THE COMPARATIVE GROWTH RESPONSE OF RATS TO THE PROTEINS OF CASEIN, YEAST, SUNFLOWER, MEAL, WHEAT GERM AND CORN GERM

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Edna Estella Leffler

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THE COMPARATIVE GROWTH RESPONSE OF RATS TO THE PROTEINS OF CASEIN, YEAST, SUNFLOWER MEAL, WHEAT GERM AND CORN GERM

by

EDNA ESTELLA LEFFLER

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INTRODUCTION

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Prior to 1940, the word protein meant "meat" to the majority of Americans. Since then nutritionists have promoted the use of plant proteins which had been considered of "poor quality". The proteins of the nuts, the yeasts, the legumes and the grains long have been used in the Orient (Vickery, 1944). Now, many Americans are aware of the more common plant sources of protein such as the peanut and the soybean.

Though yeast, as a source of protein, is less well known, Time and Reader's Digest published articles in October, 1943, which brought it to the attention of the general public. During the World War of 1914-1918 the Germans used yeast in their dietary but it was not well tolerated because too large quantities were fed (Burton, 1943). Thirty million pounds per year of surplus yeast are produced as a by-product of brewing and only need to be debittered to be palatable (Gortner and Gunderson, 1944). The production of large quantities of palatable yeast makes practical its introduction for dietary use.

Many of the plant sources of protein including sunflower seed, wheat germ and corn germ are used in livestock feeds. Plants are a less expensive source of protein than animals because animals are inefficient converters of vegetable protein (through loss of nutrients) into the more palatable protein of meat and dairy products (Gortner and Gunderson, 1944).

Once grown to attract birds to the garden and later for use in livestock and poultry feeds the sunflower seed, as a meal, now is being used as a source of protein in Canada. The seeds have been recommended to the general reader as good eating when roasted and they may be processed to produce an eggwhite substitute.

The grains, too, have been used in livestock and poultry feeds; particularly the germs of wheat and corn which are by-products of refining of flour. Present milling of wheat which yields about 0.5 per cent of the wheat as germ produces an estimated 30 to 50 million pounds annually and indicates a potential production of 150 million pounds of wheat germ. This production may be increased by a higher yield during milling (Gortner and Gunderson, 1944).

Dry milling of corn which is used in the manufacture of hominy and such products yields a germ which can be defatted to a relatively stable, attractive and palatable product (Weber, Siebel and Singruen, 1943). Large quantities of corn germ are available; Gortner and Gunderson (1944) state that about 45 million pounds of corn germ is recovered annually from the dry-milling process and used in making corn oil and livestock feeds. Mitchell and Beadles (Nutrition Review, 1944) estimate a per capita production of defatted corn germ of approximately seven pounds annually in America. This contains enough protein to supply the individual requirement for ten days and enough thiamine to supply the requirement for two to three months.

The proteins of yeast, sunflower meal, wheat germ and corn germ are a few of the plant proteins which are potential supplements to the animal proteins of the human dietary. This investigation was conducted to determine how the growth response of rats fed these proteins would compare with the growth of animals on an equivalent amount of casein.

REVIEW OF LITERATURE

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The biological value, digestibility and versatility of plant proteins as foods for the table have renewed interest in these foods.

Yeast

The protein of yeast makes up about 50 per cent of the weight of dry yeast (Hawk, Smith and Holder, 1919). Dr. Russell M. Wilder of the Mayo Clinic found yeast to be a biologically superior protein containing the essential amino acids (Wilder and Keys, 1942). Work done at the Vitamin Research Institute of the United States of Soviet Russia shows the tryptophane content to be slightly lower than that of other complete proteins. Eighty-eight hundredths per cent of tryptophane was found in the thermolabile fraction and 0.43 to 0.72 per cent in the thermostabile fractions (Kazakov, 1940). Block and Bolling (1943) reported that four different strains of yeast, corn germ, wheat germ and soybean protein yielded approximately the same proportion of amino acids as did animal proteins: 1 per cent amino acid containing sulfur, 4 to 7 per cent arginine, 2 to 3 per cent histidine, 5 to 8 per cent lysine, 3 to 5 per cent phenylalanine, 4 to 6 per cent threonine, 4 to 6 per cent valine, 10 to 20 per cent leucine and 3 to 5 per cent isoleucine.

Csonka (1935) of the United States Department of Agriculture quantitatively analyzed baker's and brewer's yeasts and found that the amounts of cystine, tryptophane and tyrosine obtained from these yeasts were about equally soluble in water after treating the yeasts with ether. When the residues of this water extraction of nitrogen were subjected first to salt and then to alkali extraction there were wider variations in the amounts of these amino acids recovered from the two types of yeasts. Acid hydrolysis of the yeasts caused histidine and cystine to decompose. Woolley and Peterson (1937) report a histidine content in dried baker's yeast of 1.03 per cent and state that this amino acid is not destroyed during the acid hydrolysis of the yeast.

Pyrimidines, choline, glucosamine and a high percentage of purines accompany the protein nitrogen of yeast (Carter and Phillips, 1944). Two other nitrogenous compounds of high nutritive value present are lecithin and glutathione (Weber, Siebel and Singruen, 1943).

There is some variability in the studies on the biological value of the protein of yeast. Weber, Siebel and Singruen (1943) report that dried brewer's yeast has a biological value of 100 per cent as compared with skim milk, biological value of 95 per cent. Andreas Hock (1942) found no difference in the growth response to beer yeast and wood-sugar yeast but found that a basal diet of a mixture of proteins from yeast, wheat and rye was not biologically complete unless the diet was supplemented with fish meal. Kon and Markuze (1931) report that wheat breads supplemented with 8 to 12 per cent of yeast yielded higher biological values than either the proteins of wheat or of yeast alone and concluded that there was a supplementary relation between the proteins of wheat flour and baker's yeast.

Mitchell (1923) reports a biological value of 85.5 per cent for yeast as determined by the nitrogen-balance method when animals were fed a diet of 5 per cent protein. Various workers using the method of Osborne, Mendel and Ferry (1919) where the growth value is expressed as the gain in weight per gram of protein ingested per week report ratios of 1.48, 1.32, and 1.36 (Boas-Fixsen, 1934). Still and Koch (1928) reported a biological value of 45 per cent for dried raw yeast proteins and of 37.9 per cent for coagulated yeast proteins as compared with casein. They assumed all the nitrogen to be protein nitrogen. Nelson, Heller and Fulmer (1923) reared three generations of animals on diets of 25, 30, 35, 40 and 45 per cent yeast containing 11.5, 13,8, 16.1, 18.4 and 20.7 per cent, respectively, of crude yeast protein; no other protein was offered. The proteins of yeast in the diet containing 45 per cent yeast furnished all the amino acids necessary for growth and reproduction; sodium chloride and calcium carbonate were the only inorganic constituents which it was necessary to add to the diet to obtain normal growth. Macrae, El-Sadr and Sellers (1942) supplemented a maize diet with casein and with pure dried yeast (Tortula utilis grown on a molasses medium) and found that yeast had the same supplementary value as casein.

Hawk, Smith and Holder (1919) report that yeast nitrogen is utilized by certain individuals to better advantage than the nitrogen of such staple proteins as meat. From 10 to 30 per cent of the nitrogen of an ordinary mixed diet was replaced by yeast nitrogen in the form of compressed yeast without detriment to the individual's nutritive interests as shown by an improved nitrogen balance and a gain in weight.

Sunflower

The composition of varieties of sunflower seed grown in South Africa is shown in Table I. Blagoveshchenskii and Schubert (1934) report 9.1 per cent arginine, 14.3 per cent histidine, 1.8 per cent lysine and 5.3 per cent proline present in the globulin of sunflower seed.

The biological value of sunflower protein has been tested in livestock feeds. Sotola (1930) reported a biological value for sunflower silage of 67 per cent for lambs as determined by the nitrogen-balance method. Using the same method on pigs, Ganchev and Popox (1936) state that sunflower cake has a biological value of 49.0 per cent but when mixed with corn the biological value is raised to 66.7 per cent which is higher than that of either corn or sunflower cake.

Table I

Composition of Sunflower Seed

Foodstuff	Per cent of Water	Ash	Protein	Oil	Fiber	Carbohydrates
Sunflower seed[1]	--	--	--	29.18	--	--
Strain B.4[2]	6.7	1.9	14.0	24.6	31.9	20.9
Strain St.3[2]	6.8	2.6	18.4	26.0	28.0	18.7
Black Sel.[3]	5.76	2.28	14.37	26.77*	25.24	25.58
Sunflower silage[3]	11.40	10.79	14.06	5.26*	14.48	44.01

* ether extract
1 Thadani, 1934
2 Fielding and Rose, 1934
3 Rhodesia Agriculture Journal, 1934

Wheat Germ

It has been known that the grains contained protein and that a large percentage of this was in the germ which was removed in milling in order to obtain a product more stable to storage. Wheat germ contains from 25 to 33 per cent protein depending upon the variety of wheat (white, 25.2 per cent; soft red winter, 25.6 per cent; hard red winter and durum, 31.2 per cent and hard spring, 33.1 per cent; Grewe and LeClerc, 1943). The germ proteins and those of wheat bran are superior in nutritive value to those of the endosperm which are adequate for maintenance of adult animals but inadequate for growth (Osborne and Mendel, 1919; Boas-Fixsen and Jackson, 1932).

Hove and Harrel (1943) report that wheat germ has a biological value of 2.87 to 2.41 as determined by the method of Osborne, Mendel and Ferry when fed to rats at levels of 9.3 to 11.7 per cent protein making it as effective as casein in promoting growth. They also state that the biological value is not affected by heat processing designed to increase the keeping qualities of the wheat germ. Boas-Fixsen and Jackson (1932) report a biological value of 69 per cent as determined by the balance sheet method when the protein of wheat germ was 7 per cent of the diet. LaPorta, Bux and Piccoli (1938) enriched wheat flour by adding about 60 per cent wheat germ. When tested on ten rats by Mitchell's method a biological value of 85 per cent was found.

Morgan (1931) made a study of the effect of heat upon the biological value of wheat proteins and casein. When raw and toasted wheat gluten was fed to rats on a diet of 18 per cent protein the toasted wheat gluten supported less growth than did the raw gluten. The same results were obtained when the nitrogen balance method of Mitchell was used with the protein fed at 8 and 12 per cent of the diet. When supplemented with 5 per cent casein, toasted whole wheat had a biological value equal to that of raw whole wheat but toasting decreased the biological value of the casein as it did that of wheat.

Chick, Boas-Fixsen, Hutchinson and Jackson (1935) report that when caseinogen was heated at 112 to 125 degrees Centigrade for 72 hours and further purified the biological value was not lowered significantly; that when it was heated at 150 degrees Centigrade for 66 hours the biological value was reduced from 64 to 44 per cent. However, Seegers, Schultz and Mattill (1936) state that so long as digestibility is unchanged by heating the biological value remains unaltered. This statement is substantiated by work on beef muscle and casein, the latter heated at 120 degrees Centigrade for 2 hours or at 150 degrees for 30 minutes. Murlin, Nasset and Marsh (1938) account for the low biological value of a puffed wheat and a flaked wheat cereal by the high degree of heat used in the process of manufacture.

Corn Germ

Analysis of wheat germ and maize germ flours by Biscaro and DeCaro (1935) show that wheat germ flour is considerably lower than maize germ flour in fat content (6.64 per cent and 21.72 per cent, respectively) but higher in nitrogenous substances and carbohydrates. These workers inferred from these chemical data that wheat germ should have a greater nutritive value which they confirmed by feeding ten rats over a five month period. However, Block and Bolling (1943) report that corn germ like yeast, wheat germ and soybeans yields a balanced though not perfect mixture of the essential amino acids similar to that found in some animal products and is of good biological value in animal and human nutrition. They also state that corn germ proteins have approximately the same proportions of essential amino acids as cow's milk proteins and that these proteins are interchangeable when fed on an equal nitrogen basis.

Work reported by Boas-Fixsen and Jackson (1932) shows no significant difference in the biological values of the proteins of wheat and maize. Mitchell (1923) reported that corn proteins had a biological value of 72 per cent when the protein was supplied as 5 per cent of the diet and of 59.6 per cent when 10 per cent of the diet. Mitchell and Beadles (1944) used the nitrogen-balance method to determine the biological value of corn germ and found that although it was only 85 per cent as digestible as the protein of beef, its biological value was as high as that of beef (77.6 per cent and 76.9 per cent, respectively).

Casein

There are numerous biological values reported for casein as shown in Table II. Greaves, Morgan and Loveen (1938) found that the growth value of heated casein decreased in proportion to the temperature and the length of time of heating even when supplemented by lysine, cystine, tyrosine, tryptophane and histidine. Lysine was the first amino acid affected, histidine the second when casein was heated for 30 minutes at 140 degrees; histidine was not damaged at 130 degrees; cystine, tyrosine and tryptophane were not affected at 140 degrees.

Table II

Biological Value of Casein

Investigators	Year	Method	Compared with	Protein in Diet	Biological Value
Boas-Fixsen & Jackson	1932	Nitrogen-balance	Whole milk	6%	76.0%
Boas-Fixsen & Jackson	1932	Nitrogen-balance	Whole milk	7%	54.5% *
Everson & Heckert	1944	Growth	Beef liver	10%	1.6 **
Hove & Harrel	1943	Growth	Dry skim milk Boiled dry egg white	10%	2.3 **
Kon	1928	Nitrogen-balance	Tuberin (Potato globulin)	8%	68.0%
Mitchell	1923	Nitrogen-balance	Whole milk	5%	70.8%

* Heated casein
** Expressed as grams gained per gram of protein ingested per week.

EXPERIMENTAL PROCEDURE

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SOURCES AND CHEMICAL ASSAY OF TEST FOODS

Sources

The food yeasts were supplied by Anheuser-Busch, Incorporated, St. Louis, Missouri. Strain K was a pure debittered yeast obtained from brewing which had been dried at above pasteurizing temperature. It was non-fermentable and quite palatable. Brewer's Type Yeast No. 200 was a pure brewer's type yeast grown in a hop-free media which was enriched with extractives of by-products from corn products and malting operations. It was dried at above pasteurizing temperature and was non-fermentable.

The sunflower meal, toasted wheat germ, defatted wheat germ and defatted corn germ were supplied by the VioBin Corporation, Monticello, Illinois.

The edible casein, with which the test foods were compared, was obtained from The Casein Company of America, 350 Madison Avenue, New York City, through the Department of Chemistry, Michigan State College, East Lansing, Michigan.

Chemical Determination of Nitrogen

The test foods which were to be used as the sources of protein in the diets of the animals were analyzed for nitrogen by the Kjeldahl Gunning method (Official and Tentative

Methods of Analysis of the Association of Official Agricultural Chemists, 1943). The determination was run on triplicate samples. If the results were not consistent two more samples were analyzed. The results are shown in Table III.

Determination of Moisture Content

The moisture content of the test foods was determined by placing a small sample in a tared moisture dish and weighing. These were then put in an electrically controlled oven set at 100 degrees Centigrade for 18 hours*, cooled in a dessicator and again weighed. Four samples of each food were dried and the average of the closest three of these was used in the data shown in Table III.

* Unpublished data from the Foods and Nutrition Department indicated that 18 hours was sufficient to dry samples to constant weight.

Table III

Protein and Moisture Content of the Test Foods

Food	Nitrogen	Protein N x 6.25	Moisture
	per cent	per cent	per cent
Casein, edible	15.290	95.56	7.60
Yeast, Strain K	8.832	55.20	5.05
Yeast, No. 200	8.767	54.79	4.75
Sunflower Meal	10.213	62,94	5.42
Toasted Wheat Germ	6.736	42.20	4.63
Defatted Wheat Germ	6.530	40.82	6.41
Defatted Corn Germ	3.761	23.51	7.06

BIOLOGICAL ASSAY

Animals

Eight litters of three-week old albino rats were obtained from the Chemistry Department of Michigan State College for this experiment; two litters, G and H, were taken from the stock colony maintained by the Foods and Nutrition Department. Each animal of a litter received a different diet. In order to have litter control it was necessary to use both males and females. The animals of a litter were allocated as shown in Chart I. The rats were housed in individual screen-bottomed wire cages.

Diet

The diet used was a modification of the Everson and Heckert (1944) and Hove and Harrel (1943) diets and consisted of the following ingredients:

10% protein (N x 6.25)
80% cornstarch
4% Osborne and Mendel salt mixture
5% Mazola
1% Patch's Cod Liver Oil

Ten per cent of protein is suboptimal for normal growth of rats (Osborne, Mendel and Ferry, 1919) but has been found by several investigators (Everson and Heckert, 1944; Hove and Harrel, 1943) Mitchell and Beadles, 1929; and Stewart, Hensley and Peters, 1943, to be a satisfactory intake estimating the quality of the protein of various foods.

Chart I

Sex Distribution

Litter	Casein	Yeast, K	Yeast, #200	Sun-flower	Toasted Wheat Germ	Defatted Wheat Germ	Corn Germ
A	♂	♂	♂	♂	♂	♂	♀
B	♂	♂	♂	♂	♀	♀	♂
C	♂	♀	♀	♀	♂	♂	♂
D	♀	♂	♂	♂	♀	♀	♂
E	♂	♀	♂	♀	♂	♂	♂
F	♂	♂	♂	♂	♂	♂	♂
G	♂	♀	♀	♂	♂	♂	♂
H	♀	♂	♂	♂	♀	♀	♀
J	♀	♂	♀	♀	♀	♂	♂
K	♂	♀	♀	♀	♂	♂	♂
No. ♀	3	4	4	4	4	3	2
No. ♂	6	6	6	6	6	7	8

Since the wheat germs and the corn germ were defatted and the yeasts were of low fat content, all non-nitrogenous material was assumed to consist of carbohydrate and was subtracted from the cornstarch so that the total carbohydrate content would not be more than 80 per cent of the diet.

To prevent vitamin B-complex deficiencies, yeast No. 200, which contained 600 micrograms of thiamine per gram of yeast, was added to all diets except those using yeast as the protein in an amount necessary to supply 4 milligrams of thiamine to each kilogram of diet (Everson and Hecker, 1944). The other components of the B-complex then were assumed to be present in quantities sufficient to prevent deficiencies.

To insure an adequate intake of cystine, this amino acid was added to the casein diet to the extent of one-half of one per cent of the entire ration.

Method of Feeding and Care of Animals

The paired feeding method of Mitchell (Mitchell and Beadles, 1929; Mitchell, 1933) was modified so one animal controlled the food intake of its litter mates during the experiment. Before being placed on the special diets the animals were ear marked, weighed and placed on the casein diet for three days. At the end of this preliminary period each animal was weighed and its food consumption recorded.

Litters A, B, and C, the first animals put on experiment, were subjected to various treatments. Each was given 30 grams of casein for the three day preliminary period. At the end of this period the animal in each litter weighing approximately the average for the litter was continued on the casein diet, each of the remaining six animals was placed on a different diet. After the first day when 30 grams of the diet were fed, each animal was given the amount consumed by the animal in the litter who had the lowest food intake on the preceeding day. However, by this method the animals progressively received less food; therefore, all were given 15 grams a day for a week to see if their food intakes would equalize. At the end of this time the animal on the casein diet was given 18 grams each day. The food remaining in the cup the following day was weighed back and the amount he had consumed was given to his litter mates.

Litters D, E, and F were given 20 grams of the casein diet on the first two days of the preliminary period and 15 grams on the third day. The average-weight animal of each litter was continued on the casein diet as the control. The amount of food this animal had eaten on the third day of the preliminary period was the amount used to start the other six animals on the assay period. During the assay period of eight weeks (Everson and Heckert, 1944; Mitchell, Hamilton and Beadles, 1937; and Shields, Fairbanks, Berryman and Mitchell, 1940) the animals of a litter were given the amount of diet consumed by the control animal.

Litters G, H, J, and K were given 20 grams of the casein diet for the three day preliminary period. The control animal was selected as before and his average daily food intake during the preliminary period was the basis for the amount of food fed on the first day of the assay period. Since Litters J and K were the same age and there were only six animals in Litter K, the casein animal of Litter J was used as a control for both litters.

The animals were weighed twice a week and daily food consumption records were kept. Spillings were sifted and returned to the food cup. Distilled water was given ad libitum. At the end of the assay period, the animals were chloroformed and autopsied for manifestations of deficiencies. The growth response, or the gain in body weight per gram of protein ingested per week, was calculated by the formula of Osborne, Mendel and Ferry (1919). The gains in weight of the animals during the eight-week period were analyzed by analysis of co-variance against the body weights at the beginning of the experiment to determine whether there were significant differences in the growth responses of the animals to the test foods.

RESULTS

RESULTS

In Tables IV through X the individual protein intakes, gains in weight and growth responses of the animals to the various diets are shown. The animals whose source of protein was casein ate an average of 30.7 grams of protein and gained an average of 40.5 grams in the eight week experimental period. Those animals who consumed dried brewer's yeast (Strain K) and defatted corn germ ate an average of 48.4 and 49.7 grams, respectively, in weight. The animals eating the brewer's type yeast (No. 200) ate an average of 31.3 grams of protein and gained an average of 47.7 grams. Those animals whose protein came from sunflower meal, toasted and defatted wheat germ ate an average of 31.2 grams of protein and gained an average of 45.0, 38.6, and 43.3 grams, respectively.

Table XI shows the growth response of each animal to the various proteins and Table XII the ration of each of the test food proteins to the control protein, casein; the ratios ranged between 0.9 and 1.2, calculated from the means of weights and protein intake of all animals on each protein. Only one of the foods tested, toasted wheat germ, had a ratio below unity indicating that the animals were able to utilize the protein of the test foods at least as well as the control protein.

Analysis of co-variance between the initial weight and the total grams gained showed that the average gain of the animals on one diet was not significantly different from the average gains of the animals on each of the other diets.

Table IV

Protein Intake, Gain in Weight and Growth Response of Animals Eating Casein

Animal from Litter	Protein Intake grams (8 weeks)	Gain in Weight grams (8 weeks)	Growth Response*
A	35.5	63	0.222
B	died at the end of 5 weeks		
C	27.6	57	0.258
D	36.1	67	0.232
E	31.9	35	0.137
F	24.6	33	0.168
G	29.0	28	0.121
H	34.1	28	0.103
J	26.6	13	0.061
K	no animal of this litter on casein diet		
Mean	30.7	40.5	0.163
Standard error	1.53	6.82	0.024

* Grams gain per gram protein ingested per week

Table V

Protein Intake, Gain in Weight and Growth Response of Animals Eating Yeast, Strain K

Animal from	Protein Intake grams (8 weeks)	Gain in Weight grams (8 weeks)	Growth Response*
A	38.6	77	0.249
B	36.6	56	0.192
C	29.5	54	0.229
D	36.3	57	0.196
E	32.2	58	0.225
F	24.9	39	0.141
G	29.0	44	0.190
H	33.6	52	0.194
J	26.5	28	0.132
K	26.5	30	0.142
Mean	31.4	48.4	0.189
Standard error	1.56	5.03	0.012

* Grams gain per gram protein ingested per week

Table VI

Protein Intake, Gain in Weight and Growth Response of Animals Eating Yeast, No. 200

Animal from Litter	Protein Intake grams (8 weeks)	Gain in Weight grams (8 weeks)	Growth Response*
A	38.2	82	0.269
B	34.2	57	0.208
C	died at the end of 4 weeks		
D	36.3	58	0.120
E	32.2	53	0.206
F	24.9	39	0.196
G	29.0	39	0.168
H	33.7	50	0.186
J	26.5	25	0.118
K	26.5	26	0.134
Mean	31.3	47.7	0.186
Standard error	1.28	5.93	0.015

* Grams gain per gram protein ingested per week

TABLE VII

Protein Intake, Gain in Weight and Growth Response of Animals Eating Sunflower Meal

Animal from Litter	Protein Intake grams (8 weeks)	Gain in Weight grams (8 weeks)	Growth Response*
A	37.0	65	0.220
B	35.1	60	0.214
C	30.7	46	0.187
D	36.3	54	0.186
E	32.2	54	0.210
F	24.9	33	0.166
G	29.0	39	0.168
H	33.6	47	0.175
J	26.5	21	0.099
K	26.5	31	0.146
Mean	31.2	45.0	0.177
Standard error	1.38	5.51	0.011

* Grams gain per gram protein ingested per week

Table VIII

Protein Intake, Gain in Weight and Growth Response of Animals Eating Toasted Wheat Germ

Animal from Litter	Protein Intake grams (8 weeks)	Gain in Weight grams (8 weeks)	Growth Response*
A	38.7	58	0.188
B	35.8	47	0.156
C	28.6	48	0.210
D	36.3	47	0.162
E	32.2	41	0.159
F	24.9	30	0.151
G	29.0	35	0.151
H	33.5	37	0.138
J	26.5	15	0.071
K	26.5	28	0.132
Mean	31.2	38.6	0.152
Standard error	1.51	3.89	0.011

* Grams gain per gram protein ingested per week

Table IX

Protein Intake, Gain in Weight and Growth
Response of Animals Eating Defatted Wheat Germ

Animal from Litter	Protein Intake grams (8 weeks)	Gain in Weight grams (8 weeks)	Growth Response*
A	37.4	64	0.214
B	36.6	48	0.164
C	29.7	50	0.218
D	36.3	59	0.203
E	32.2	51	0.198
F	24.6	30	0.152
G	29.0	36	0.155
H	33.6	44	0.164
J	26.5	26	0.123
K	26.5	25	0.118
Mean	31.2	43.3	0.171
Standard error	1.51	4.3	0.011

* Grams gain per gram protein ingested per week

Table X

Protein Intake, Gain in Weight and Growth Response of Animals Eating Defatted Corn Germ

Animal From Litter	Protein Intake grams (8 weeks)	Gain in Weight grams (8 weeks)	Growth Response*
A	37.4	69	0.231
B	36.7	63	0.215
C	31.9	55	0.216
D	36.3	67	0.231
E	32.2	53	0.206
F	24.3	23	0.118
G	29.0	47	0.203
H	33.6	55	0.205
J	26.5	29	0.137
K	26.5	36	0.170
Mean	31.4	49.7	0.193
Standard error	1.48	5.0	0.012

* Grams gain per gram protein ingested per week

Table XI

Growth Response of the Animals in Each Litter to Each Protein

Source of Protein	Growth Response of Litter										
	A	B	C	D	E	F	G	H	J	K	Mean
Casein	.222	----	.258	.232	.137	.168	.121	.103	.061	----	.163 ± .024
Yeast, Strain K	.249	.192	.229	.196	.225	.141	.190	.194	.132	.142	.189 ± .012
Yeast, No. 200	.269	.208	----	.120	.206	.196	.168	.186	.118	.123	.186 ± .015
Sunflower Meal	.220	.214	.187	.186	.210	.166	.168	.175	.099	.146	.177 ± .011
Toasted Wheat Germ	.188	.156	.210	.162	.159	.151	.151	.138	.071	.132	.152 ± .011
Defatted Wheat Germ	.214	.164	.218	.203	.198	.152	.155	.164	.123	.118	.171 ± .011
Defatted Corn Germ	.231	.215	.216	.231	.206	.118	.203	.205	.137	.170	.193 ± .012

Table XII

Ratio of the Test Food Proteins to Casein

Source of Protein	Number of Animals	Mean Protein Intake grams	Mean Gain in Weight grams	Mean Growth Response	Ratio to Casein
Casein	8	30.7 ± 1.53	40.5 ± 6.82	0.163 ± .024	1.00 (given
Yeast, Strain K	10	31.4 ± 1.56	48.4 ± 5.03	0.189 ± .012	1.16
Yeast, No. 200	9	31.3 ± 1.28	47.7 ± 5.93	0.186 ± .015	1.14
Sunflower Meal	10	31.2 ± 1.38	45.0 ± 5.51	0.177 ± .011	1.09
Toasted Wheat Germ	10	31.2 ± 1.51	38.6 ± 3.89	0.152 ± .011	0.93
Defatted Wheat Germ	10	31.2 ± 1.51	43.3 ± 4.30	0.171 ± .011	1.05
Defatted Corn Germ	10	31.4 ± 1.48	49.7 ± 5.0	0.193 ± .012	1.19

DISCUSSION OF RESULTS

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Still and Koch (1928) report that raw and coagulated yeast protein are not as satisfactory as casein in the diet of the rat as a source of protein. Macrae, El-Sadr and Sellers (1942) state that yeast is as effective as casein in supplementing maize in the diets of pigs. Block and Bolling (1943) found that yeast, corn germ and wheat germ supply the essential amino acids in approximately the same proportions as animal protein and state that these plant proteins are of good biological value in animal and human nutrition. Carter and Phillips (1944) report a study made by Von Soden and Dirr who found that only 80 per cent of the nitrogen of yeast is actually protein nitrogen. The above statement would indicate that the animals in this experiment were not receiving a diet of 10 per cent yeast protein. If so, these animals grew as well as those on casein though actually eating less protein and if allowance had been made for such non-protein nitrogen of yeast they may have made significantly greater gains. However, the animals consuming the proteins of yeast and corn germ grew slightly, but not significantly, better and appeared to be slightly more sleek than the animals receiving the other proteins.

Biscaro and DeCaro (1935) fed 10 rats for 5 months diets of wheat germ and corn germ and report considerable differences between the pairs on each diet. Boas-Fixsen and Jackson (1932) state that there is no significant difference in the biological value of the proteins of wheat and maize. Hove and Harrel (1943) report wheat germ to be of high biological value and that it is as effective as casein in supplementing poor-protein diets. The rats in this laboratory eating defatted wheat germ show a growth response which compares favorably with casein and the other protein foods tested. The animals consuming sunflower meal showed approximately the same response.

Previous work (Morgan, 1931; Seegers, Schultz and Mattill, 1936; Greaves, Morgan and Loveen, 1938) show that the temperature and length of time of heating effect the assortment of amino acids and the utilization of them. Hove and Harrel (1943) report no effect on biological value when wheat germ was heat processed to increase its keeping qualities and to make it adequate for human consumption. The animals in this experiment receiving protein in the form of toasted wheat germ, though consuming approximately the same amount of the diet as the other animals, did not respond as well as the animals receiving other protein; this response is not significantly lower. The degree and time of heating required for the toasting process apparently was not great enough to affect the quality of the protein. A tendency toward temporary alopecia during the natural shedding of hair was observed to occur more often in these animals than in others of the same litter; particularly in those consuming less than the mean protein intake. This may be due to a deficiency of an essential fatty acid or a vitamin of the B-complex.

Autopsy at the end of the experimental period disclosed that most of the animals were normal though the kidneys of the casein animals from Litters G and J had a slightly irregular surface. Livers, which were mottled but not abscessed, were found in 17 of the animals; the corn germ consuming animals were the only ones entirely free of this condition of the liver. This condition was seen more often in the first six litters than in the latter four and, if fat, may be related to the greater gains in weight as the gains of the last four litters was undulating due to environmental factors and these animals were called on more often to use body stores of fat.

SUMMARY AND CONCLUSIONS

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Seven groups of ten animals, one from each of ten litters were fed an adequate diet, in so far as could be determined, containing 10 per cent protein from casein, dried brewer's yeast (Strain K), brewer's type yeast (No. 200), sunflower meal, toasted wheat germ, defatted wheat germ and defatted corn germ for 8 weeks. The paired feeding method was modified so all animals of each litter were getting equivalent amounts of food. The growth response was measured as grams gained per gram of protein ingested per week.

Statistical analysis showed that there was no significant difference in the gains made by the animals on the various protein diets. Therefore, the plant proteins of yeast, sunflower meal, toasted and defatted wheat germ and defatted corn germ were as satisfactory as casein in promoting growth in this experiment when these foods were consumed as the sole source of protein in the diet.

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