CLXXVII. AN EXPERIMENTAL STUDY OF BROWN AND WHITE BREAD IN THE DIET OF THE RAT.

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THE question of the superiority of brown over white bread has been the subject of many discussions. A number of people *assume* that brown bread has a far greater dietetic value than white bread, but there are very few experimental data to warrant such an assumption. Perhaps the point most usually quoted in favour of brown bread is its vitamin B content. It is frequently stated that white bread is lacking in this factor, and therefore brown bread *must* be the better food. That this is not so, was shown by the author in a previous communication [1924, 1]. In this paper experiments were described in which rats were kept for as long as a year on a diet of white bread, butter and salt mixture. The animals showed no symptoms indicative of lack of vitamin B, the only source of which was the white bread. From a common-sense point of view, also, it seems ridiculous to state that white bread contains no vitamin B, when yeast, used in the manufacture of white bread, is accepted as being one of the richest sources of this vitamin. From information obtained from various bakers, it is found that the amount of yeast used in bread manufacture is by no means the minute amount accepted by the general public, but varies from 2-8 % of the flour used. It is not claimed that the vitamin B content of white bread is *equal* to that of brown, but that at least *some* of the vitamin is present in white bread (sufficient to provide for the needs of the rat). Even if brown bread does contain more vitamin B than does white bread, why are some people so insistent on its use in England, a country where the ordinary mixed diet of the nation must be very rich in this vitamin? Brown bread, being made from whole-meal flour, must contain more non-digestible material (frequently designated by dietitians as "roughage") than white bread, but fruit and vegetables are even better sources of this factor. Thus from a commonsense basis there seems little reason to accept the superiority of brown over white bread. The experimental side of the question is presented in this paper.

Animals and Diets.

Two series of rats, twelve in each set, six females and six males, were fed on bread (brown or white), butter, salt mixture and water [for details of composition see Hartwell, 1924, 1]. The brown bread experiment lasted for 25 weeks and the white bread experiment for 21 weeks. The brown bread used was made from pure wheat meal, from which a portion of the endosperm,

but not the germ, had been removed¹. It is therefore stronger in the supposedly good elements of protein and vitamin B than 100 % whole meal would be.

Growth.

On the white bread diet the females grew more rapidly than the males, the reverse of what occurs on a good mixed diet. With brown bread instead of white, the relative rate of growth was normal. At the end of 21 weeks the average weight of the males fed on brown bread was 280 g., while those fed on white bread weighed only 167 g. At this time the females on both diets were of about equal weights. The exact weights at the twenty-first week cannot be given because the females were all in different stages of pregnancy. Thus from the point of view of growth, the females grew equally well on either brown or white bread, but the males did better on the brown bread diet.

Maintenance.

The rat is regarded as fully grown at the end of a year, and as these experiments only lasted 5-6 months the effects of the two diets from the point of view of maintenance cannot be given. Since the requirements for maintenance are not greater than the demands for growth, it is probably correct to assume that both diets would meet the needs of the rat for maintenance, though possibly the males would only be getting a low ration of vitamin B on the white bread diet.

Reproduction.

There are two aspects of reproduction to consider, viz. gestation and lactation.

Gestation.

Both sets of animals produced litters, but the young were of low weight, and the litters (especially those of the mothers fed on brown bread) were small. Details are given in the following table:

White bread diet			Brown bread diet		
11 litters from 6 does in 21 weeks	5 litters born dead		14 litters from 6 does in 25 weeks	4 litters born dead	
	0 whole litters died within one week			3 whole litters died within one week	
	6 litters, some young of each were reared (see next table)			7 litters, some young of each were reared (see next table)	
White bread diet			Brown bread diet		
No. in litter	No. successfully reared		No. in litter	No. successfully reared	
9 reduced to 6	4*		9 reduced to 6	6*	
9 " 6	6		8 " 6	5*	
7 " 6	5		7 " 6	4	
6	6*		5	2*	
5	3		4	—	
5	4*		4	3	
Average 6.85	Total 28		4	3	
			4	—	
			2	2	
			2	—	
Control average 10 per litter			Average 4.9	Total 25	

* Mother rat fed on bread and milk during lactation.

¹ I wish to thank Messrs Wheatley's Ltd. for kindly giving me this information.

Lactation.

The question of lactation needs special consideration. If the mother rat is fed on the bread diet throughout her existence, and if she then fail to rear her babes, the conclusion might be that this diet is unsatisfactory for lactation. This would not be a justifiable conclusion, because the failure to rear her offspring might be due to the unsuitability of the diet for gestation. Hence to throw light on this point, a separate series of experiments was necessary, in which the rats were fed on a good mixed diet during pregnancy, and the bread diets were only started after the birth of the litter. Again, the rat might be able to produce stronger young on a poor diet, if she had been well fed before fertilisation took place and therefore had good reserves.

The following experiments were therefore made, the results being shown in Fig. 1.

1. *Main experiment.* The rats were fed on bread (white or brown), butter, and salt mixture throughout growth, gestation and lactation. The does seldom reared all six young, even if given a diet of bread and milk from the birth of the young.

2. *Experiment A.* The rats received a good mixed diet until the young were born, after which they had the bread, butter and salt mixture diet. The mother rats were generally able to rear six young, but the growth of the sucklings was very slow. Very little difference was found in the rate of growth of the litters if the mothers received brown or white bread (butter and salt mixture in addition), but the ones belonging to the mothers fed on brown bread were, perhaps, just the better. Also, although the mothers lost weight while suckling their young, the loss was not quite so great when brown bread was used. Compared with the control animals (whose mothers had bread and milk) the rate of growth was distinctly poor. It is suggested that the slow growth of the sucklings is due to the low protein content of the diet, for the addition of small quantities of extra protein (*e.g.* 0.9 g. food casein to 15 g. bread) to the mother's diet resulted in an appreciable improvement in the growth of the young, even when butter and salt mixture were omitted from the diet [Hartwell, 1924, 2].

3. *Experiment B.* The rats were fed on a good mixed diet until old enough to breed, when they were given a white bread, butter and salt mixture diet. Four does and two bucks were used, and the females produced litters of twelve, eleven, ten, and five young respectively. They were of better weight than when the mothers had received the bread diet throughout their lives. During lactation two does were given the bread diet and two had bread and milk. Two mothers reared six young (one mother on each diet), and the other two mothers each lost one baby. These results, however, are distinctly better than when the rats had been having the bread diet since they were weaned. This is very understandable, for although the litters were all first ones (to make the experiments comparable), the mothers were heavier and better

grown animals than those fed entirely on the bread mixture. Summing up, one may say that neither brown nor white bread (with butter and salt mixture) is a satisfactory diet for the rat during gestation or lactation, and further that, in this respect brown bread has practically no advantages over white.

Fig. 1.

- I. Brown bread diet. Comparative growth of males and females.
- II. White bread diet. Comparative growth of males and females.
- III. Comparative growth of males on:
 - A. Brown bread diet;
 - B. White bread diet.
- IV. Comparative growth of females on:
 - A'. Brown bread diet;
 - B'. White bread diet.

McCollum, Simmonds and Parsons [1919] find that "with wheat proteins at 9 %, only an occasional litter of one or two young has been secured. None of these was weaned." In the diets used by me the protein would be approximately 10 % of the dry constituents, and the percentage of butter is also greater than that used by McCollum, etc. This may be the reason why the breeding of my animals, although below normal, was better than that of McCollum's rats.

CONCLUSIONS.

1. The rate of growth of young rats on a diet of bread (white or brown), butter and salt mixture is slow.
2. Male rats grow more rapidly on brown bread than on white. Female rats grow equally slowly on either kind of bread.
3. For gestation and lactation, brown and white bread appear to be equal. With both diets, the litters are of poor weight at birth, and only a few young are weaned.

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REFERENCES.

- Hartwell (1924, 1). *Biochem. J.* **18**, 120.
- (1924, 2). *Biochem. J.* **18**, 785.
- McCollum, Simmonds and Parsons (1919). *J. Biol. Chem.* **37**, 155.