CLXX. THE RELATIVE VALUES OF THE MEALS FROM OILY AND WHITE FISH FOR GROWTH AND CALCIFICATION.

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McFARLANE, GRAHAM AND RICHARDSON have shown in a recent communication [1931], that fish meal fed at a level of 15 % of the diet is sufficient to promote normal growth in chicks: if, however, the fish meal is extracted with ether before use, poor results are obtained notwithstanding the addition of cod-liver oil to the ration.

The second statement is of great importance as it is well known that in practice it has been found necessary to extract fish meals with solvents, as an excess of oil in the meal produces taint in the flesh of animals to which it is fed.

Results obtained in experiments carried out over a period of many years prove, however, that the value of fish meals for feeding purposes is not affected by the extraction with solvents but that it depends on the quality of the raw material used and on the method of manufacture.

Already Maynard, Goldberg and Miller [1925, 1, 2], and Maynard and Miller [1927] had shown that a low calcium, high phosphorus basal ration containing linseed oil meal, produced, in growing animals, a bone very low in mineral constituents as compared with the bone developed when fish meal was substituted, on an equal protein basis, for the linseed oil meal.

The better calcification is due, according to these authors, to the presence in the fish meal of a factor aiding calcium assimilation, and this factor is contained neither in the oil fraction of the meal nor in its alcoholic extract.

These results were confirmed by Davidson [1927] who in feeding experiments on pigs found also that a fish meal prepared from so-called oily fish, from which the oil had been extracted by ether, gave a higher growth rate than a white fish meal not extracted with ether, and that the better growth was also obtained at a smaller expense of food. He came also to the conclusion that oil in fish meal appears not only to be of no special value for growth, but to have a slight depressing effect on live-weight increase [1928].

Results similar to those of Davidson were obtained by us in laboratory experiments on rats, and form the subject of the present communication.

One of the first difficulties experienced was that of obtaining, from a commercial source, products of which the raw material used and the method of manufacture were known. In another paper in course of preparation, we shall show how the latter has considerable influence on the experimental results, as commercial fish meal, and especially that prepared by the rotary-dryer method, contains highly oxidised oils which cause disturbances during the periods of reproduction and lactation.

For this reason it was decided to prepare our own meals.

EXPERIMENTAL.

(a) *Preparation of the meals.* The meals used in all the experiments were prepared by drying the fish in a small laboratory plant by means of superheated steam, thus avoiding, because of the absence of air, any danger of oxidation.

For the white meal cod and haddock were used, while for the oily meal, bream, herring or mackerel were chosen. After drying, the meals were completely extracted with ether; several batches were prepared and, after mixing, stored for use. They had the following average composition:

	Meal from white fish %	Meal from oily fish %
Crude protein ($N \times 6.25$)	66.56	63.75
Moisture	9.02	9.68
Calcium phosphate	13.65	13.46
Fat, soluble in alcohol	0.46	0.40

(b) *Diet.* In preliminary experiments several diets were tried but finally it was decided to use the diet suggested by Maynard and Miller [1927], the composition of which is as follows:

Yellow cornmeal	73.5 parts
Wheat gluten	7.0 „
Fish meal	15.0 „
Calcium carbonate	2.5 „
Calcium phosphate	0.5 „

The proportions of calcium carbonate and calcium phosphate were altered when necessary in order to maintain the ratio Ca: P practically constant throughout the experiment [Karelitz and Shohl, 1927]. No sodium chloride or other salts were added as fish meal already contains sufficient.

Lemon juice and small quantities of marmite were added to the water used in mixing the food.

(c) *Feeding experiments.* The experiments recorded in this paper were carried out on more than 100 inbred rats, albinos and blackhoods, divided into five groups.

Three of the groups, before being fed on fish meal, were kept, immediately after weaning, on the Steenbock diet No. 2965 [1925] for a period of three weeks

or, if necessary, until the rate of growth was very small. The other two groups were, instead, fed on a vitamin-free diet (British Drug Houses) until growth had completely ceased. The rats of the first groups were apparently always in good health and very lively although small; those of the other two groups became very ill, losing their fur and showing symptoms of vitamin deficiency.

The Steenbock diet has been criticised because of the deficiency in salts and especially phosphorus; such deficiency according to Chick and Roscoe [1926] may complicate experiments with regard to vitamins A and D by setting up severe competition for phosphorus between the bones and the soft tissues. It was, however, decided to compare this diet, not wholly deficient in vitamins but deficient in mineral salts, with the other diets containing a proper balance of salts, in relation to the results obtained after feeding the animals on a diet containing fish meal.

The reason for adopting this course is that in agricultural practice young animals are fed, after weaning, on diets which although not necessarily deficient in vitamins are, practically always, deficient in the proper balance of salts.

The rats used in these experiments were fed *ad libitum*, and it was noticed that when they were transferred to the diet containing fish meal, that prepared from white fish seemed to be more palatable, as the rats on it ate more freely and grew more rapidly at the beginning. Those on the ration containing meal from oily fish soon became accustomed to it and after a week ate it freely. It was also noticed that the amount of white fish meal consumed was always greater.

The animals were weighed once a week, and the experiments continued until the growth curves showed a tendency to become flat.

There were a few instances when individual rats on a particular diet did not respond in the same way as the average animal, growing either more or less. The growth in these rare cases was not included in the results given.

In the different groups the sexes and litters were distributed as evenly as possible, but the results are given separately for males and females. Two males and two females from each group were killed at the beginning of each experiment as controls for the bone analysis, while the remainder were killed at the end of the test, the tibia and the femur being removed for the estimation of the ash.

In Figs. 1, 2, 3 and 4 are shown the average growths in g. for rats fed on white and oily fish meal after a preparatory period on the Steenbock diet, while Figs. 5 and 6 represent the growth of rats fed on the same meals but kept for a period on a vitamin-free diet.

The results obtained for the estimations of ash are given in Table I; the value A/R is the ratio of the amount of mineral substance to the amount of organic matter contained in a fat-free and moisture-free bone [Chick, Korenchevsky and Roscoe, 1926].

The results obtained in these experiments show without doubt that a fat-free meal prepared from oily fish gives a better growth rate (10–20 %) than a white fish meal, and also a better calcification of the bones.

Both meals were extracted with ether and the amount of fat, insoluble in this solvent but soluble in alcohol, was practically the same in the two meals.

Fig. 1. Group I.

Fig. 2. Group II.

Fig. 3. Group III. (Male rats.)

Fig. 4. Group III. (Female rats.)

Fig. 5. Group IV.

Fig. 6. Group V.

— Oily fish meal.

- - - White fish meal.

Table I.

	Group I (Albinos)		Group II (Blackhoods)		Group III (Blackhoods)		Group IV (Albinos)		Group V (Blackhoods)	
	Ash %	A/R	Ash %	A/R	Ash %	A/R	Ash %	A/R	Ash %	A/R
Control	43.5	0.77	43.6	0.77	—	—	43.4	0.77	38.7	0.63
Oily fish meal ♂	57.2	1.34	59.9	1.49	57.8	1.35	56.9	1.32	56.13	1.30
White fish meal ♂	52.2	1.10	58.2	1.39	56.8	1.28	55.4	1.24	55.4	1.24
Oily fish meal ♀	57.8	1.35	58.6	1.41	58.2	1.40	57.6	1.36	56.0	1.28
White fish meal ♀	53.0	1.13	58.2	1.40	55.7	1.24	56.4	1.29	54.7	1.23

It is not, therefore, possible to attribute the better growth and calcification to traces of oil left in the meal prepared from oily fish.

In the first three groups the growth is, as would be expected, considerably better owing to the ration supplied in the preparatory period. The results for calcification were, however, equally good in all the rats fed on oily fish meal, whatever the ration used in the preparatory period, proving therefore that the oily meal is richer in the necessary factor. On the other hand, the bone calcification of rats fed on white fish meal was, in many cases, below normal, whichever preliminary diet had been used.

Fig. 7. Male rats.

Fig. 8. Female rats.

— Air-dried meal—9.2 % oil.
 - - - Meal dried in absence of air—1.8 % oil.

It appears, therefore, from the foregoing results that the extraction of the meal with ether does not alter its properties. These properties are however considerably modified by the methods used in the drying of the raw material as shown by the following experiments.

For purpose of comparison two commercial meals were used, prepared in different plants, but from material as far as possible of the same kind.

The meal prepared in the first plant had been partially de-oiled during the process, the drying taking place in absence of air. The oil content was 1.8 %.

The second meal was dried in a current of air and was not de-oiled, the final product containing 9.2 % of oil.

The diets used were similar to those of the previous experiments.

Seventy-five rats were fed with these two meals but as the results obtained showed very little variation the figures for one set of experiments only are given. Two litters of albino rats were used—13 females and 12 males—born on the same day. For three weeks after weaning they were kept on the Steenbock diet and then transferred to the diets containing the two fish meals.

The growth curves are given in Figs. 7 and 8.

It will be noticed that the rats fed on the second meal, containing 9.2 % of oil, showed a better growth and this was evidently due to the amount of fat present in the meal, because in these rats the adipose tissue was considerably more developed than in the rats fed on the other meal containing only 1.8 % of oil.

The calcification of the bones, however, in the heavier rats was not as good as that of the rats fed on the first diet as shown by Table II.

Table II.

	Group VI (1.8 % oil)		Group VII (9.2 % oil)	
	Ash (%)	A/R	Ash (%)	A/R
Control	41.0	0.70	—	—
♂	59.25	1.45	57.21	1.33
♀	59.06	1.44	57.24	1.34

These results confirm those of the previous experiments and show that the de-oiling does not affect bone calcification as much as the method of preparation of the meal.

It is also of interest to note that the oil which solvents would extract is a body oil, the livers and other internal organs having been removed, as a rule, from the fish immediately after it was caught. These body oils, as shown by Ahmad and Drummond [1930], are of little value for growth promotion.

SUMMARY.

The nutritive properties of a fish meal depend largely on the kind of raw material used and the method of manufacture.

De-oiling of a meal prepared by drying so as to avoid oxidation during the process does not affect the property of the meal in aiding bone calcification.

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