to see whether the previous conclusion held for still higher energy rations.

The basal diet was the same as that used in previous experiments, with test groups constructed as shown in Table VI.

Table VI

Ration No.	Parts		
	Basal ration	White fish meal	Fat mix*
9	80	20	—
10	80	20	4·5
11	80	30	—
12	80	30	13·0

* Fat mix—Blend of cod liver oil and vegetable oil to give 1% of cod liver oil in the ration and the same vitamin potency as synthetic vitamins used in Rations 9 and 11. (See also note under Table IV.)

Having regard to their R value, rations No. 10 and No. 12 should give the best results, as the other rations were not balanced for energy. The weight increases and feed efficiencies are given in Table VII.

Table VII

Ration No.	Weight increase g.	Food conversion	T.D.N. of ration	C.P. of ration	$R = \frac{\text{T.D.N.}}{\text{C.P.}}$
9	435	3·23	74·6	21·8	3·4
10	450	2·60	83·8	20·9	4·0
11	416	3·52	74·0	25·8	2·9
12	477	2·50	93·8	22·8	4·0

From this test it is apparent that higher levels of fat—to which the cod liver oil has contributed as well as providing vitamins A and D—lead to still greater rates of live-weight gain and feed efficiency.

Discussion

The experiments described give a method of preparing balanced rations with high levels of fat. By establishing the correct proportion of T.D.N. which has to be present as crude protein, balanced rations containing varying levels of fat with an adjusted protein content can be calculated.

The experimental evidence shows that it is a fallacy to assess the value of fat in a ration by comparing the ration plus fat with the same basal ration without fat, as two quite differently constructed rations are being compared, because of the effect of the high energy value of the fat. The true value of fat in a poultry feed can only be assessed when the effect of rations of equivalent T.D.N./C.P. ratio are compared. One would not expect to obtain improved feed efficiency and growth rate by adding, say, 5% of fat to a proprietary balanced chick mash unless extra protein was added. If the addition of fat to a chick mash resulted in improved growth rate and feed efficiency, then the mash was not balanced initially.

The addition of fat to chick feeds is of considerable importance, as correctly balanced, high-energy rations are essential if good feed efficiencies are to be expected. From the results obtained, it is seen that when two rations of the same T.D.N./C.P. ratio are compared and one of them contains a high level of fat, it is this ration and not the one with the higher carbohydrate content which gives a better feed efficiency and rate of live-weight gain.

The use of high-energy rations is of considerable importance to the broiler producer, and it is intended to show in subsequent papers that the incorporation of fat in broiler rations leads to cheaper meat production, although the ration itself is, of course, more expensive per ton, but may not be more expensive if based on T.D.N. The use of fat in the ration of range laying birds in the winter time will probably lead to increased egg production under these conditions, and work of this nature will also be reported in a further paper.

Conclusions

1. To obtain the full benefit from the addition of fat to a chick feed, the ration must have a correct balance between T.D.N. and crude protein.
2. There is a narrow range of T.D.N./C.P. ratio which gives maximum efficiency.
3. The addition of oil or fat to a properly constructed ration consistently improves growth rate and feed conversion.

Acknowledgment

The author thanks the Directors of British Cod Liver Oils (Hull & Grimsby) Ltd. for permission to publish this work.

Biological Testing Station
British Cod Liver Oils (Hull & Grimsby) Limited
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Received 16 September, 1955

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A NOTE ON THE HEAT RESISTANCE OF A SOUTH AFRICAN STRAIN OF *CLOSTRIDIUM BOTULINUM* TYPE B

By G. G. KNOCK and M. S. J. LAMBRECHTS

The z and D values for a South African strain of *Clostridium botulinum*, type B, have been determined by a method described. The results indicate that the South African strain at least equals in heat resistance the maximum resistance for *Clostridium botulinum* assumed in process calculations for canned foods.

Botulism is associated with the consumption of foods subjected to treatments such as moderate heating, smoking or salting, which destroy or limit the growth of concomitant organisms having antibiotic or toxin-destroying properties.[1, 2, 3] Many foods of this type are produced in South Africa, e.g., home-preserved meat and vegetables, hams, various types of smoked sausage, and dried, salted, smoked or pickled fish. It is curious, therefore, that no case of human botulism has been recorded in the Union,[4] and it was thought that the level of heat resistance exhibited by a strain of *Clostridium botulinum* type B isolated locally from soil by the senior author[5] would be of interest.