LXXXIV. THE BIOLOGICAL VALUES OF PROTEINS.

V. THE COMPARATIVE BIOLOGICAL VALUES OF THE PROTEINS OF WHOLE WHEAT, WHOLE MAIZE AND MAIZE GLUTEN, MEASURED BY THE GROWTH OF YOUNG RATS.

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IN the previous paper of this series [Boas-Fixsen and Jackson, 1932] experiments were described in which the biological values of the proteins contained in various wheat and maize products were determined by the "balance sheet" method, using adult rats. These experiments revealed no difference in value, for maintenance of nitrogenous equilibrium, between the proteins of whole wheat and whole maize. It was pointed out that this result had an important bearing on the theory attributing pellagra, which in its epidemic form is closely associated with the consumption of maize, to an amino-acid deficiency.

A survey of previous work on the subject suggested that, whereas the proteins of wheat and maize might be of equal value for maintaining nitrogenous equilibrium during a short period, a disparity might be revealed by tests in which the growth of young rats during long periods was the criterion employed. The present paper describes experiments of this nature.

The growth of young rats has been used extensively for determining the relative nutritive values of proteins, and the method has been extended to include longevity and reproduction as criteria, by McCollum *et al.* [1921]. Osborne and Mendel [1916; 1920] and Osborne, Mendel and Ferry [1919] have made a detailed study of proteins using this method and devoted much attention to the precautions necessary in this type of experiment in order to permit of trustworthy deductions. They emphasised the importance for growth of the total food intake apart from the protein intake. They considered that ideal conditions for comparison of the biological values of different proteins were attained when rats of similar weight grew at equal rates and ate about the same amount of similarly constituted diets, the only variable in the diets being the nature and proportion, and hence the amount, of protein ingested. This amount was held to be in inverse proportion to the biological value [Osborne and Mendel, 1916].

Subsequently Osborne and Mendel adopted the value of the ratio $\frac{\text{g. gain in weight}}{\text{g. protein ingested}}$ as a numerical expression of the biological value for any given protein. The value of this ratio was found to increase at first as the proportion

of protein in the diet was raised, reaching a maximum after which it declined. This maximum value, obtained under conditions which favoured the most economical use of the protein, was taken as the most trustworthy estimate of its biological value [Osborne, Mendel and Ferry, 1919]. This method involved a long series of experiments with diets containing different proportions of each protein investigated and, besides being very laborious, did not conform to the ideal conditions set out above, for the total consumption of food was not the same in parallel experiments.

Most investigators who have used this method have calculated the weight increase per g. protein ingested from the results of experiments in which the different proteins were present at the same level in the diets and not necessarily at the level at which the above ratio has the maximum value [see also Osborne and Mendel, 1920].

Mitchell [1924, 1; 1928] has offered an explanation for the fact that, for any given protein, the value of the ratio $\frac{\text{g. gain in weight}}{\text{g. protein ingested}}$ (subsequently referred to in this paper as Ratio X₁) has been found to increase with increasing protein intake. He has suggested that in this expression no account is taken of the protein requirement for maintenance, apart from the requirement for growth, and that the former is a greater proportion of the total intake when this is small; in order to obtain uniformity of intake in comparative experiments, he devised his paired feeding method [Mitchell and Beadles, 1930].

Results reported later in this paper tend to support Mitchell's view and show further that if allowance is made for the protein required for maintenance, the above expression tends to give a constant figure for the biological value for growth of any given protein, irrespective of the intake.

Technique.

The experiments here described were confined to diets containing wheat or maize products as source of protein. Most observations were made with whole wheat or whole yellow maize, a few only being made with white maize for comparison with the yellow. The protein content of the maize was low (from 9 to 11 % on the dry weight) compared with that of the wheat, which was relatively high (16.4 %). It was not therefore possible to construct a diet, within the capacity of the animals' appetite, containing sufficient protein to support normal growth derived from whole maize. To see whether, in any case, normal growth could be obtained on maize proteins, diets were prepared containing the gluten of yellow and white maize at various levels up to 23 %. These glutes are by-products obtained in the manufacture of corn starch and consist of a mixture of maize-glutelin and zein, the water-soluble globulins and a proportion of the glutelin having been washed away [Osborne and Mendel, 1914]. They do not therefore represent true concentrates of maize-proteins.

The provision of the vitamin B complex has always been a difficulty in experiments of this type. In work on cereals reliance has been placed either on the cereals themselves for the source of supply (in which case the results are complicated by their differing contents of these vitamins) or on whole yeast. The drawback of a yeast supplement is the addition by this means of small amounts of extraneous protein of good quality [Osborne and Mendel, 1919; Mitchell, 1924, 3].

Osborne and Mendel used chiefly "protein-free milk", while Hoagland and Snider [1926; 1927] used yeast extracts, all of which supplements contain an appreciable amount of nitrogen. In the present work a dilute acetic acid extract from brewer's yeast was used from which the proteins had been precipitated by boiling [Chick and Roscoe, 1929].

The diets were designed to support a subnormal degree of growth, which should be limited only by the amount of protein present. In this connection it is noteworthy that Osborne and Mendel [1916], in a comparison of caseinogen, lactalbumin and edestin, found that the differences

between the nutritive values of these proteins for growth could not be detected if the amounts present corresponded to more than 12.5 % of the total calories. It is found, however, that with diets which contain a very low percentage of protein, the food intake and growth are poor, and the results are very irregular. A 10 % level of protein (on the dry weight) was therefore chosen for the diets with whole wheat and whole yellow maize; the white maize, however, was so poor in protein that it was not possible to make a diet containing more than 9 % protein.

The few recorded estimations of the biological values of proteins of maize and wheat using the criterion of Osborne and Mendel are summarised in Table I. The values are not consistent, those for whole wheat-proteins vary from 1.1 to 2.1; a value of 1.2 was found for whole maize-protein.

Table I. *Nutritional value of proteins of wheat and maize for supporting growth in young rats.*

Source of protein	% protein in diet	Duration of exp. days	Initial wt. of rats g.	Source of vitamin B complex	No. of rats	Gain in body wt. per g. protein ingested	Observer
Whole wheat	10	30	43	Yeast	6	2.1	Hoagland and Snider
	10	60	43	concentrate	6	1.6	[1927]
"	10	70	60-70	Wheat	3	1.3	Osborne and Mendel
"	8	70	"	"	6	1.1	[1920]
"	5	70	"	"	4	1.1	"
"	10	56	35-60	Dried yeast	10	1.7	Morgan [1931]
Whole maize	9	56	35-60	"	4	1.2	"
	9	63	—	Maize (in 3 exps. vit. B extract)	8	1.2	Maynard <i>et al.</i> [1923]

Materials used.

Table II gives the description and analysis of the cereal products used as sources of protein. The nitrogen was estimated by the Kjeldahl method and the crude fibre and fat by the methods of Weender and Dormeyer, respectively [see Lunge and Keane, 1911]. The carbohydrate was calculated by difference, and the calorie value of the diet as made up was estimated from these data. The composition of the diets, their water and protein contents and their calorific values are set out in Table III. The diets were fed chiefly in the raw condition, but some observations were made using the whole wheat and whole maize diets after mixing with 40-60 % of water and steaming for one hour.

Table II.

Material	Description	Composition (% of air-dry weight)							Calories (kg.-cal.) per g. (dry wt.)
		Water	Total protein (N $\times$ 6.25)	Zein*	Ash	Fibre	Fat	Carbo-hydrate (diff.)	
1. Whole wheat	Soft, red English	14.3	14.1	—	1.4	1.6	1.9	66.7	3.40
2. Whole yellow maize†	S. American	(1) 14.0 (2) 15.2	(1) 9.3 (2) 9.8	3.3 (34)†	1.2	1.4	2.8	69.6	3.43
3. Whole white maize	S. African	10.7	8.4	2.6 (32)†	1.1	1.9	4.1	73.8	3.66
4. Yellow maize gluten	Prepared from S. American yellow maize	8.7	27.0	11.7 (43)†	0.6	1.3	5.2	57.2	3.92
5. White maize gluten	Prepared from (3)	6.9	41.5	22.0 (53)†	0.7	0.7	5.6	44.6	3.95

* (N soluble in 90 % alcohol) $\times$ 6.25.

† Two samples used.

‡ % of total protein.

Table III. *Composition of diets used.*

Cereal % protein approx.	Wheat 10	Yellow maize 10	White maize 9	Yellow maize-gluten				White maize- gluten	
				9	13	17.6	22	14.5	23
Wheat	690	—	—	—	—	—	—	—	—
Yellow maize	—	1058	—	—	—	—	—	—	—
White maize	—	—	1053	—	—	—	—	—	—
Yellow maize-gluten	—	—	—	312	469	624	815	—	—
White maize-gluten	—	—	—	—	—	—	—	333	535
Salts	25	25	25	25	25	25	25	25	25
Butter fat	35	35	35	35	35	35	35	35	35
Cottonseed oil	23	—	—	20	13	6	—	20	12
Corn starch	363	—	—	709	557	409	225	688	483
% water in diets	12.9	(1) 13.3* (2) 14.0*	10.4	12.3	11.1	10.9	10.1	11.9	10.1
% protein in dry diet (N × 6.25)	9.73	(1) 9.77* (2) 10.1*	9.04	9.02	13.0	17.6	22.5	14.5	(1) 23.0 (2) 24.5†
% total cal. from protein	8.90	(1) 9.58* (2) 9.89*	8.65	7.66	11.3	15.5	20.2	12.3	(1) 20.2 (2) 21.5†
Calorie value per g. dry diet	4.37	4.08	4.18	4.71	4.61	4.54	4.46	4.70	4.56

* A sample of maize containing lower percentages of water and protein was used in earlier experiments.

† Diet used for last 10 days of experiments.

Digestibility. The digestibility of the protein in the whole maize and whole wheat diets was determined as follows. Young rats were kept in pairs in metabolism cages and fed on the experimental diet for a preliminary period of 3 days; the faeces were collected during a subsequent period of 4 days and the daily faecal output of nitrogen (N) and the nitrogen intake (I) estimated. The daily faecal output of endogenous nitrogen (E) was also determined for each pair of rats during a period in which a nitrogen-free diet was fed [see Boas-Fixsen, 1930]. The undigested nitrogen of the protein tested is then equal to $N - E$, and the digestibility to $\left(1 - \frac{N - E}{I}\right) \times 100$. The average figures, calculated from four experiments on each diet, were as follows: wheat, raw 84 %, cooked 85 %; maize, raw 92 %, cooked 89 %. Cooking did not therefore appear to alter the digestibility of these proteins, although it increased the food intake (see below, p. 597). The slightly higher values obtained for maize are probably not significant.

Mitchell [1924, 2] also found the proteins of whole maize and whole wheat to be equally digestible, but the value determined, 94 %, was higher.

There is some disagreement among different authorities as to the allowance that should be made for nitrogen of endogenous origin in the faecal nitrogen [see Schneider, 1934]. According to Mitchell [1924, 2], E is proportional to the amount of food taken, and in the expression $N - E$, the value of E should be adjusted to correspond with the actual food intake in the experiments with the proteins under consideration, which is almost invariably greater than in the trials on nitrogen-free diets. If such an allowance be made in the present case, the digestibility values are slightly raised, and those for the wheat diets slightly more than the corresponding figures for the maize diets, since rather more was eaten of the wheat than of the maize diet. The figures become: wheat-protein, raw 88 %, cooked 91 %; maize-protein, raw 94 %, cooked 92 %.

EXPERIMENTAL.

Black and white rats from the Lister Institute stock were used. At first, litters of young rats were placed on experiment at 21–22 days of age, irrespective of the body weight, which varied from 34 to 54 g. Subsequently it was found more satisfactory to keep the young rats on the ordinary breeding diet until they weighed 50 g. or over. The experiment proper lasted for 10 weeks; the first week was treated as a preliminary period to enable the animals to become accustomed to the diet and calculations were made only on the results of the subsequent 9 weeks. Each rat was kept in a separate cage of the type used in

vitamin B work, a fine wire grid being placed over the coarse wire mesh of the cage floor to prevent loss of food. The legs of the cage rested on a sheet of blotting-paper which covered a tray containing peat. This facilitated the recovery of scattered diet and enabled trustworthy figures to be obtained for the intake of food.

The diets were mixed and stored as air-dry powders. The daily ration was weighed accurately to 0.5 g., added to the residue of the preceding day and mixed with water to a paste. At the end of the experiment, or at the end of any of the periods into which it might be desired to subdivide it, the residue was collected in a weighing-bottle dried at 100° and weighed to 0.1 g.

The diets to be compared were distributed as evenly as possible among litter-mates. Each rat received, five times a week, a supplement of 4–6 drops (85 mg.) of cod-liver oil to provide vitamins A and D, and 1.5 ml. of yeast fraction "5" as source of the B-vitamins (see above, p. 593); 1 ml. of this extract was derived from 0.5 g. of the yeast, and contained 0.0065 g. nitrogen. The total nitrogen obtained from this source during the 9 weeks period of the observation amounted to 0.46 g.

Results.

The performances of the different groups of rats and a description of their general condition are given in Table IV. In no case was the growth normal, although this standard was approached with diets containing 22–24 % maize-gluten, where the average gain in weight was 100–109 g. in 9 weeks.

Table IV.

Material	% protein in diet (dry wt.)	No. of rats used	Condition of rats at end of 10 weeks on diet	Increase in wt. g.		Total food intake (dry) g.		Total caloric intake (mean) kg.-cal.	Protein intake g. (mean)	Ratio $X_1 =$ g. gain in wt./g. protein intake
				Variation	Mean	Variation	Mean			
1. Wheat	9.7	14	Good. No long silky hairs in fur	44–66	55	324–510	424	1820	40.5	1.36
2. Wheat (cooked)	9.7	9	Excellent	42–94	72	364–624	489	2140	47.6	1.51
3. Yellow maize	9.9	16	Not so good as (1). Coat poorer	32–79	52	327–567	406	1660	40.4	1.29
4. Yellow maize (cooked)	9.9	9	Good. Coats nearly normal	26–87	65	285–631	471	1920	47.2	1.38
5. White maize	9.0	6	As group 3	19–85	59	323–628	501	2095	45.3	1.30
6. Yellow maize-gluten	9.0	4	Poor	(–4)–(+17)	6	176–286	227	1070	20.4	—
7. „	13.0	5	Fair	6–78	24	213–285	261	1200	34.0	0.71
8. „	17.6	9	Good	31–74	58	287–505	413	1870	72.6	0.80
9. „	22.5	4	Good	83–128	100	475–666	550	2450	124.0	0.81
10. White maize-gluten	14.5	7	Stools rather loose	52–77	64	387–520	460	2160	67.0	0.96
11. „	23.0*	3	„	93–125	109	565–674	637	2900	148.0	0.74

* 24.5 for last 10 days.

The amounts of the food intake, protein intake and increase in body weight of rats receiving the whole raw wheat diet (10 % protein, Group 1) are of the same order as those of the animals on the similar diet made with whole raw yellow maize (Group 3). There is a similar correspondence in the results obtained with the cooked wheat and cooked maize diets (Groups 2 and 4). In these experiments, therefore, the values obtained for the biological value of the protein, as estimated by the ratio X_1 , are comparable. The value for the protein

of whole raw wheat, 1.32, is slightly higher than for raw yellow maize, 1.29. In the six observations with raw white maize (Group 5, 9 % protein) the average food intake and growth were higher than for Groups 1 and 3; the growth per g. protein was the same (1.30) as for yellow maize.

Of the cooked maize and wheat diets (Groups 4 and 2) more was eaten and there was a larger increase in body weight, also the values of the ratio X were greater than for the raw diets, and that obtained for cooked wheat-proteins (1.51) was definitely larger than for cooked maize-protein (1.38). Since it is unlikely that the nutritive value of the proteins of these cereals is improved by steam cooking, it would appear that the palatability of the diets, apart from the quality of the protein, affected the values for biological value obtained by this method of calculation.

In the experiments with the maize-glutens, a much lower food intake and less growth occurred when the diets contained from 9 to 13 % protein. Only when 14–18 % protein was present did the food intake and weight increase reach the levels (413–460 g. and 58–64 g. respectively) obtained with 10 % protein derived from the whole grains. The amount of protein ingested in the experiments with the maize-gluten was much greater, and the values obtained for the ratio X_1 are correspondingly lower and vary from 0.71 to 0.96 (see Table IV).

Relation between protein intake and weight increase.

In Fig. 1, increase in weight is plotted against protein intake for each rat in the groups receiving diets containing 10 % protein from whole wheat and

Fig. 1. Relation between gain in weight and protein intake for young rats on diets containing 9–10 % protein from whole wheat and whole maize.

× Wheat, raw. + Wheat, cooked. ● Yellow maize, raw
 ⊙ Yellow maize, cooked. ◻ White maize, raw.

whole yellow maize, and 9 % protein from white maize. The experimental points lie grouped about a straight line, which, if produced backwards, cuts the base line at a distance from the origin corresponding to about 10 g. protein. Although it may seem unlikely that 10 g. protein could represent the maintenance requirements for rats whose average body weights varied from 60 to 100 g., yet if this amount is subtracted from the total protein ingested and the excess regarded as being used for growth requirements, the increase in weight is found to be proportional to this excess. The value of the ratio X_2 thus calculated $\left(\frac{\text{g. increase in weight}}{\text{g. protein ingested} - 10} \right)$ was found to be roughly constant in value, irrespective of food or protein intake.

10 g. protein in 9 weeks, together with the nitrogen (0.46 g.) derived from the B-vitamin supplement, provided a daily ration of $(25.4 + 7.3)$ 33 mg. nitrogen, an amount which is about what might be expected for maintenance requirements. Mitchell and Carman [1924] found that about 30 mg. was the daily total nitrogen output on a "N-free" diet of young rats from 60 to 130 g. weight. Using their figure for the biological value of wheat-proteins (av. 67) the daily requirement of wheat-nitrogen to balance this expenditure would be about 44 mg. From the results of experiments with another series of rats, from 45 to 80 g. weight [Mitchell, 1924, 3] the endogenous daily nitrogen requirements can be calculated at from 17 to 23 mg. or about 30 mg. wheat-nitrogen.

Table V. *Biological values of the proteins of whole wheat and whole maize.*

Diet	No. of rats	Caloric intakes	Gain in weight Prot. intake = (X_1)		Gain in weight Prot. intake - 10 = (X_2)		X_2 mean value
			Variations	Mean	Variations	Mean	
10 % wheat*	7	1415-1694	1.20-1.53	1.36	1.69-2.27	1.91	1.85 ± 0.0256
	8	1837-2000	1.14-1.53	1.37	1.48-2.02	1.80	
	8	2026-2727	1.31-1.69	1.50	1.64-2.05	1.87	
10 % yellow maize*	10	1153-1505	0.93-1.45	1.22	1.46-2.03	1.76	1.73 ± 0.0229
	6	1713-1846	1.10-1.47	1.31	1.61-1.87	1.69	
	9	2005-2574	1.29-1.52	1.40	1.61-1.90	1.74	
9 % white maize	5	1520-2626	1.07-1.50	1.30	1.44-1.81	—	1.65

* The figures in this Table are derived from all experiments made with these diets, both raw and cooked.

In Table V, which includes the results of all experiments with wheat and maize diets, both cooked and uncooked, values are given of the ratio X_2 , obtained after subtraction of this "maintenance protein" from the denominator. Values are also given of ratio X_1 , in which this correction is omitted. The data from which these ratios are calculated show great individual variation as regards food intake and gains in weight and the results from the 23 and 25 rats which received respectively the wheat and yellow maize diets are ranged in three groups according to the caloric intake. As this is increased, so the value of X_1 is found to increase, whereas that of X_2 remains approximately constant.

The values for X_2 calculated from experiments with the cooked wheat and maize diets are grouped together with the values derived from the experiments with the raw diets, because they showed no significant difference. The figures were: for wheat-proteins, raw 1.83, cooked 1.90; for maize-proteins, raw 1.72, cooked 1.74. As shown in Table IV, both intake, growth and the values for X_1 were greater for the cooked than for the raw proteins, but since the correction in the denominator, employed in calculating X_2 , is proportionally less for the cooked than for the raw diets, the values for X_2 tend to become more nearly

identical than those for X_1 (wheat-proteins, raw 1.36, cooked 1.51; maize-proteins, raw 1.29, cooked 1.38).

The average value of X_2 obtained for whole wheat-protein, 1.85, is slightly higher than that for the whole maize-protein, 1.73. The difference between these mean values (0.12) is more than three times the probable error of this difference (0.0343); there is therefore a more than 20 : 1 chance that the difference found between the nutritive values of wheat- and maize-proteins for growth is significant. On the other hand, in comparison with the maize diet, the wheat diet contained a slightly lower proportion of protein relative to the total calories; and the protein may therefore have been utilised with slightly greater efficiency for that reason.

Maize-gluten. The results in Table IV indicate an inferiority of the maize-gluten diets as compared with those composed of the whole grain. For example, the rats in Group 8, receiving diets containing 17.6 % protein from yellow maize-gluten ingested food of about the same total calorie value (1870 kg.-cal.) and showed about the same average increase in weight (58 g.) as the rats in Group 3, receiving diets with only 10 % protein derived from the whole maize grain (1660 kg.-cal.; increase in weight 52 g.) and as those in Group 1 receiving a similar diet prepared from whole wheat (1820 kg.-cal.; increase in weight 55 g.). In the first case this amount of growth was supported by a total of 73 g. protein whereas in the second and third instances only 40 g. protein were needed.

Fig. 2. Relation between gain in weight and protein intake for young rats on diets containing 9 to 23 % protein from maize-gluten.

	% protein
⊕ Yellow maize-gluten	9.0
⊙ " "	13.5
⊠ " "	17.5
⊡ " "	22.0
x White maize-gluten	15.0
+ " "	23.0

Fig. 2 shows graphically the results of the whole series of experiments with the yellow and white maize-glutens. In this case the points appear to lie on a flat curve and no simple relation is shown between the weight increase and protein intake. It should be remembered, however, that in the experiments with whole wheat and whole maize illustrated in Fig. 1, the protein was fed throughout at approximately the same level (10 %) whereas, in the experiments

with the glutens, the protein level varied from 9 to 24 %. The form of the curve indicates that the gluten is utilised with less efficiency when present in the diets at higher levels.

The point at which the curve cuts the abscissa corresponds with an intake of about 18 g. protein in 9 weeks, which would suggest that the amount of maize-gluten-protein required for maintenance is greater than the amount required of whole maize-protein.

Since, however, this point for maize-gluten is determined mainly by experiments with diets containing over 14 % protein, this value for maintenance (18 g.) cannot fairly be compared with that obtained for the whole cereal diets (10 g.). The results of the experiments with 9 % protein from yellow maize-gluten appear, at first sight, to indicate that about 15–25 g. maintenance protein are required at this level also. It must, however, be remembered that, in these experiments (Group 6, Table IV), the caloric intake was very low, so that some protein may have been used to provide energy and the protein maintenance requirements raised on that account.

In the samples of white and yellow maize the proteins contained 32 % of zein (calculated from the amount of nitrogen soluble in strong (90 %) alcohol) and presumably about 68 % of glutelins and globulins [see also Osborne and Mendel, 1914]. The similarity in nutritive value between the total proteins of whole wheat and of whole maize indicates that the glutelin and globulins contained in the maize are able to supplement the deficiencies of the zein.

In the specimens of maize-gluten used, the proportion of alcohol-soluble protein was much greater than in the whole grain, and amounted to 43 and 53 % of the total protein in the yellow and white maize-glutens, respectively. Presumably the 57 to 48 % present of other maize-proteins retained in the gluten was insufficient to supplement this larger proportion of zein.

SUMMARY.

1. An attempt has been made to measure the relative nutritive values of the proteins of wheat and maize for the growth of young rats, using the criterion adopted by Osborne and Mendel, *viz.* the gain in weight per g. protein ingested.

2. The proteins of whole wheat and of whole yellow and white maize administered in diets containing 9–10 % of these proteins were found to have nutritive values of about the same order, being 1.36, 1.29 and 1.30 respectively, as determined by the above method. After cooking, these cereal diets were taken better by the animals, and the nutritive value of their proteins appeared to be slightly greater (1.51 and 1.38 for wheat and yellow maize-proteins respectively).

3. Graphic representation of the above results indicated that, if an amount of protein (10 g.) were subtracted from the total protein ingested over the experimental period of 9 weeks, the ratio, growth/g. protein ingested, was roughly constant in value and independent of the food intake. This 10 g. might be supposed to represent "maintenance requirements" apart from those of growth.

The value of the ratio $\frac{\text{g. weight increase}}{\text{g. protein ingested} - 10}$ would then indicate the biological value of the proteins for the growth of young rats.

4. The value of this ratio was 1.85 for the proteins of wheat, and 1.73 for those of maize, when present in the diet at a 9–10 % level. There was no difference between values obtained for the cooked and raw cereals.

5. The nutritive value of "maize-gluten" was found to be inferior to that of the proteins of the whole grain, doubtless due to the greater proportion of zein contained.

6. The results of the above experiments, showing only a slight difference between the nutritive values of the proteins of whole wheat and whole maize for support of growth in the young rat, is in accord with previous work showing their similar values for maintenance of the adult rat.

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