CXI. A NOTE ON AN IMPROVED TECHNIQUE FOR USE WITH SYNTHETIC DIETS.

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THE usual method of making synthetic diets is to mix all the dry constituents together and then add sufficient liquid to form a stiff dough. It appears to me that there are many drawbacks to this method of procedure. Primarily, such a mixture bears no resemblance at all to the ordinary articles of food. It is much too concentrated and does not contain anything like the quantity of water usually found in foods (the common foods vary from 40–90 % in water content, e.g. meat 40–70 %, bread 40 %, vegetables 76–96 % [Plimmer, 1921]). In consequence the animals are being fed too small a bulk.

About a year ago, I started using synthetic diets, having previously fed rats on different foods using white bread as a basis. I was immediately struck by the difference in general condition of the animals. When on a synthetic diet the rats were limp to feel, whereas the animals fed on ordinary foods were far fitter and their muscles of better tone. Also the rats fed on the synthetic diet became pot-bellied and had flaccid abdominal walls; some died and *post mortem* examination showed a dilated large intestine, frequently with gaseous contents. I understand from other researchers that this condition is usually present in animals fed on synthetic diets and that nutrition workers have attempted to remedy it by adding some form of "roughage," such as agar, filter paper, charcoal, etc. to the diet. Even with such addition I feel that the bulk taken by the animal is far too small as compared with the normal consumption of food. Therefore, I tried to devise some method by which more water could be incorporated in the synthetic food, so that its composition should approximate more closely to that of an ordinary mixed diet. It was impossible to add more water with the present method because on standing the liquid separated out on top. The next attempt was to add more water to the diet and heat in a saucepan, stirring well until the starch grains burst and so thickened the mixture. By this means no water separated out and a diet prepared in this way gave excellent results when fed to rats. Details of the preparation are given below.

EXPERIMENTAL.

(a) *Foods.*

The composition of the diet used in these experiments was as follows:

- 20 g. caseinogen.
- 64 g. starch.
- 4 g. salt mixture [Hartwell, 1922].
- 12 g. butter.
- 2 g. yeast extract (marmite).

The caseinogen, starch and salt mixture were ground together in a mortar in bulk. The butter and marmite were added to the ration daily, so that the food was freshly made. The marmite was used as a 5 % solution. This diet may be adversely criticised as being too low in vitamin B, since the majority of nutrition workers in England use 5 g. marmite in 100 g. synthetic diet. The experiments quoted here form part of a series of experiments now in progress to determine the relative amounts of vitamin B required by the lactating and non-lactating rat, and as yet no data have been given for the minimum vitamin B needs of the rat (except by Osborne and Mendel [1922] who find that at least 200 mg. of compressed yeast per day are necessary for it to attain its full weight). In these experiments the average daily intake per animal was 0.2 g. marmite for a rat weighing about 40 g., whilst with older animals the marmite ration was as much as 0.5 g. per day.

Lemon juice was not added to the diet, because it was desirable that the marmite should be the only source of vitamin B. The antiscorbutic vitamin has been omitted in previous experiments of the author's without any detrimental results [Hartwell, 1924], and Simmonds [1924] states that "the rat is apparently immune to scurvy and does not require this vitamin in its diet."

The two diets were prepared as follows:

Method 1. 22 g. of the dry constituents, 10 cc. of 5 % solution of marmite, 6.5 cc. distilled water and 3 g. butter (melted) were beaten together to form a stiff dough.

Thus the total liquid used with 22 g. solid was 16.5 cc.

Method 2. A double saucepan was used. 22 g. of the dry constituents were mixed to a smooth paste with warm distilled water (about 40°), the 10 cc. of marmite solution and the 3 g. butter (melted) were then added and the whole well mixed. Then more distilled water (40°) was added, the total amount used being 65 cc. to the 22 g. of dry solid. This mixture, in the inner saucepan, was then placed in the outer pan containing boiling water and stirred rapidly until it thickened, after which it was left for 1 minute before being removed from the gas. When made in this way, the synthetic diet resembles a rather firm blancmange. The time required for thickening, $2\frac{1}{2}$ – $3\frac{1}{2}$ minutes, is too short for any destruction of vitamins to take place. Very hot water cannot be used or the mixture becomes lumpy.

Thus for 22 g. dry food in Method 1, 16.5 cc. liquid were used, whilst in Method 2, 75 cc. were needed. Microscopically this "cooked" food differs from the "raw" mixture in that the starch grains are swollen and the majority are broken.

The animals were not given a definite ration, but were fed so that small quantities were left.

(b) *Experiments.*

Exp. 1. Method of preparing diet changed part way through the experiment. Twelve rats, 6 ♀ and 6 ♂, weighing about 40 g. each, were given the synthetic diet in the usual form, *i.e.* mixed to a stiff dough. After 19 weeks on this diet the method was changed and the food "cooked" as described above. The experiment was continued for 17 weeks longer.

Exp. 2. Method of preparing the diet kept constant, but two groups of animals used, one group being fed on the "raw" and one on the "cooked" food.

A. Rats weighing approximately 40 g. at the beginning of the experiment; 12 animals, 6 ♀ and 6 ♂, fed on each diet.

B. Rats weighing approximately 70 g. at the beginning of the experiment; 8 animals, 4 ♀ and 4 ♂, fed on each diet.

RESULTS.

1. *Growth.* At first the rate of growth of all the rats was equal but after a few weeks the growth curve of those fed on the "cooked" diet was better than that of those fed on the "raw." The average weights of the male rats at the beginning and end of the experiments are given below. (The average weights of the does cannot be given because they became pregnant at different times.)

	Average weight at beginning of experiment	Average weight at end of experi- ment (10 weeks)	Diet
Exp. 2. A.			
	39 g.	215 g.	"Cooked"
	39	197	"Raw"
Exp. 2. B.			
	69 g.	242 g.	"Cooked"
	68	229	"Raw"

In Exp. 1 the growth curve improved when the "cooked" method was adopted.

2. *General condition of the animals.* The difference in the condition of the two groups of rats was quite obvious. From the first the rats fed on the "cooked" diet were the better animals. They were firm to feel, and equal in all respects (except rate of growth) to the control animals fed on a mixed diet of kitchen scraps, supplemented with bread and milk. The rats fed on the "raw" synthetic diet were limp and pot-bellied. At one period their fur came out, but eventually grew again. This loss of fur (thought to be due to some

dietetic deficiency [Boas, 1924; Hartwell, 1924, 1925]) did not occur at all in any of the rats fed on the diet prepared by Method 2; but every animal on the "raw" diet (three experiments with 32 rats) lost some of its fur and showed bald patches for a week or two. The fact that these differences occurred with diets of the *same* composition, but prepared differently suggests that the "cooked" food can be metabolised more effectively in the animal's body.

3. *Post mortem examinations.* These were made by Miss W. M. Clifford who had no knowledge of the diets used.

The rats fed for the whole experiment on the "cooked" diet were normal when compared with those fed on an ordinary mixed diet, whilst those fed on the "raw" diet had a very enlarged caecum and distended large intestine, with prominent lymphatics.

SUMMARY.

A method is described for the preparation of synthetic diets so that the composition and texture approximate more closely to those of ordinary foods.

Evidence is given that rats fed on a diet prepared by this method grow more quickly and are in better condition than others fed on the same synthetic diet mixed to a stiff paste with water in the usual way.

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REFERENCES.

- Boas (1924). *Biochem. J.* **18**, 422, 1322.
Hartwell (1922). *Biochem. J.* **16**, 78.
—— (1924). *Biochem. J.* **18**, 120.
—— (1925). *Biochem. J.* **19**, 75.
Osborne and Mendel (1922). *J. Biol. Chem.* **54**, 739.
Plimmer (1921). *Analyses and Energy Values of Foods*.
Simmonds (1924). *Amer. J. Hygiene*, Sept. Sup. 1.