# XCVII. THE DIETETIC VALUE OF OATMEAL PROTEINS.

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(*Received June 29th, 1926.*)

Proteins of vegetable origin, on the whole, are regarded as being of lower biological value than those from animal sources, and even if the vegetable protein be a good one, there is usually such a small amount present that it is of little use in contributing to the protein ration of man. Thus the biological value of potato protein is 79 [Karl Thomas, quoted by Lusk, 1917] but the amount present is only 1·6 % in new, and 2·1 % in old potatoes [Plimmer, 1921].

The percentage of protein in oatmeal varies according to different authorities; Plimmer [1921] gives 11·9 %, Bailey [1921] 14·7 % and Sherman [1924] 16·1 % of protein. Taking even the lowest figure, oatmeal appears to be a rich source of protein compared with vegetables and fruits. Research on oatmeal protein has a varied history. The earlier observations of American workers showed oat protein to be of poor quality, but their later work caused them to modify this opinion. Osborne and Mendel [1918] fed rats on protein concentrates from various cereals and found that the young animals failed to grow adequately on the oat diet. In more recent experiments these observers [1920] used the entire cereal grains (finely ground) and found that, with the addition of salt mixture and butter fat, a satisfactory diet was produced, and some of the animals grew to a large size indicating that the oat protein was adequate in meeting the needs of the rat. They state, however, that the animals did not eat the diet well, and suggest that this may be the reason why some of them failed to grow.

McCollum and his co-workers, in their earlier experiments, also found oat protein to be of poor value, but further work evidently altered this opinion, for McCollum [1922] says: "the oat kernel is comparable with wheat or maize in its dietary properties in nearly all respects." The omission of the necessary mineral salts from the diet is recognised as sufficient to account for the failure of the earlier experiments.

Sherman, Winter and Phillips [1919] made interesting, though rather short experiments on human beings. Two subjects were fed on "scones" made from oatmeal, starch and butter, eaten with apple and sugar. In the main experiment, which lasted 12 days, a small quantity of milk was added to the diet.

The two subjects showed N balances of ± 0·0 and + 0·2 g. per day, although they only received sufficient calories to meet their energy requirement and 0·57 or 0·55 g. of protein per kg. of body weight. In another experiment, also of 12 days' duration, but in which no milk was added to the diet, the nitrogen balance was − 0·7 and − 0·6 g. of N per day respectively. These workers therefore conclude that as nitrogenous equilibrium was maintained with such a low protein intake in one series, and so closely approximated to in the other, oatmeal proteins are "efficiently utilised in the maintenance metabolism of healthy adults."

Opinion differs as to the proteins in oats. Sherman [1924] writes: "the proteins of oats have proven particularly difficult to purify, and have therefore not yet been studied so thoroughly as have some of the other grain proteins."

According to Wiley [1917] oats contain three proteins, one soluble in alcohol, one soluble in dilute salt solution, and one soluble in alkali. Bailey [1921] also gives three proteins, avenin or oat myosin, oat legumin or oat casein, and oat gliadin. Plimmer [1920] states that oat protein consists of gliadin and is a little vague as to the presence of a globulin, an albumin or both. Onslow [1920] gives avenalin as a kind of globulin found in oat seeds. By simple qualitative analysis the author has obtained three proteins from oatmeal, two of which are soluble in cold water and the third is insoluble in water, but soluble in strong alkali. Of the two found in the cold water extract, one coagulated on heating and the other did not. At first, therefore, one is tempted to say that a protein of the albumin variety is present, but as suggested by Onslow [1920] it is quite possible that this protein is a globulin and that the seeds themselves contain sufficient salt to provide for the dissolving of the protein. All three proteins gave a positive sulphur test and a positive Millon's reaction, and the coagulable and insoluble ones in addition contained tryptophan. From this simple analysis one would expect that oatmeal should prove a good source of protein in the diet.

## Experimental.

### *Growth.*

(*a*) *Diet.* In order to test the efficiency of oat protein, the diet must obviously be complete as regards other food factors. Oatmeal contains carbohydrate, protein, fat, some mineral salts and vitamin B; butter and salt mixture [Hartwell, 1922] were added. It has been shown that cereals are low or deficient in calcium and other mineral constituents necessary for animal welfare, and it was thought better to add salt mixture entire than to try and pick out those elements required to supplement the mineral content of oatmeal, and so to avoid a possible risk of deficiency. Butter was used to supply vitamins A and D. Many dietetic workers may criticise this adversely and say that as oatmeal itself contains fat, it would have been better to use cod-liver oil which is notably rich in vitamins A and D and these factors could

thus have been provided and yet less fat have been added to the diet. The reason for using butter is that this substance is a food eaten by human beings, while cod-liver oil cannot be regarded as an ordinary article of diet.

The proportions used were 100 g. oatmeal, 2·88 g. salt mixture, 14 g. butter and 500 cc. water. Details of preparation are given in an earlier paper [Hartwell, 1925].

(*b*) *Animals and method.* Piebald rats were used in these experiments; they were bred in the laboratory and were given the oatmeal diet from the age of 23 days (2 days after weaning). Five females and 5 males were used; they were kept in one large cage so that they could breed as soon as they were old enough; food was given *ad lib.*, with water to drink. The animals ate the diet readily (Osborne and Mendel [1920] found that some of their rats did not do so, possibly because they gave the oats in an uncooked form). Weighings were made daily at first, but when the animals were older and therefore growing less rapidly, once per week.

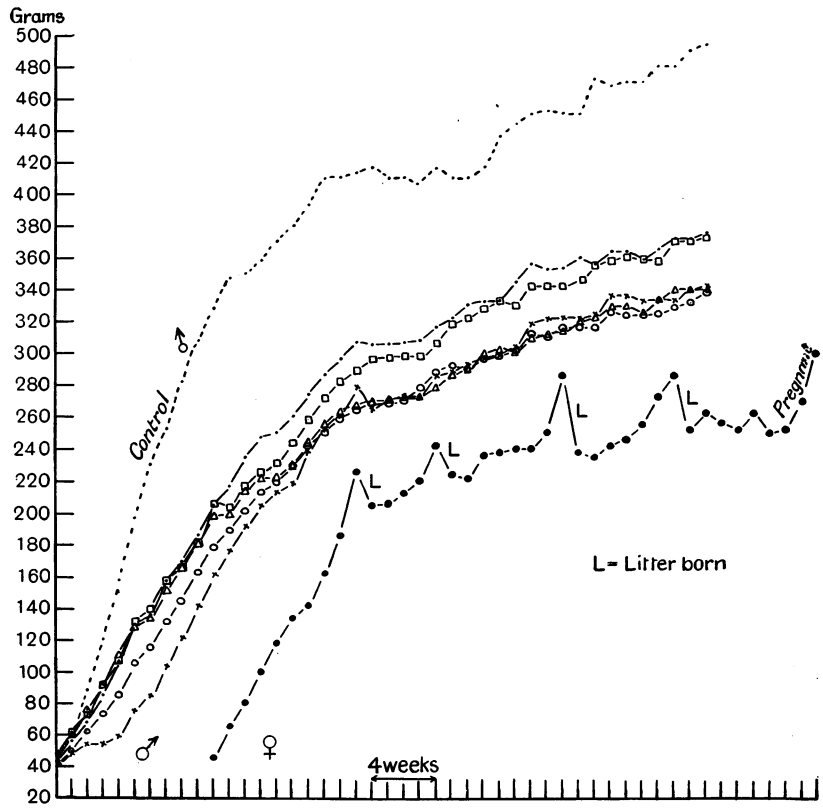


Fig. 1. Growth curves of rats fed on a diet of oatmeal, butter and salt mixture.

(*c*) *Results.* The rats grew well, though not so rapidly as control animals which received a mixed diet of kitchen scraps and bread and milk. The average weight of the five bucks after 8½ months on the oatmeal diet was

353·4 g. as compared with 272·5 g. given by Donaldson [1924] as the weight at a corresponding age. The growth curves of the bucks and one of the does (as examples) are given in Fig. 1.

The animals were fit and well throughout the experiment and their coats were especially thick and glossy. Litters were born, but this is dealt with under lactation.

*Lactation.*

It is highly probable that the requirements of the animal vary with different phases of its existence; for instance, a diet may be eminently suitable for growth, but quite unsatisfactory for gestation or lactation. The does belonging to the experiment previously described produced litters, but the young were not always reared. This may be due to the unsuitability of the diet for gestation or lactation or both. A second series of experiments was therefore made in which the does received a good mixed diet during gestation and the oatmeal diet was only given after the birth of the litter.

*Exp.* 1. The oatmeal diet was given from 3 weeks of age.

In some cases the diet was changed during lactation to bread and milk. The results are shown in the following table. When necessary the litters were reduced to 6 on the day after birth.

| | Exp. number | Number in litter | Average weight 2nd day (g.) | Number reared | Average weight at weaning (g.) | Diet of mother |
|---|---|---|---|---|---|---|
| Rat 1 | 1615 | 8 | 4·9 | 0 | — | Oatmeal diet |
| | 1651 | 8 | 4·9 | 6 | 21·5 | ,, |
| Rat 2 | 1621 | 1+2 dead | 4 | 0 | — | ,, |
| | 1671 | 6+1 ,, | 4·66 | 1 | 20 | ,, |
| | 1748 | 4+1 ,, | 5 | 2 | 21 | ,, |
| | 1793 | 7 | 5·7 | 1 | 15 | ,, |
| | Litter born dead | | | | | |
| Rat 3 | 1647 | 6+1 dead | 5·5 | 0 | — | ,, |
| | Rat died at birth of litter | | | | | |
| Rat 4 | 1641 | 8 | 5·6 | 1 | 45 | Bread and milk |
| | 1715 | 3+3 dead | 5·6 | 3 | 29·6 | ,, |
| | 1788 | 4 | 7 | 0 | — | ,, |
| | Died with a cold | | | | | |
| Rat 5 | 1616 | 5 | 6·8 | 5 | 34·4 | ,, |
| | 1677 | 3+2 dead | 4·66 | 3 | 42·6 | ,, |
| | 1746 | 8 | 6 | 6 | 40 | ,, |
| | Died at birth of litter | | | | | |

The results may be summed up as follows:

1. The litters were of small size, 8 being the greatest number born, while the stock animals have, on an average, 9 or 10 young per litter and have had as many as 17.

2. Many of the young were below average weight at birth (5·79 g. is the average weight for this stock of rats).

3. There was noticeable failure to rear all 6 young, even when bread and milk were given to the doe after the birth of the litter. This fact, together with the low weight at birth, suggests that the oatmeal diet is unsatisfactory for gestation.

4. When the oatmeal diet was continued during lactation there was not only a failure in rearing the young, but any of them which survived weighed only about 20 g. instead of approximately 40 g. at weaning time. The young rats had very poor and thin fur.

Thus the oatmeal diet is not satisfactory during lactation or gestation, but, as far as this experiment is concerned, the lactation test is hardly a fair one, because the young were often of low weight and so might be weakly from birth. Further experiments therefore were made in which the does were given the experimental diet only after the birth of the litter.

*Exp.* 2. The three following diets were given and at least three rats were fed on each diet.

(*a*) Raw oatmeal and water.

(*b*) Cooked oatmeal and water.

(*c*) Cooked oatmeal, butter, salt mixture and water as given in Exp. 1.

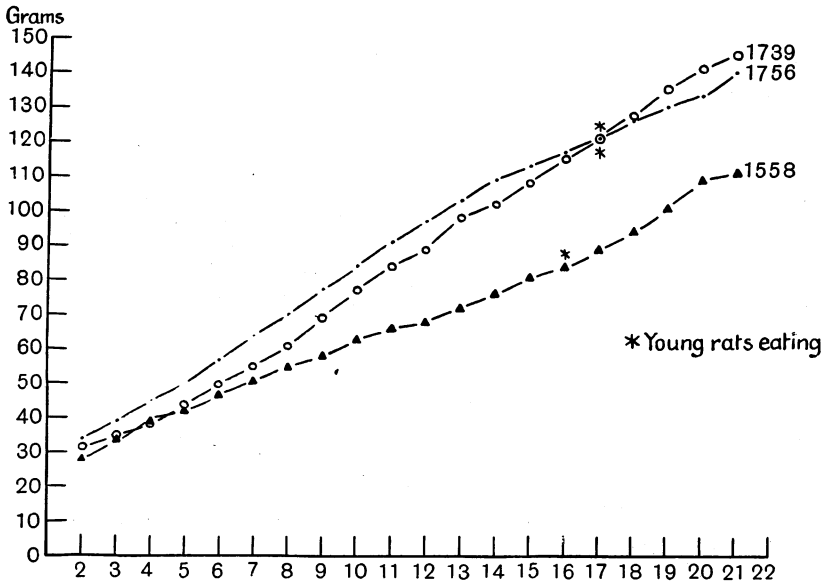


Fig. 2. Weights of litters.

*Mothers' diets.*

○——○ 1739 Cooked oatmeal and water.
•——• 1756 Raw oatmeal and water.
▲——▲ 1558 Cooked oatmeal, butter and salt mixture.

Representative curves of the growth of the litters are shown in Fig. 2. The litters seem to grow equally if the mother receives either cooked or raw oatmeal and to do less well when she is given the diet of oatmeal, butter and salt mixture. From results obtained with other unpublished work it is possible that this failure is due to the food containing too great a proportion of vitamins A or D (or both) as compared with vitamin B. The oatmeal, butter and salt mixture diet is low in vitamin B content for the lactating rat, because

symptoms due to this lack appeared in some of the young. It was thought that the low percentage of protein in the diet might account for the poor weight of the young at weaning, and therefore an attempt was made to supplement the oatmeal with other proteins. Butter and salt mixture were omitted.

*Exp.* 3.

(*a*) Diet of 20 g. raw oatmeal, 1 g. gluten and 20 cc. water.

(*b*) Diet of 20 g. raw oatmeal, 1 g. gelatin and 20 cc. water.

(*c*) Diet of 20 g. raw oatmeal, 1 g. egg albumin and 20 cc. water.

(*d*) Diet of 20 g. raw oatmeal, 1 g. food casein and 20 cc. water.

(*e*) Diet of 20 g. raw oatmeal, 1 g. purified caseinogen and 20 cc. water.

As in Exp. 2 at least three rats were fed on each diet.

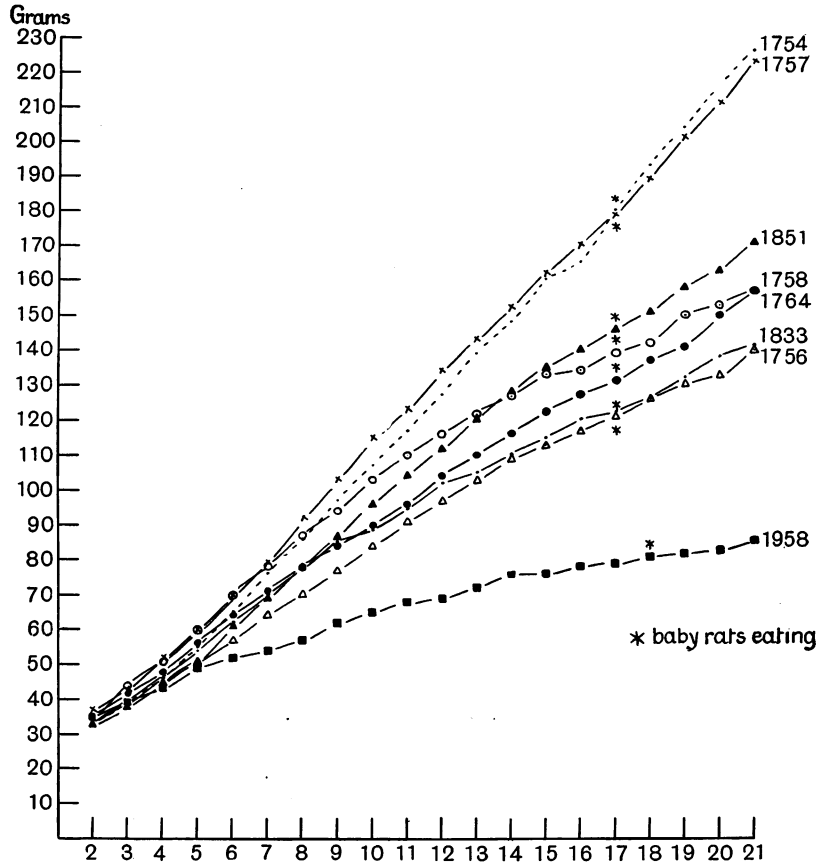


Fig. 3. Weights of litters.

*Mothers' diets.*

△——△ 1756 20 g. raw oatmeal + 20 cc. water.
×——× 1757 „ „ + 1 g. food casein + 20 cc. water.
▲——▲ 1851 „ „ + 1 g. egg albumin + „
○——○ 1758 „ „ + 1 g. gluten + „
●——● 1764 „ „ + 1 g. gelatin + „
•——• 1833 „ „ + 1 g. pure caseinogen + „
■——■ 1958 Synthetic diet containing 10 % of pure caseinogen.
•----• 1754 Bread and milk (control).

One curve from each experiment is given in Fig. 3, and it is obvious that the addition of other protein to the mother rat's diet produces better growth in the young.

## Conclusions.

From the experiments described in this paper, it is seen that oatmeal used as the sole source of protein in the diet provides for growth in the rat, but the rate of growth is slower than when the animals are given a mixed diet such as kitchen scraps and bread and milk. Litters were born, which shows that the oatmeal diet was also adequate for fertilisation. From the point of view of gestation and lactation, however, the diet was by no means satisfactory. It is probable that the quantity rather than the quality of the oat protein is responsible for this failure. Had the quality of the protein been poor, it is unlikely that the animals themselves would have attained such good weight.

The protein in the given diet would be about 10 %. Even with caseinogen (which is regarded by nutrition workers as a good protein) the author has found very slow growth for the suckling rats when the doe was fed on a synthetic diet containing only 10 % of this protein (see Fig. 3). In fact when the mother rat had the oatmeal diet the growth of the young was distinctly better than when she was given a synthetic diet containing 10 % of caseinogen.

Except pure caseinogen, all the proteins added to the oatmeal diet of the mother produced better growth in the suckling rats. Even gelatin, which is regarded as a poor protein, and is lacking in the essential amino-acids tryptophan and cystine, caused some improvement in the growth of the young. This also seems to support the suggestion that oatmeal proteins are of good quality, but the amount present is too low for a good diet for a lactating animal. Osborne and Mendel [1918] found that both caseinogen and gelatin were effective supplements for oat proteins, but they were dealing with direct growth, and not with mammary secretion, consequently their results are not strictly comparable with those discussed here. According to Wiley [1917] the oat protein soluble in alkali constitutes 11·25 % of the whole grain, while the amounts for the other two proteins are 1·25 % and 1·5 % respectively. If the "oat casein" is similar to milk caseinogen in composition, the above figure suggests an explanation as to why the addition of pure caseinogen to the oatmeal diet gave less good results than the addition of other proteins.

The great improvement due to the supplementing effect of food casein [Hartwell, 1922] is worthy of comment. Simple experiments show that this substance contains two proteins, probably lactalbumin and caseinogen, and since the addition of egg albumin gave better results than gelatin, gluten or pure caseinogen, it is reasonable to assume that the lactalbumin is largely responsible for the noticeable improvement in Curve 1757.

Not only did the extra protein result in better growth of the young rats, but also in an improvement in general condition. Their fur was thick and, even when the young were not up to standard weight, they were quite normal as regards general condition.

SUMMARY.

1. The proteins of oatmeal are of good value as regards growth in rats.

2. For gestation and lactation a diet of oatmeal, butter and salt mixture is not adequate. This is probably due to the quantity rather than the quality of the protein.

3. The addition of food casein, gluten, gelatin and egg albumin to the oatmeal diet produced better growth in the suckling young.

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