THE VITAMIN B (B_1) CONTENT OF YEAST BREADS FROM WHEAT PRODUCTS

by

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INTRODUCTION

It is recognized that the average American diet has undergone great changes. Some nutrition workers believe the American diet to be deficient in vitamin B (B_1). Attention has been given to wheat, one of our most important food cereals, as a source of the vitamin B (B_1) a factor of the B complex. F. G. Hopkins (28) has said, "Except in arctic climates, bread and cereals are always important items in the food of mankind, and except where wealth accumulated and luxury came in its train, they are by far the most important. Circumstances have to be very exceptional indeed when the growing of cereals does not yield an energy supply for the worker at less cost and with less relative effort than any other method of food production. Economic and social factors usually tend to make bread by far the most convenient form in which the cereals can reach the individual consumer. The nations of the West have acquired the habit of demanding a well-piled loaf, and for this the special properties of wheat glutin seem necessary. Hence the reliance on wheat in the West".

At the present time there are a number of wheat milling products used in the commercial breads which made it seem worth while to study the question of the occurrence of vit-

amin B (B_1) in yeast breads. Differences of opinion are held as to the value of yeast used in the wheat breads prepared for human consumption.

LITERATURE

The extensive literature of the vitamins and the early work of vitamin B complex have been recently reviewed (11, 25,41,42). In view of the work done it seems necessary to discriminate between the nutritional factors which have been differentiated from the former undifferentiated vitamin B now called the vitamin B complex. Sherman (42) has said, "In terms of the knowledge of 1930-31, there are recognized as belonging to this general group of nutritional factors:

(1) Vitamin B (B_1) commonly characterized as anti-neuritic, relatively thermo-labile, and needed by both rats and pigeons;

(2) a second heat-labile factor needed for pigeons - Williams and Waterman's vitamin B_3;

(3) another heat-labile factor necessary for rats - Reader's vitamin B_4 (formerly called B_3);

(4) a relatively heat-stable factor needed by the rat (Smith and Hendrick) - the British vitamin B_2 or American vitamin G;

(5) at least another heat-stable factor - probably more than one (indicating by the work, among others, of Coward et

al.; Chick and Roscoe; Hunt, Salmon, et al.; Stiebeling)".

In this paper the antineuritic, thermo-labile factor will be designated as vitamin B (B_1).

The distribution of vitamin B (B_1) has received considerable attention as the diet of man includes highly milled products, sugar and fat and is believed to be lacking in vitamins. The whole grains of cereals are considered to be rich in vitamin B (B_1). Plimmer and co-workers (31,32,33) based their work on maintenance tests with pigeons and adopted the same standard of comparison, then compiled the vitamin B (B_1) values of pulses, nuts and cereal food. In green vegetables the vitamin was found more in the leaves but was lost to a great extent in cooking (9,28). The vitamin B distribution in the most common food cereals has received much attention (7,12,14,20,22,28,38,43). Bell and Mendel (1) found vitamin B (complex) dispersed throughout the entire wheat kernel, the percentage distribution of the vitamin in the different milling products being patent flour 0 to 5, first clear 10 to 15, second clear 5, low grade 16, middlings 40, and bran 24 per cent. Croll and Mendel (12) found nearly all the vitamin located in the embryo of maize. Croll (13) found the vitamin in both the embryo and endosperm ends of unpolished rice kernel but the bran was on the endosperm. Pure white polished rice is very deficient in vitamin B (B_1).

Brewer (3) investigated milling products made from a

country run of hard winter wheat from Salina, Kansas. It was found that middlings, bran and low grade were richer than the whole wheat in decreasing order as named, that patent flour and first clear were less rich than the whole wheat, and germstock, (similar to middlings but containing practically all of the germ) was about four times as rich as whole wheat. The patent flour contained definite but small measurable amounts of vitamin B (B_1), a physiologically significant finding in view of the fact that patent flour is prominent in the American dietary.

Yeast is recognized as a rich source of vitamin B (B_1). For this reason the introduction of yeast into bread making must increase the vitamin B (B_1) content, (on account of the yeast introduced and also because of the growth of the yeast). The stability of vitamin B (B_1) must be taken into consideration in order to determine the influence of yeast upon the nutritive properties of bread.

Sherman and Axtmayer (38) found that heating two and one half hours at 15 pounds pressure destroyed the thermolabile factor B (B_1) in bakers' yeast. It has been shown that oxidation does not seem to destroy vitamin B (B_1) (37). An important influence upon the antineuritic property of bread is the pH at the time of baking. Much work has been done with yeast in alkaline and acid medium (9,15,16,36,37). The change in pH from 4.28 to 10.9 accelerated the destruc-

tion to a greater degree than did a change in temperature from 100° to 130°C.

Some work has been done directly with breads. While Bell and Mendel (1) have stated that patent flour contains no appreciable amount of vitamin B, others have reported favorable results with yeast bread made from white flour. Chick and Hume (6) report that the "exposure of wheat embryo to a temperature of about 100°C. for 2 hours resulted in no significant loss in antineuritic 'vitamine', if, therefore, it is included in the flour from which bread or biscuit is made, it can be relied upon to retain its antineuritic properties after baking. At a temperature of 120°C. there is a swift destruction of the antineuritic properties". They also reported that white flour was deficient in the antineuritic vitamin and that it would produce polyneuritis if it made up the entire diet. Hartwell (18) found that white bread contains sufficient vitamin B to supply the needs of a rat, both for growth and reproduction. Growth is slow, but continuous. The slow growth is probably due to a deficiency in the quality and quantity of the protein. White flour contains a little vitamin B, but the main source is the yeast. Morgan and Barry (26) worked with underweight school children supplying rolls for the noon meal, one half the children receiving rolls made of white flour, the other half receiving rolls made with white flour and wheat germ so

that each received five ounces of wheat germ a week. The children receiving the wheat germ increased in weight three times as much as those in the other group and showed certain other superiorities as well.

The Japanese workers, Hashitani and Sako (46) found from their experiments that it was "apparent that white bread is deficient in nutritive properties, particularly in vitamin B (B (B_1)), such deficiencies in nutritive properties may be compensated for by the use of other articles of food in the diet. The addition of small quantities of dried brewers' yeast has been found to be helpful in making good the nutritive defects of white bread. The addition of brewers' yeast does not affect the quality (palatability) of the bread". The weight of compressed yeast in their original formula was 1.5 per cent. They studied the pH of the dough and the temperatures during the baking process, and found "the pH of the dough at proofing time was 5.6, and the temperature of the inner part of the loaf of bread did not quite reach 100°C. Temperatures in excess of 90°C. were not exceeded for over 10 to 20 minutes". Their experiments seem, "to prove that vitamin B (B (B_1)) contained in bread is not decomposed by heat".

Various investigators (2,4,7,8,11,17,19,21,26,29,30,38, 44,45) have found that vitamin B (B_1) is necessary for normal growth and appetite, metabolic function, reproduction and

lactation and to prevent neuromuscular disorders. The weight curve may be used for the measurement of vitamin B (B_1) but failure of appetite and the development of polyneuritis are also very characteristic of the lack of this vitamin. "Vitamin B produces growth in two ways, by possessing the physiological function of stimulating growth per se unrelated to food intake; and it produces growth by increasing the plane of nutrition through a stimulation of the appetite" (45). Lack of vitamin B (B_1) causes a more rapid loss of appetite than a lack of G (B_2) (8,10,23,29,35,40). Polyneuritis appears in cases of severe shortage of the vitamin B (B_1) while in complete deprivation, death results before the appearance of nerve symptoms (4,7,24,35,41). Many observations indicate that for successful lactation as well as reproduction much more vitamin B (B_1) is needed even than for rapid growth (44).

Many points must be considered in developing satisfactory methods for the quantitative determination of vitamin B (B_1). Rats are able to store some vitamin B (B_1) in their bodies (5) and coprophagy will supply the rat with plenty of vitamin B (B_1) for growth even if the diet is deficient (34). It is on this account that raised wire screen floors are used in the cages.

Vitamin B (B_1) has been found to be soluble in 60 per cent alcohol (35,39) and Bisbey (2) found it no more soluble

in acid alcohol than alcohol alone. This is important for the work in testing diets for quantitative determinations of vitamin B (B_1). Chase and Sherman (5) defined the unit of vitamin B (B_1) as that amount which when fed as a daily allowance to a standard test animal sufficed to support three grams per week of gain with no apparent symptoms of polyneuritis during an eight week experimental period.

The method of Chase and Sherman (5) adopted for these investigations was carefully developed with due consideration to these various points.

METHOD

This investigation was planned to determine the antineuritic vitamin B (B_1) content of breads baked in the commercial way from wheat products. The method used was much like that developed by Chase (4) and Chase and Sherman (5), essentially as follows: Normal young albino rats from the stock animals fed on Sherman's diet of ground whole wheat, dried whole milk and sodium chloride, were separated from their mothers when four weeks of age. Since from preliminary experiments it has been shown rats store vitamin B (B_1) they were placed on the basal diet until they ceased to increase in weight indicating depletion of bodily surplus of vitamin B (B_1). Each animal was kept in an individual round galvanized iron wire cage with a raised wire screen bottom

to prevent access to excreta. Fresh distilled water was always available. The cages were cleaned frequently and the scattered food was recovered. Weekly records of the food eaten was kept and the rats were weighed weekly. A representative number of male and females were continued on the basal diet only to serve as (negative) control and the same on the basal diet only the yeast not autoclaved to serve as (positive) controls.

In this particular study young rats of Wistar stock, after depletion, were placed on the various diets. Fresh distilled water and a weighed amount of diet were given ad libitum. The cages had removable pans with wire screens of half inch mesh. Several layers of newspapers were laid in the pans, which were changed every other day and the cages, screens, pans and jars were sterilized once a week. Animals were selected so as to have nearly equal numbers of males and females, uniform in weight with none unusually large or unusually small. At least 10 or more were placed on the diet so that one could discard those that were suspected of the coprophagy habit or any other abnormalities. Notes were made regarding any unusual observations or symptoms of the animal.

The B (B_1)-free diet of Chase and Sherman (5) used as a basal ration was made as follows:

Casein which has been extracted to free it of vitamin B 18%

Autoclaved yeast 15%

Osborne and Mendel Salt Mixture (28) 4%

Cod liver oil 2%

Butterfat 8%

Cornstarch 53%

The casein was freed of vitamin B (B_1) by cold extraction with 60 per cent alcohol. Four hundred grams of casein were treated with two liters of 60 per cent alcohol and the whole stirred for one-half hour, then allowed to stand 5.5 hours, filtered with suction and washed with one liter of 60 per cent alcohol. It was again treated with two liters of 60 per cent alcohol and stirred for another half hour. After standing 18 hours it was filtered again, washed with another liter of 60 per cent alcohol and spread out to dry.

Dried brewers' yeast was placed in uniform open petri dishes and heated at 15 pounds pressure under steam for 2.5 hours. The yeast was left in the autoclave until it was cool enough to handle and then run through a sieve.

The salt mixture was prepared according to the method of Osborne and Mendel (28). The butterfat was prepared by melting at a temperature of 45°C.

and allowing it to solidify. The fat was separated from the curd, salt and water, washed with water and filtered through filter paper at 45°C. The cod liver oil was of a good grade throughout the experiment. Cornstarch was a commercial grade of good quality.

For these experiments, bread was made under controlled conditions according to commercial methods. The patent flour, whole wheat for the so-called 50-50 bread, and germ-stock were milling products prepared by the Department of Milling Industry of this college from a country run of winter wheat containing 11.5 per cent protein. The protein content of the whole wheat flour was estimated as 11.2 per cent (N x 5.7) and of the patent flour 10 per cent (N x 5.7). A commercial brand of whole wheat flour was also used, assumed to have the same protein content as the whole wheat flour above. Details concerning the breads used are given in Table I.

Diets, based upon the Chase and Sherman (5) B (B_1)-free basal ration, were planned including definite percentages of the milling products to determine the minimum quantity necessary to supply sufficient vitamin B (B_1) for a gain of three grams per week with no apparent symptoms of polyneuritis during an eight week experimental period. It was necessary to incorporate the cereal product in the diet as daily supplementary doses of sufficient size could not be

TABLE I

FOUR KINDS OF BREAD USED IN THE EXPERIMENTS

Ingredients of bread	Baked: In laboratory of Department of Milling Industry: white bread (grams): starter	white bread (grams): dough	whole wheat bread 50-50 per cent (grams): starter	whole wheat bread 50-50 per cent (grams): dough	In commercial bakery: whole wheat bread 100 per cent: one mixing	germstock bread 10 per cent: starter	germstock bread 10 per cent: dough
Patent flour	340.0	160.0	90.0	160.0		73 lbs.	44 lbs.
Whole wheat flour			250.0				
Germstock						13 lbs.	
Commercial whole wheat flour					25.0 lbs.		
Yeast	10.0		10.0		12.0 oz.	3 lbs.	
Shortening		10.0		10.0	1 lb.		3 lbs.
					4 oz.		12 oz.
Sugar		22.0		22.0	1.5 oz.		6 lbs.
Arkady	2.5		2.5			7 oz.	
Salt		9.0		9.0	10.0 oz.		2 lbs. 4 oz.
Powdered Milk							2 lbs. 10 oz.
Water	220.0	130.0	220.0	130.0	18.0 lbs.	52 lbs.	32 lbs.
Per cent of yeast in terms of of dry ingredients	1.8		1.8		2.7	2.0	
Remarks:	Starter rises 4 hrs. Dough rises 50 min. Bake 25 to 30 min. at 230°C. This amount makes 2 loaves.		Starter rises 4 hrs. Dough rises 50 min. Bake 25 to 30 min. at 230°C. This amount makes 2 loaves.		Total mixed at once Water at 70°F. at start all for 25 min. the mixture now 81°F. Let rise 2.5 hrs. This amount makes 30 loaves of uniform weight before proofing. Bake at 260°C for 20 min. Each loaf represents 378 grams of whole wheat flour.	Starter rises 4 hrs. Dough rises 50 min. Bake 20 min. at 260°C. This amount makes 180 loaves of uniform weight before proofing. Each loaf represents 33 grams of germstock.	

TABLE II

CALCULATION FOR DIET 9 FORMULA FOR 2 LOAVES

10 PER CENT WHOLE WHEAT FLOUR FURNISHED BY 50-50 BREAD

Weight of one formula -			grams	grams
2 loaves of 50-50 bread contained				
250 grams whole wheat flour				
250 grams patent flour				
With whole wheat flour 10 per cent weight of total formula (10 x 250)				2500
Wheat products in the bread			500	
Casein,	18 per cent of formula	2500 = 450		
	11.2 x 250	= 28		
	10.0 x 250	= 25		
	(11.2 per cent protein in whole wheat flour)			
	(10.0 per cent protein in patent flour)			
	Casein to make up balance of 18 per cent by difference		397	
Yeast,	15 per cent of	2500 =	375	
Osborne and Mendel salt mixture				
	4 per cent of	2500 =	100	
Cod liver oil,	2 per cent of	2500 =	50	
Butterfat,	8 per cent of	2500 =	200	
Starch,	Total for formula - the sum of wheat products, casein, yeast, Osborne and Mendel salts, cod liver oil and butterfat.		878	

TABLE III

SERIES OF DIETS TESTED

Diet	No.	Milling product in bread	Percentages dry weight: Casein	Starch	Yeast*	O & M Salts	cod liver oil	butter fat
Negative	1		18	53	15	4	2	8
Positive	2		18	53	15	4	2	8
Patent	3	60	11		15	4	2	8
flour	4	50	12	9	15	4	2	8
furnished	5	45	13	13	15	4	2	8
by white	6	40	14	17	15	4	2	8
bread	7	30	15	26	15	4	2	8
	8	20	16	35	15	4	2	8
Whole	9	10	16	35	15	4	2	8
wheat	10	7	16	41	15	4	2	8
flour	11	5	17	44	15	4	2	8
furnished by 50-50 per cent bread	12	4	17	46	15	4	2	8
Whole	13	10	17	44	15	4	2	8
wheat	14	8	17	46	15	4	2	8
flour	15	5	18	49	15	4	2	8
furnished by 100 per cent bread	16	3	18	50	15	4	2	8
Germstock	17	3	14	27	15	4	2	8
furnished	18	2	16	35	15	4	2	8
by 10 per cent germstock bread	19	1	17	44	15	4	2	8

* Yeast - autoclaved for all diets except the positive.

fed. The milling products were contained in the four different kinds of bread. Calculations were made so that the protein of the bread plus the protein of the casein would always total 18 per cent. Starch was varied to make the difference. No allowance was made for the yeast, salt, fat and other small items as they seemed to be of negligable importance. In order that diets might all be uniform, the formulae for mixing were calculated so that at least one whole loaf was used at a time. The loaf was used as a unit as the ingredients were known. Complete figures for Diet 9 are given in Table II, to illustrate methods used in calculating.

In using the bread, a loaf was always sliced, dried at room temperature until sufficiently dry to grind, and then ground to a coarse powder in a hand mill and stored in covered glass containers until used. It is thought this treatment did not materially reduce the vitamin B (B_1) content of the baked bread (37). Some type of subdivision was necessary in order that homogenious mixtures could be prepared for the animals. The series of diets used in this experiment are listed in Table III.

Tables IV to XXII were compiled from the records and composite curves were prepared from the averages obtained. Comparisons were then possible, based largely upon the unit as defined by Chase and Sherman (5). The gains and survival periods of animals receiving various per cents of different

breads were compared directly with those of negative controls receiving only the basal vitamin B (B_1)-free diet, and also with those of the positive controls. The positive control animals received a diet planned to be optimal in all respects, yeast which had not been autoclaved supplying the vitamin B (B_1).

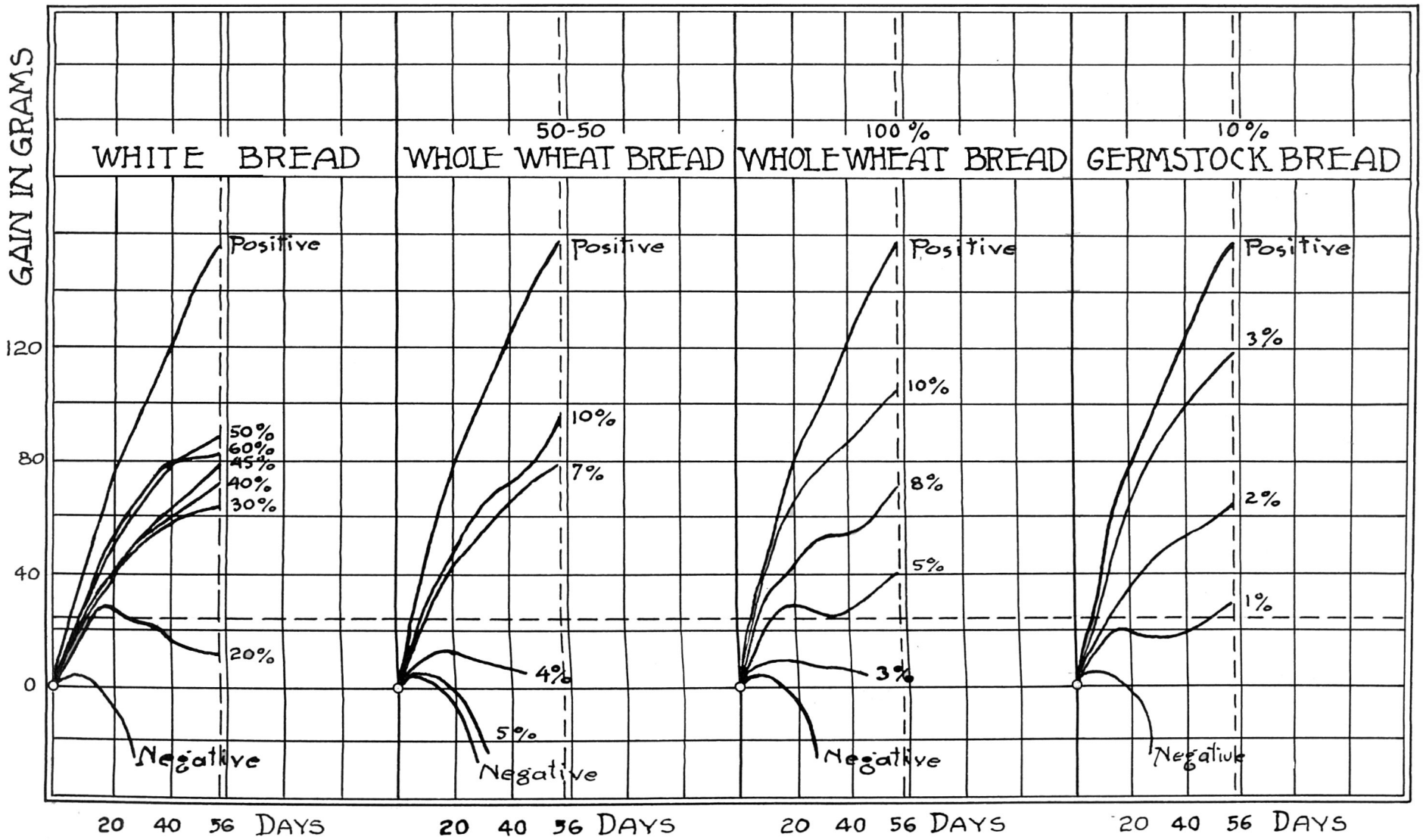

Fig. 1. AVERAGE GAIN CURVES

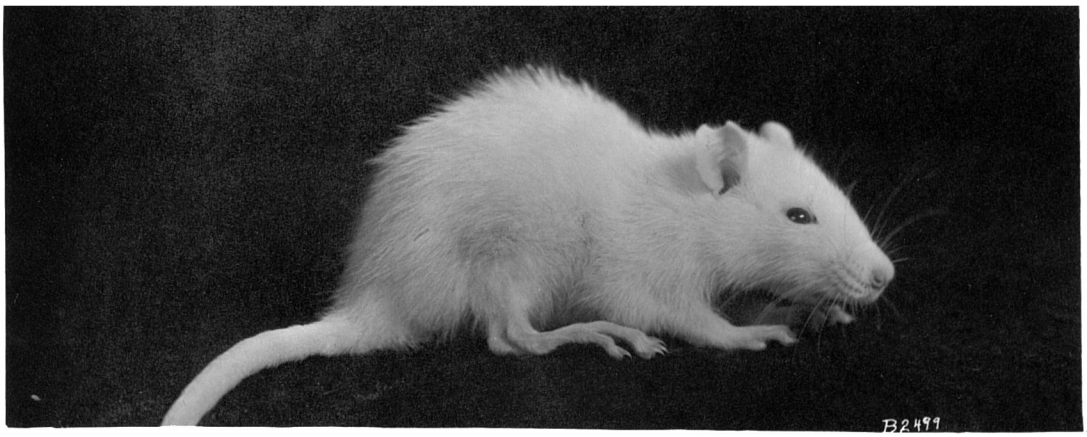

Figure 1.

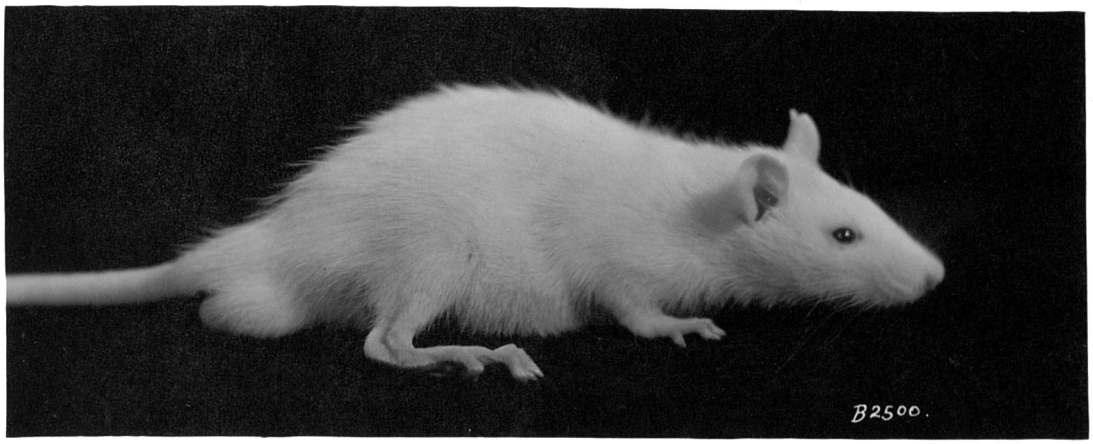

Figure 2.

Figure 3.

TABLE IV

RATS ON VITAMIN B (B_1)-FREE DIET ONLY

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5638M	46	13	22	65	0	-4	-4	-9	+2				-15	30	-
5641	42	13	26	66	-2	-5	-9	-10					-26	24	-
5645	45	11	24	68	0	-7	-5	-10					-22	25	-
5702	44	13	37	81	-2	-1	-11	-12	-7				-33	29	-
5758	48	13	30	72	+7	-17	-12	-2					-24	23	-
5821	51	10	32	83	+9	-2	-20	-15					-28	25	-
5824	52	12	26	78	+12	+14	-12	-16	-20				-22	29	-
5648F	45	11	21	66	+4	-7	-7	-14					-24	26	-
5823	53	10	28	81	+5	-1	-10	-20					-26	26	-
Av.	47.5	11.7	27.3	73.3	3.6	-3.3	-10	-12	-8.3				-25.3	26.3	

- = Free of polyneuritis

TABLE V

RATS ON VITAMIN B (B_1)-FREE DIET YEAST NOT AUTOCLAVED

Rats No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5637M	48	13	30	78	+36	+33	+9	+31	+23	+43	+24	+15	214	56K	-
5647	40	11	24	64	+23	+49	+47	+20	+37	+20	+20	+18	234	56K	-
5866	45	12	19	62	+37	+23	+34	+20	+17	+11	+11	+9	162	56K	-
5649F	41	11	21	61	+24	+29	+25	+11	+12	+1	+17	+6	125	56K	-
5650	37	11	19	55	+35	+17	+6	+4	0	+11	+22	+12	107	56K	-
5651	35	10	16	48	+22	+18	+23	+18	+21	+9	+15	+9	135	56K	-
5740	54	11	26	78	+28	+26	+16	+21	+9	+16	+8	+8	132	56K	-
5859	45	12	27	72	+34	+26	+22	+17	+15	+7	+4	+9	134	56K	-
Av.	43.1	11.3	22.8	64.8	30	27.6	22.7	17.8	16.8	14.8	15.0	10.8	156	56	

K = Killed after 56 days on diet
- = Free of polyneuritis

TABLE VI

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 60% PATENT IN WHITE BREAD

Rats No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5626M	43	16	29	72	+30	+31	+15	+17	*						-
5627	39	16	32	68	+32	+24	+24	+9	*						-
5630	40	16	27	67	+32	+27	+21	+12	*						-
5703	43	12	18	60	+11	+37	+22	+19	+17	+14	+4	+5	129	56K	-
5629F	41	16	19	54	+15	+19	+12	+10	*						-
5631	37	16	22	58	+19	+6	+10	+12	*						-
5695	46	12	15	61	+27	+13	+11	+8	+2	+7	-2	+3	69	56K	-
5696	46	12	22	67	+11	+3	+12	+10	+11	+6	-2	-3	48	56K	-
Av.	42	14.2	23	63.4	22.1	20	16	12.1	10.0	9.0	0	1.7	82	56	

* These rats were not kept on the diet on account of the rapid growth and the large amount of food consumed.

K = Killed after 56 days on diet

\- = Free of polyneuritis

TABLE VII

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 50% PATENT IN WHITE BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5625M	44	16	15	51	+25	+23	+15	+15	-3	+3	+3	-3	78	56K	-
5628	37	16	23	56	+23	+27	+19	+12	+12	+9	+7	0	109	56K	-
5701	49	12	17	65	+5	+20	+38	+20	+24	+20	+7	+11	145	56K	-
5633F	47	14	19	66	+18	+24	+21	+7	+6	+3	+3	+1	83	56K	-
5634	45	14	22	67	+13	+21	+20	+3	+10	+3	+3	+1	74	56K	-
5635	41	14	21	62	+10	+26	+10	+9	+9	+3	+11	+5	83	56K	-
5694	46	13	23	68	+15	+21	+9	+11	+2	+1	-4	+1	68	56K	-
5697	43	13	26	69	+8	+8	+13	+14	+10	+6	+2	+3	64	56K	-
5802	40	9	16	56	+22	+14	+15	+7	+6	+10	+10	+13	97	56K	-
5803	38	9	22	60	+23	+17	+16	+10	+7	+3	+8	+5	89	56K	-
Av.	43	13	20.4	62	16.2	20.1	17.6	10.8	9.0	6.1	5.0	3.7	89	56	

K = Killed after 56 days on diet
\- = Free of polyneuritis

TABLE VIII

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 45% PATENT IN WHITE BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5828M	50	12	23	74	+15	+17	+18	+9	-5	+7	+6	+21	88	56K	-
5829	44	12	23	66	+13	+11	+8	+6	+9	+5	+16	+2	70	56K	-
5830	39	12	19	58	+20	+12	+14	+16	+6	0	+5	+3	76	56K	-
5831	37	12	21	58	+28	+11	-2	+7	+3	+8	+16	+15	86	56K	-
5832F	47	12	28	74	+18	+10	+10	+11	+15	+7	+6	+3	80	56K	-
5833	41	12	15	56	+21	+12	+7	+4	-6	+10	+16	+7	71	56K	-
5834	35	12	21	55	+6	+9	+9	+9	+5	+7	+2	+20	67	56K	-
5835	35	12	16	51	+15	+4	+3	+5	+5	+6	+3	+16	57	56K	-
5896	48	12	17	65	+23	+20	+12	+14	+6	+10	+10	+5	100	56K	-
5897	48	12	24	72	+16	+13	+9	+9	+10	+15	+10	+2	84	56K	-
5898	45	12	26	70	+12	+22	+6	+10	+12	+12	+12	+5	91	56K	-
Av.	43	12	21	63.5	17	12.8	8.4	9	5.4	8	9	9	79	56	

K = Killed after 56 days on diet
- = Free of polyneuritis

TABLE IX

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 40% PATENT IN WHITE BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5632M	43	14	25	67	+18	+12	+11	+12	-3	-9	-8	+12	45	56K	-
5698	55	13	35	90	+33	+17	+28	+7	+14	+15	+12	+7	133	56K	-
5642F	43	13	21	63	+12	+12	+14	+5	-9	-14	-3	+19	36	56K	-
5643	40	13	19	59	+17	+13	+13	+7	-4	-9	-12	+6	31	56K	-
5693	47	13	22	69	+16	+4	+5	+4	+11	+5	+1	+1	47	56K	-
5800	44	9	26	69	+31	+22	+10	+8	+8	+1	+7	+12	99	56K	-
5801	50	9	20	70	+26	+24	+11	+14	+10	+2	+3	+7	97	56K	-
5810	41	9	26	65	+35	+11	+2	0	+23	+14	+4	+9	98	56K	-
Av.	45	11.6	24	69	23.5	14.3	11.7	7	6.2	0.6	0.5	9	73	56	

K = Killed after 56 days on diet
- = Free of polyneuritis

TABLE X

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 30% PATENT IN WHITE BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5733M	49	14	18	77	+4	+9	+17	0	+3	-10	-17	-4	2	56K	-
5738	50	11	20	70	+22	+22	+15	+6	+4	+1	+2	-10	62	56K	-
5754	42	11	24	66	+10	+12	+16	+19	+10	0	+15	+2	84	56K	-
5757	51	11	24	74	+3	+7	+13	+17	+16	+10	+10	-1	75	56K	-
5759	47	11	20	66	+3	+11	+14	+10	+11	+13	-8	-3	51	56K	-
5760	47	13	32	79	+24	+11	+17	+22	+2	-3	-1	0	72	56K	-
5735F	49	14	17	76	+14	+9	+22	+1	+7	+6	-12	+6	47	56K	-
5761	40	11	22	62	+8	+10	+7	+3	+22	+16	+7	+7	80	56K	-
5813	40	10	21	61	+21	+17	+11	+10	+8	-3	+9	0	73	56K	-
5814	37	10	20	57	+23	+24	+6	+17	+6	+7	+10	+3	95	56K	-
Av.	45.2	11.6	21.8	68.8	13.2	13.2	13.8	10.5	8.9	3.7	1.5	0	64.1	56	

K = Killed after 56 days on diet
- = Free of polyneuritis

TABLE XI

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 20% PATENT IN WHITE BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5728M	53	14	28	80	-4	0	+14	0	+5	+7	+8	+10	40	56K	H
5729	52	14	31	82	+4	+9	+25	+27	+6	-8	-1	+3	65	56K	H
5732	50	14	29	79	+1	-4	-2	-8	-6	-9			-28	37	H
5736	53	11	27	78	+5	+21	+5	-12	-11	-22	-5		-29	43	P
5737	52	11	31	83	+8	-7	-5	-17	-2	-8			-31	37	SP
5739	47	11	33	79	+12	+2	-10	0	+6	-12	+23	+7	+28	56K	H
5753	44	11	28	72	+3	0	+4	+16	+15	-1	-1	-3	33	56K	H
5763	54	11	33	86	+15	+7	-12	-15	-21				-26	35	P
5741F	52	11	30	81	+22	+14	+2	-13	+3	-6	+5	+2	29	56K	-
5756	42	13	33	75	-2	+11	+11	+1	+1	+2	+3	+21	48	56K	-
Av.	49.9	12.1	30.2	79.5	6.4	5.3	3.2	-2.1	-0.4	-6	+4	6.6	12.9	48.8	

K = Killed after 56 days on diet
H = Humped
P = Polyneuritic
SP= Slightly polyneuritic
- = Free of polyneuritis

TABLE XII

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 10% WHOLE WHEAT IN 50-50 BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5654M	45	11	20	61	+18	+9	+20	+18	0	+10	+16	+12	103	56K	-
5615	46	15	36	77	+12	+1	+16	+11	-7	0	+9	+7	49	56K	-
5616	44	15	35	72	+7	+13	+14	+14	-4	-5	+3	+16	58	56K	-
5619	40	15	15	49	+13	+2	+6	+3	-3	-2	+15	+22	56	56K	-
5790	45	9	29	73	+34	+33	+28	+26	+5	+11	+13	+14	164	56K	-
5791	44	9	26	68	+40	+27	+19	+15	+7	0	+20	+1	129	56K	-
5792	40	9	28	67	+33	+31	+26	+23	+7	+1	+8	+14	143	56K	-
5793	39	9	24	62	+30	+24	+29	+21	+9	+11	+5	+2	131	56K	-
5660F	45	11	19	62	+ 22	+9	+6	-5	-4	+8	-3	+12	45	56K	-
5612	43	17	39	78	+9	0	+13	+15	-2	-13	+18	+7	56	56K	-
5614	41	17	33	70	+6	+7	+17	+20	-2	+13	+15	+8	84	56K	-
5826	50	13	30	79	+21	+4	+23	+9	+14	+7	+6	+3	87	56K	-
5875	51	10	24	75	+17	+22	+29	+13	+15	-4	+10	+15	117	56K	-
Av.	44	12.3	27.5	69	20.1	14	19	14	3	3	10.4	10.2	94	56	

K = Killed after 56 days on diet
- = Free of polyneuritis

TABLE XIII

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 7% WHOLE WHEAT IN 50-50 BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5764M	42	11	32	74	+20	+10	+2	+3	+3	-4	-8	+22	48	56K	-
5765	37	11	24	60	+9	+26	+21	+20	+8	+7	0	+8	99	56K	-
5768	40	11	26	65	+1	+9	+10	-4	+9	+7	-2	+4	34	56K	-
5770	53	9	28	81	+24	+21	+18	+8	+9	+7	-2	+10	95	56K	-
5766F	40	11	25	65	+21	+14	+14	+6	+10	+5	+10	-5	75	56K	-
5769	42	11	26	68	+10	+11	+9	+3	+15	-4	-7	0	37	56K	-
5782	53	11	27	80	+20	+14	+5	+11	+19	+16	+9	+13	107	56K	-
5783	50	11	28	78	+21	+11	+16	+12	+20	+5	+8	0	92	56K	-
5784	46	11	27	73	+15	+11	+11	+9	+12	+11	-5	+7	71	56K	-
5795	38	9	23	60	+28	+17	+10	+5	+5	+10	+12	+8	95	56K	-
5796	38	9	18	58	+21	-2	-7	+18	+4	+8	+10	+17	69	56K	-
5825	51	13	35	84	+31	+23	+16	+4	+10	+7	+8	+1	100	56K	-
5882	47	14	23	70	+26	+17	+17	+11	+10	+6	+4	+5	96	56K	-
Av.	44.4	11	26.3	70.4	19	14	11	8	10.5	6.1	3.0	7.0	78.3	56	

K = Killed after 56 days on diet
- = Free of polyneuritis

TABLE XIV

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 5% WHOLE WHEAT IN 50-50 BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5610M	41	17	35	72	+4	-1	-16	-9					-22	22	P
5617	43	15	22	60	+1	-2	+6	-11	-11	-5			-22	37	P
5618	42	15	21	57	+7	-1	-2	-10	-10				-16	32	P
5718	41	17	35	76	+2	-11	-10	-12					-31	26	P
5730	52	14	30	82	0	-7	-2	-16					-25	25	P
5613F	42	17	28	63	-5	-4	-1	-7					-17	26	P
5657	48	11	22	68	+15	-5	-8	-3	-12	-9			-22	37	P
5658	47	11	23	65	+14	-9	-7	-16	-3				-21	29	P
5661	43	11	24	66	+10	-2	-7	-12	-12				-25	34	P
5722	42	16	40	82	+4	-5	-10	-2	+3	-18	-8		-36	46	P
Av.	44.1	14.4	28	69.1	5.2	-4.7	-5.7	-9.8	-7.5	-10.6	-8		-23.5	31.5	

P = Polyneuritis

TABLE XV

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 4% WHOLE WHEAT IN 50-50 BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5608M	47	17	38	80	-7	-4	-10	-11					-32	25	P
5611	41	17	44	77	+17	+23	-18	-11	-4	-17			-10	42	P
5653	49	11	29	78	-2	+1	+8	-4	+7	-24			-14	38	P
5856	45	12	37	82	+11	+2	+1	-4	-8	-7	-17		-26	49	H
5620F	39	15	24	58	+1	0	+11	+12	+2	-4	-3	-1	18	56K	H
5621	38	15	19	51	+4	0	+7	+3	+3	-2	+4	-2	17	56K	H
5622	36	15	18	52	+1	+5	0	-10	-10				-14	33	P
5655	50	11	20	70	+17	+1	-4	-13	-10	-11			-20	38	P
5656	49	11	22	71	+23	+10	+4	-7	+2	+7	-2	+2	37	56K	Sl P
5858	48	12	32	80	+14	+4	-5	-3	-1	-6	+9	0	12	56K	Sl P
5881	48	13	24	68	+11	+16	+12	+13	+18	+7	+5	+4	86	56K	-
Av.	44.5	13.5	28	70	8	5.2	0.5	-3	-0.1	-6.3	-.7	0.6	5.0	46	

K = Killed after 56 days on diet
P = Polyneuritic
H = Humped
Sl P = Slightly polyneuritic

TABLE XVI

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 10% WHOLE WHEAT IN 100% BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5838M	46	10	33	79	+31	+25	+18	+27	+1	0	-1	+11	112	56K	-
5839	43	10	26	69	+32	+27	+27	+17	+8	+13	+2	+10	136	56K	-
5841	43	10	25	68	+17	+38	+30	+11	+13	+11	-1	+12	131	56K	-
5893	44	12	21	65	+23	+22	+24	+8	-2	+2	+24	+11	112	56K	-
5842F	44	10	21	65	+29	+11	+18	+13	+7	+6	+5	+1	90	56K	-
5847	54	12	31	85	+23	+15	+16	+11	+17	+6	+2	+10	100	56K	-
5849	53	7	23	76	+24	+15	+9	+11	+11	+9	+7	+10	96	56K	-
5850	50	7	30	80	+28	+18	+14	+17	+21	+6	+4	+9	117	56K	-
5851	50	7	23	71	+27	+12	+6	-2	+5	+2	+11	+10	71	56K	-
5860	42	12	30	72	+23	+14	+18	+13	+8	+2	0	0	78	56K	-
5861	42	12	36	78	+28	+14	+27	+8	+16	0	+2	+5	100	56K	-
Av.	46.4	10	27	73.4	26	19	18.8	12	9.5	5.1	5	8	104	56	

K = Killed after 56 days on diet
- = Free of polyneuritis

TABLE XVII

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 8% WHOLE WHEAT IN 100% BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5663M	44	11	19	63	+24	+15	+10	-4	-3	+5	+7	+11	65	56K	-
5664	42	11	21	63	+18	+16	+13	+4	-11	-6	+2	+5	41	56K	-
5688	40	14	26	65	+17	+3	-5	+4	0	-7	+4	+1	17	56K	Sl H
5704	41	14	20	61	+24	+15	+6	+7	+15	+2	-2	-12	55	56K	-
5788	47	9	26	73	+35	+27	+12	+30	+3	-10	+2	+11	110	56K	-
5789	47	9	27	73	+24	+20	+15	+14	0	0	-6	-1	66	56K	-
5855	52	14	41	89	+29	+8	+14	+8	+12	+20	+20	+18	129	56K	
5668F	46	11	21	67	+9	+18	+6	+12	+6	-2	-3	-4	42	56K	-
5690	38	14	24	61	+16	+7	0	0	+2	+4	+14	+10	53	56K	-
5794	40	9	15	54	+25	+22	+14	+19	+2	-4	+7	+18	103	56K	-
5827	43	12	25	66	+21	+19	+8	+6	+4	+1	+5	+5	69	56K	-
5797	37	9	21	57	+24	+17	-6	+6	-10	+4	+10	+18	63	56K	-
Av.	43	11.4	23.8	66	22.2	15.6	7.2	8.8	1.8	0.6	5.0	6.6	70	56	

K = Killed after 56 days on diet
- = Free of polyneuritis
Sl H = Slightly humped

TABLE XVIII

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 5% WHOLE WHEAT IN 100% BREAD

Rat No.	Wt. at 4 weeks grams	De-ple-tion days	Maxi-mum gain during deple-tion grams	Weight at end of deple-tion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Sur-vival days	remarks
5840M	43	10	19	62	+10	+10	+18	0	+5	+4	-2	-4	41	56K	-
5665F	48	11	30	78	+18	+2	+3	-11	-5	-5	+4	+11	17	56K	-
5666	47	11	23	70	+17	+5	+1	-1	-11	-3	+2	+6	15	56K	-
5667	46	11	19	65	+14	+15	-3	+5	-3	+3	0	0	31	56K	-
5684	50	14	35	80	+19	+5	0	-13	-1	+13	+12	+5	40	56K	-
5689	48	14	28	77	+6	+1	+6	-1	+15	+12	+12	+5	46	56K	-
5707	47	14	32	79	+15	+24	+1	-15	-6	-5	-1	-10	3	56K	Sl H
5807	54	9	22	75	+9	+30	+11	+3	+10	+1	+13	+8	85	56K	-
5809	49	9	23	70	+16	+12	+4	+13	+15	+7	+11	+12	90	56K	-
Av.	48	10.3	25.6	73	13.8	11.5	4.5	-2.2	-2.1	3	5.6	3.6	40	56	

K = Killed after 56 days on diet
Sl H = Slightly humped
- = Free of polyneuritis

TABLE XIX

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 3% WHOLE WHEAT IN 100% BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5771M	50	9	31	81	+13	+7	+3	+3	-12	-31			-17	37	
5885	46	11	26	72	+8	0	-8	-17					-17	27	H
5886	40	11	23	63	+12	-1	+1	+5	+10	-1	-5	+4	25	56K	H
5742F	50	13	26	76	+9	-4	-5	-1	-7	-4	-13		-25	47	H
5743	49	13	31	80	+1	-12	-7	+2	-4	0	-5	-8	-33	50	H
5744	48	13	31	79	+3	0	-8	-5	-5	-8			-23	36	H
5772	48	9	30	78	+14	0	-1	+11	+11	+10	0		55	56K	Sl H
5773	46	9	24	70	+17	+6	-7	0	-1	-1	+6		30	56K	Sl H
5873	53	13	32	85	+11	+4	+6	-2	+3	-2	-3	+12	29	56K	-
5874	52	14	36	87	+7	+1	+4	+8	+8	+11	+4	+16	59	56K	-
5888	50	12	32	82	+5	+14	-8	-2	-13				-32	35	P
Av.	48.3	11.5	29.2	77.5	9.9	1.3	-2.7	0.2	-1.0	-3.0	-2.3	6.0	4.6	46.5	

K = Killed after 56 days on diet
H = Humped
P = Polyneuritis
Sl H = Slightly humped

TABLE XX

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 3% GERMSTOCK IN 10% GERMSTOCK BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5836M	48	10	35	83	+43	+38	+14	+18	+7	+14	+8	+4	146	56K	-
5837	47	10	28	75	+40	+25	+23	+25	+3	+22	+10	+7	155	56K	-
5862	55	12	25	79	+31	+12	+28	+25	+16	+13	+7	+11	143	56K	-
5864	54	12	25	79	+21	+24	+32	+11	+14	+6	+5	+10	123	56K	-
5865	52	12	35	86	+25	+25	+37	+14	+18	+14	+20	+1	154	56K	-
5878	49	13	35	84	+31	+35	+27	+23	+15	+5	+9	+3	148	56K	-
5843F	37	10	23	60	+28	+16	+11	+10	+15	+7	+5	+3	95	56K	-
5844	36	10	19	54	+26	+21	+16	+13	+10	+3	+5	+2	96	56K	-
5867	54	12	25	79	+17	+14	+19	+5	+11	+6	+7	+7	86	56K	-
5868	53	12	29	82	+18	+5	+22	+11	+10	+2	+5	+5	78	56K	-
5869	45	12	28	73	+18	+19	+17	+7	+12	+4	+7	+1	83	56K	-
5880	49	13	28	77	+23	+20	+15	+10	+9	+10	+11	+1	99	56K	-
Av.	48	11.5	28	76	26.8	21	21.7	14.3	11.7	9	8.3	4.6	117	56	

K = Killed after 56 days on diet
- = Free of polyneuritis

TABLE XXI

RATS ON VITAMIN B (B_1)-FREE DIET PLUS 2% GERMSTOCK IN 10% GERMSTOCK BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5680M	43	13	21	62	+13	+2	+9	+16	+25	+12	+5	+7	89	56K	-
5734	47	12	22	69	0	+11	+1	+8	+28	+17	+16	+4	85	56K	-
5798	55	9	35	90	+27	+13	+17	+20	+2	+3	+5	0	87	56K	-
5799	45	9	28	73	-2	+33	+22	+28	+12	+9	-1	-3	98	56K	-
5804	54	9	25	76	+34	+17	+20	+22	-7	+15	+7	+9	117	56K	-
5805	53	9	24	75	+21	+20	+34	+20	+8	-8	-9	-3	83	56K	-
5894	43	12	30	73	+26	+24	+21	+18	+12	+5	+11	+2	119	56K	-
5674F	54	13	34	85	+14	+20	+13	+6	0	+10	+6	+11	80	56K	-
5676	49	13	32	80	+3	+12	+14	+12	-4	-8	+3	+6	38	56K	-
5682	35	13	18	52	+8	+9	-2	+6	-2	0	+8	+10	37	56K	-
5705	55	14	26	81	+19	0	-13	-9	-7	-10			-20	38	Sl H
5721	43	16	32	75	+10	-8	-9	+12	+19	+7	0	+7	38	56K	-
5724	39	14	27	66	+17	+4	-13	-13	-11	-5			-21	36K	Sl H
Av.	47.3	12	27.2	73.6	14.6	12	9	10.3	6	3.6	4.5	4.5	64	54	

K = Killed after 56 days on diet
- = Free of polyneuritis
Sl H = Slightly humped

TABLE XXII

RATS ON VITAMIN B (B)-FREE DIET PLUS 1% GERMSTOCK IN 10% GERMSTOCK BREAD

Rat No.	Wt. at 4 weeks grams	Depletion days	Maximum gain during depletion grams	Weight at end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	remarks
5677M	49	13	30	71	+19	+16	+5	-7	-4	+10	+23	+23	85	56K	-
5678	47	14	26	82	+11	+12	+5	-14	-6	-15	-10	-9	-26	50	H
5679	44	13	20	64	+10	+7	+12	+6	+1	0	+3	+7	46	56K	-
5731	51	12	26	77	+12	+1	-10	-19	-3				-21	29	H
5884	55	11	33	87	+3	+1	+6	0	-3	-6	0	+12	+13	56K	-
5675F	50	13	22	67	+27	+1	-4	-5	-7	-13			-1	39	H
5681	44	13	23	67	+3	+6	-1	-1	+12	+15	+4	-5	33	56K	-
5719	46	14	31	76	+15	+2	-12	-1	-3	+8	+15	+20	44	56K	-
5723	41	16	33	74	+10	+11	0	0	+7	-7	-14	-6	1	56K	Sl P
5887	53	11	28	81	+22	+7	-8	-10	+5	-1	+4	+10	29	56K	S H
5879	50	13	23	73	+6	+16	+15	+20	+24	+6	+15	+5	107	56K	-
Av.	48.1	13	27	74.4	12.5	7.3	0.8	-3	+2	-0.3	+4.0	6.3	28	51.4	

K = Killed after 56 days on diet
- = Free of polyneuritis
H = Humped
Sl P = Slightly polyneuritic

TABLE XXIII

SUMMARY OF DATA COLLECTED FOR ANIMALS ON THE VARIOUS DIETS

No.	Diet		Wt. at 4 weeks grams	Depletion days	Weight of end of depletion grams	Weekly gains - grams 1	2	3	4	5	6	7	8	Net gains grams	Survival days	Remarks*
1	Negative		47.5	11.7	73.3	3.6	-3.3	-10.0	-12.0	-8.3				-25.3	26.3	-
2	Positive		43.1	11.3	64.8	30.0	27.6	22.7	17.8	16.8	14.8	15.0	10.8	156.0	56	-
3	Patent	60%	42.0	14.2	63.4	22.1	20.0	16.0	12.1	10.0	9.0	0.0	1.7	82.0	56K	-
4	flour	50	43.0	13.0	62.0	16.2	20.1	17.6	10.8	9.0	6.1	5.0	3.7	89.0	56K	-
5	furnish-	45	43.0	12.0	63.5	17.0	12.8	8.4	9.0	5.4	8.0	9.0	9.0	79.0	56K	-
6	ed by	40	45.0	11.6	69.0	23.5	14.3	11.7	7.0	6.2	0.6	0.5	9.0	73.0	56K	-
7	white	30	45.2	11.6	68.8	13.2	13.2	13.8	10.5	8.9	3.7	1.5	0.0	64.1	56K	-
8	bread	20	49.9	12.1	79.5	6.4	5.3	3.2	-2.1	-0.4	-6.0	4.0	6.6	12.9	48.8	P.,Sl.P.,H.
9	Whole	10	44.0	12.3	69.0	20.1	14.0	19.0	14.0	3.0	3.0	10.4	10.2	94.0	56K	-
10	wheat	7	44.4	11.0	70.4	19.0	14.0	11.0	8.0	10.5	6.1	3.0	7.0	78.3	56K	-
11	flour in	5	44.1	14.4	69.1	5.2	-4.7	-5.7	-9.8	-7.5	-10.6	-8.0		-23.5	31.5	P.
12	50-50 bread	4	44.5	13.5	70.0	8.0	5.2	0.5	-3.0	-0.1	-6.3	-0.7	-0.6	5.0	46.0	P.,Sl.P.,H.
13	Whole	10	46.4	10.0	73.4	26.0	19.0	18.8	12.0	9.5	5.1	5.0	8.0	104.0	56K	-
14	wheat	8	43.0	11.4	66.0	22.2	15.6	7.2	8.8	1.8	0.6	5.0	6.6	70.0	56K	-
15	in 100%	5	48.0	10.3	73.0	13.8	11.5	4.5	-2.2	-2.1	3.0	5.6	3.6	40.0	56K	-
16	bread	3	48.3	11.5	77.5	9.9	1.3	-2.7	0.2	-1.0	-3.0	-2.3	6.0	4.6	46.5	P.,H., Sl.H.
17	Germstock	3	48.0	11.5	76.0	26.8	21.0	21.7	14.3	11.7	9.0	8.3	4.6	117.0	56K	-
18	in 10%	2	47.3	12.0	73.6	14.6	12.0	9.0	10.3	6.0	3.6	4.5	4.5	64.0	54.0	-
19	germstock bread	1	48.1	13.0	74.4	12.5	7.3	0.8	-3.0	2.0	-0.3	4.0	6.3	28.0	51.4	-,H.,Sl.P.,Sl.H.

* - = Free of polyneuritis
P = Polyneuritic
H = Humped
Sl.H = Slightly humped
Sl.P = Slightly polyneuritic
K = Killed

DISCUSSION

Rats four weeks of age and weighing 35 to 55 grams, after a depletion period usually of 11 to 14 days, weighed on the average 70 grams at the beginning of the experimental period. Data concerning the animals receiving the different experimental diets have been assembled in the tables.

Polyneuritis occurred quite regularly among the animals receiving diets deficient in the vitamin B (B_1). The gradation of symptom correlated with the extent of the vitamin deficiency of the food supplied. Polyneuritic symptoms varied from the curved spine and spastic gait to a complete loss of coordination followed by convulsions. Autopsies showed crowded chest organs and empty alimentary tracts. Figure 2 shows a typical polyneuritic animal after four weeks and four days on a diet containing 3 per cent whole wheat in 100 per cent bread and deficient in vitamin B (B_1). Figure 3 shows a rat, of the same age, after five weeks on a diet containing 8 per cent whole wheat in 100 per cent bread, evidently enough vitamin B (B_1) for a gain of 24 grams in eight weeks. Figure 4 shows a typical healthy rat of the same age, on a positive diet the same time.

When non-autoclaved brewers' yeast was used in the diet as a source of vitamin B (B_1) no polyneuritis occurred. All these positive control animals, as shown in Table V and

Figure 4, made high gains with a correspondingly large intake of food for the eight week survival period.

On the basal vitamin B (B_1)-free diet (Table IV) the negative controls declined rapidly and died within an average of 26 days. The three surviving beyond 29 days might have been practicing coprophagy. The majority died evidently of starvation, as autopsy showed the alimentary canal empty, before the characteristic symptoms of polyneuritis occurred. These observations are in agreement with Sandels (35) and Chase (4) who found that when vitamin B (B_1) is absent or very low in the diet, the animals die of inanition before polyneuritis occurs.

When incorporating the bread in the diets it was necessary to try different percentages of the milling product, used in the yeast breads, till the correct amount was found to provide 24 grams of gain in eight weeks. The first diets were based on the previous work done on these milling products (3). Other diets were made as found necessary. Tables VI to XI give data for the animals receiving white bread. In starting these experiments, 60 per cent of patent flour from yeast bread was used, as 60 per cent of the patent flour had previously been found about sufficient to provide 24 grams of gain in eight weeks. Decreasing percentages were also used. The animals receiving 60, 50, 45, 40, and 30 per cents of patent flour in yeast bread all gained

much more than 24 grams in eight weeks. On the diet containing 20 per cent, the animals had an average net gain of 13 grams and average survival period of 49 days with slight polyneuritis in three cases only. It is evident that the amount of patent flour, supplied as white yeast bread, to provide a gain equal to that of Sherman's "unit" is somewhat more than 20 per cent, between 20 and 30 per cents.

Diets containing 4 and 5 per cents of whole wheat furnished by the 50-50 bread (Tables XIV, XV) were fed, as 7 per cent of the whole wheat had been found sufficient for 24 grams of gain in eight weeks. The animals on these diets had a net average loss of 15 grams and average survival period of 38 days with polyneuritis in practically every case. The percentages were increased to 7 and 10 per cents with an increase in gain and no polyneuritis (Tables XII, XIII). The first animals on the 10 per cent diet lost weight during the fifth and sixth weeks which could not be accounted for. When a new supply of diet was prepared and given to the animals they gained and there was no further trouble. It is evident that the amount of whole wheat supplied as whole wheat 50-50 yeast bread, to provide a gain equal to that of the Sherman "unit" is between 5 and 7 per cents.

The results from the addition of different percentages of whole wheat furnished by 100 per cent whole wheat bread

are given in Tables XVI to XIX. The animals on 3 per cent made an average net gain of 4.6 grams during 46.5 average survival days with polyneuritic symptoms which shows a deficiency in vitamin B (B_1). Although some exceptions occurred, the average net gains in weight were much higher than 24 grams for eight weeks with the animals on the 10, 8, and 5 per cents. This indicates that 3 to 5 per cent would provide 24 grams of gain in eight weeks. It was noted that the animals receiving larger per cents of this bread were very superior in appearance. They grew well as indicated in Figure I. In addition their fur was very soft, glossy and smooth.

Tables XX to XXII give data for rats receiving the germstock bread. Some difficulty was encountered, as the formula for baking this bread was changed at the commercial bakery without notifying the laboratory. Less germstock was used, so that the animals received less B (B_1). Afterwards bread was again baked according to the original formula. The 1 and 2 per cent diets were being fed at the time of this change in formula, and the reason for the peculiar growth was not understood. The 3 per cent diet was started at this time to learn more about the nutritive value of this bread. The 2 per cent diet provided growth far above the Sherman "unit". About 1 per cent should promote growth equal to that provided by the Sherman "unit". These exper-

iments will be continued further to gain more exact information.

The results of these experiments with yeast breads may be compared with the results previously obtained for the milling products:

Kind of milling product:	Source	Minimum percentage in a diet to give 24 grams gain in 8 weeks: Milling product tested alone	Milling product supplied in bread:	Comments
Whole wheat flour	Salina hard winter wheat	7-8	4-6	Used in 50-50% bread, but the amount of patent flour present would furnish negligable amounts of vitamin B (B_1). The B (B_1) content is increased about 50% by the yeast.
Whole wheat flour	Commercial product	---	4-5	Used in the 100% bread, which had a large per cent of yeast and also sugar and mixing to promote the growth of the yeast. The yeast apparently supplied at least as much B (B_1) as in the 50-50% bread.
Patent flour	Salina hard winter wheat	60	20-30	Used in white bread. Apparently the yeast supplies much extra vitamin B (B_1) so that the bread contains 2-3 times as much as could be accounted for by the amount of patent flour present in the bread.

Germ-stock	Salina hard winter wheat	1.5-2	1 ∓	Used in the 10% germstock bread, more vitamin B (B_1) was present than would have been supplied by the germstock. The yeast and the patent flour would supply this extra B (B_1).

The following points are of interest:

1. White yeast bread contains more than twice as much vitamin B (B_1) as the milling products, patent flour, used in making it.

2. Eating the same weight of milling products, about twice as much B (B_1) is obtained from whole wheat (50-50) bread or from germstock bread as from white bread.

3. Likewise, the same weight of milling products in the form of whole wheat bread (100 per cent) yields four to five times as much B (B_1) as in the form of white bread.

SUMMARY

Animal feeding experiments have been conducted to study the vitamin B (B_1) of yeast breads made of wheat milling products of known vitamin B (B_1) content. Outstanding results are as follows:

1. White bread made from patent flour contained two to three times as much vitamin B (B_1) as could be accounted for by the amount of patent flour present in the bread. The yeast is apparently responsible for this increased amount of

B (B_1).

2. Whole wheat bread, 50-50 per cent, contained about 50 per cent more vitamin B (B_1) than could be accounted for by the amounts of whole wheat flour present. As the amount of B (B_1) in the patent flour at these low levels was almost negligable, the yeast must have supplied the additional B (B_1).

3. Whole wheat bread, 100 per cent, contained at least as much extra vitamin B (B_1) as did the 50-50 per cent bread. The large per cent of yeast, the sugar and the very thorough mixing might account for the extra B (B_1).

4. Germstock bread, 10 per cent germstock, was about 50 per cent richer in vitamin B (B_1) than could be accounted for by the germstock alone. The yeast and the patent flour would supply this extra B (B_1).

5. Eating equal weights of wheat milling products in the form of different yeast breads, vitamin B (B_1) is obtained as follows:

Kind of Bread	Vitamin B (B_1)
White	At least twice as much as in patent flour used in making the white bread
Whole wheat 50-50 germstock	Twice as much as from white bread
Whole wheat 100%	Four to five times as much as the white bread

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