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A NUTRITIOUS BREAD

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COLUMBIA, MISSOURI

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INTRODUCTION

Bread has always been important in the history and development of mankind. Good bread is a heritage which most Americans regard as an essential part of a well-balanced and enjoyable meal. In low cost diets the use of bread and cereals are fundamental.

Man by choice has turned to white flour in preference to the darker flour. This appetite appeal for products made with white flour results in the use of highly refined flour from which has been removed the bran, the germ, and from 15 to 25 per cent of the endosperm.

Despite educational efforts to encourage the use of whole wheat bread, the consumer continues to prefer white bread; therefore it should be made as nourishing as possible. The movement to improve the quality started before the United States entered World War II. In 1938 a joint committee of the Council on Foods and Nutrition and the American Medical Association, approved the fortification of certain staple foods including flour. The war led to an active program to promote better nutrition. Hearings were held in 1941 on the subject of flour enrichment and in January, 1943, War Food Order No. 1 required the enrichment of all commercial white bread by the addition of thiamine, riboflavin, niacin and iron.

A survey made by the Millers National Federation in 1948 revealed that the average American adult consumes approximately six and one-half slices of bread per day. A food so universally used and in such quantities should carry its load of nutrients in proportion to the calories it furnishes.[1]

Bread is one of the chief articles of diet in many state eleemosynary institutions. Particularly in state mental hospitals many patients prefer bread to other foods and eat little else. Hence, the nutrients it furnishes become increasingly important.

Nutritious bread would be a valuable contribution in providing adequate

*The data reported in this paper were taken from theses presented by Elizabeth R. Harding and Elizabeth Hamilton Bay to the Faculty of the Graduate school of the University of Missouri in partial fulfillment of the requirements for the degree of Master of Arts and from a special problem by Dorothy Tyrrell, a graduate student.

[1]Dr. Clive M. McCay and his associates at the Cornell School of Nutrition have developed a high quality bread which is sold through their cooperative store. Personal communication, also references in Bibliography.

school lunches. The usual American breakfast consisting of fruit, toast, butter and coffee would become much more adequate if the toast were made of bread providing the essential nutrients in balanced proportions.

The obvious need of a more nutritious bread led to the study herein reported. It was decided that in the attempt to make a wholesome bread no synthetic supplements, as such, would be used. The bread would be composed, in the main, of wheat flour, egg and milk used in such proportions as to give the desired food value.

Eggs and milk are important sources of the nutrients which are needed to combine with enriched white flour to produce a balanced food. The dehydrated products are in a convenient form to incorporate in bread. If it could be shown that a palatable and nutritious loaf can be made by using them, it should encourage the use of these products.

PURPOSES OF THE INVESTIGATION

The study was undertaken with the following purposes:

Part I. To develop a formula and standardize the preparation of a nutritious bread; and to study the nutritive value of the bread by biological assay.

Part II. To investigate further the nutritive value of the bread in relation to growth and reproduction; and to determine its chemical composition.

Part III. To prepare the bread, adapting the method to the facilities available, in the usual home kitchen.

PART I. DEVELOPING A FORMULA

The study was undertaken in two parts: (1) the determination of a formula which would carry the desired nutritive values and the subsequent trial bakings to standardize procedures to produce a satisfactory loaf; and (2) the determination of the nutritive value of the baked loaf by biological assay.

Experimental

The Formula. The proportions used in the formula were based on the recipe for white bread as given in America's Cook Book (1937) and so devised as to produce a loaf weighing about one pound. Whereas a pound loaf of commercial white bread carries about 1150 calories, a pound loaf made from the nutritious bread formula carries approximately 1600 calories to the pound.

Sixteen-hundred calories is a little more than half the daily energy allowance of a moderately active man according to the allowances proposed by the Food and Nutrition Board of the National Research Council (1945). The ingredients were employed in such amounts as would give to the loaf nutritive value in proportion to its caloric value, that is, approximately one-half of the daily allowances of a moderately active man, namely:

Calories	1500	Vitamin A	2500 I.U.
Protein	35 gm.	Thiamine	0.75 mg.
Calcium	0.4 gm.	Riboflavin	1.0 mg.
Iron	6.0 mg.	Niacin	7.5 mg.

The nutrients were incorporated through the use of enriched flour, dried whole eggs, dried whole milk, fortified margarine and yeast. No synthetic vitamins or mineral salts, as such, were used. Ascorbic acid was not included.

The nutritive values were calculated from tables compiled by Sherman (1941), Chaney and Ahlborn (1943), and the analyses obtained from the producers of the various ingredients. Since no standardized set of figures on dehydrated eggs was available, the nutritive components were computed on the fresh egg basis with the exception of vitamin A. Hauge and Zscheile (1942) published findings on the vitamin A content of dehydrated eggs which have been confirmed by later analyses and their value of 44 I.U. of vitamin A per gram of freshly dried eggs was used. The possible loss of vitamin A during storage was not taken into account in calculating the nutritive value of the prebaked loaf.

Thirty grams of dehydrated eggs was considered the equivalent of two and one-half fresh eggs of average size (Wilson and Slosberg, 1942). The egg powder used in this experiment was obtained, on the day it was processed, from the Stamper Company in Moberly, Missouri. Enriched white flour was used throughout the experiment.

The only known vitamin deficit of the values incorporated was that of vitamin A and that deficit was slight. The total calcium content about paralleled the allowance and the protein, iron, thiamine, riboflavin and niacin were well above the allowances.

The formula used is as follows:

	grams
Flour	290
Dried milk	36
Dried eggs	30
Margarine	26
Sugar	12.5
Yeast	12.5
Salt	4.5
Water, dist.	188 ml.

The calculated nutritive values of the constituents of the prebaked loaf are shown in Table 1.

Preparation. The methods for mixing and baking were standardized in order to minimize variations which might conceivably affect either the quality of the bread itself or its nutritive value. The procedure was adapted from the

TABLE 1--CALCULATED NUTRITIVE VALUES OF THE CONSTITUENTS OF THE PRE-BAKED LOAF

Ingredients	Grams	Per cent	Calories	Protein (gm.)	Calcium (gm.)	Iron (mg.)	Vit. A (I.U.)	Thiamine (mg.)	Riboflavin (mg.)	Niacin (mg.)
Flour, enriched	290	100.0	1029	31.3	0.043	9.28	----	1.407	0.861	11.50
Milk, whole dried	36	12.4	178	9.3	0.324	0.61	558	0.115	0.576	0.39
Egg, dried	30	10.3	197	16.0	0.072	3.87	1320	0.187	0.437	----
Margarine, fortified	26	8.9	195	----	----	----	515	----	----	----
Sucrose	12.5	4.3	49	----	----	----	----	----	----	----
Yeast, Fleischmann's	12.5	4.3	13	1.7	----	0.04	----	0.060	0.225	1.38
Salt	4.5	1.5	----	----	----	----	----	----	----	----
Water, distilled (188 ml.)	----	----	----	----	----	----	----	----	----	----
Totals	411.5	----	1661	58.3	0.439	13.80	2393	1.769	2.099	13.27
Nutritive Value										
Solids basis	1.0	----	4.0	0.14	0.0011	0.034	5.8	0.0043	0.0051	0.0322
Calorie basis	----	----	3000	105	0.78	24.9	4320	3.21	3.78	24.0
Recommended allowances (Moderately active man)	----	----	3000	70	0.80	12.0	5000	1.50	2.00	15.0

directions given by the American Association of Cereal Chemists (1941) for bread baking tests for wheat flours and are presented in detail on page 25.

The dry ingredients were weighed on a torsion balance and the liquids measured in a graduated cylinder. The flour and dried milk were sifted together. The other ingredients were reconstituted where necessary, combined and added to the flour-milk mixture. The dough was mixed for two minutes in an electric mixer with the bread hook attachment. Fermentation and proofing were carried out in a cabinet, the temperature of which was maintained at from 28° to 30°C. The bread was baked in a Despatch Rotary Oven at a temperature of 204°C. for 45 minutes. The baked loaves were allowed to cool and then stored overnight in metal bread boxes.

Three other workers in our Foods Laboratories have been able to produce loaves of standard quality and appearance using these methods.

Biological Assay. The young, growing white rats used in these experiments were reared by mothers on Sherman's Diet 13, consisting of one-third whole milk, two-thirds whole wheat, and sodium chloride equal to two per cent of the weight of the wheat.* When weaned, their average weight was 43 grams. The groups of rats on the various diets were made up of a representative number from each litter. The distribution was such that the average weight and sex of each group were approximately the same. Each rat was placed in a separate cage and given food and water *ad libitum*. Weekly records were kept of weights and food consumption. At the end of the experimental period the rats were sacrificed and autopsies performed on a representative number of each sex from the various groups.

In each assay a control group was fed Sherman's Diet 13, referred to as the stock diet. The loaf diet was prepared from bread baked under the conditions described on page 5. After standing overnight the loaves were sliced

*Sherman's Diet 13 is used in this laboratory as the stock diet.

in one-fourth inch slices and placed in a drying oven at a temperature of 60°C. for two hours. The dried bread was ground fine. When fed alone, this bread was referred to as the plain loaf diet.

In the beginning the rats were divided into two groups. Sixteen received the stock diet and 24 the plain loaf diet as their sole food. At the end of three weeks it was obvious that the rats on the loaf diet were not growing at the rate of those on the stock diet. In an attempt to determine whether the bread suffered nutritive losses in baking and drying, the 24 rats were redistributed into three groups. Group I was continued on the plain loaf diet; Group II was fed the loaf which had been baked but not dried, referred to as the fresh loaf diet; and Group III was fed the solid constituents of the loaf, combined and thoroughly mixed, but not baked, referred to as the unbaked loaf diet. The rats were kept on the new diets four weeks.

The succeeding experiments were conducted with the purpose of finding the minimum amount of whole dried milk which when added to the loaf diet would promote a rate of growth comparable to that of the stock diet. All of the bread used in this test was prepared from ingredients purchased in one lot. The bread was dried, ground, and stored in the refrigerator in sealed containers until needed.

The rats were distributed into groups and fed varying amounts of dried whole milk as supplements to the plain loaf diet. Parallel with the rats on the supplemented loaf, groups were fed the stock diet and the plain loaf diet for purposes of comparison. The supplements added were sufficient to provide one-third, one-fourth, or one-sixth part, of whole milk in the diets as fed. The rats were kept on these diets for a five-week experimental period.

Reproduction Study. It is recognized that reproduction ability is the ultimate test of the vitality of an animal. Time did not permit an extensive reproduction experiment but a limited test was made and a tentative comparison may be drawn from it.

The rats used had received either the control or the plain loaf diet during the six-week experimental period. They were continued on these diets throughout the reproduction study of six months. There were three rats, two females and one male in each group. The rats were nine weeks old at the time of the first mating.

Results and Discussion

The Bread. From the point of appearance and palatability, the loaf as baked was considered to be acceptable or "definitely more than acceptable" by members of the Home Economics faculty and other interested persons who saw and tasted it. The taste of the bread is definitely not the bland flavor customarily found in commercial white bread.

The loaf had good volume and held its shape well. There was a break of about three inches on one side and a very slight break on the other side. The crust was crisp and flaky, characteristics which could be assigned to the

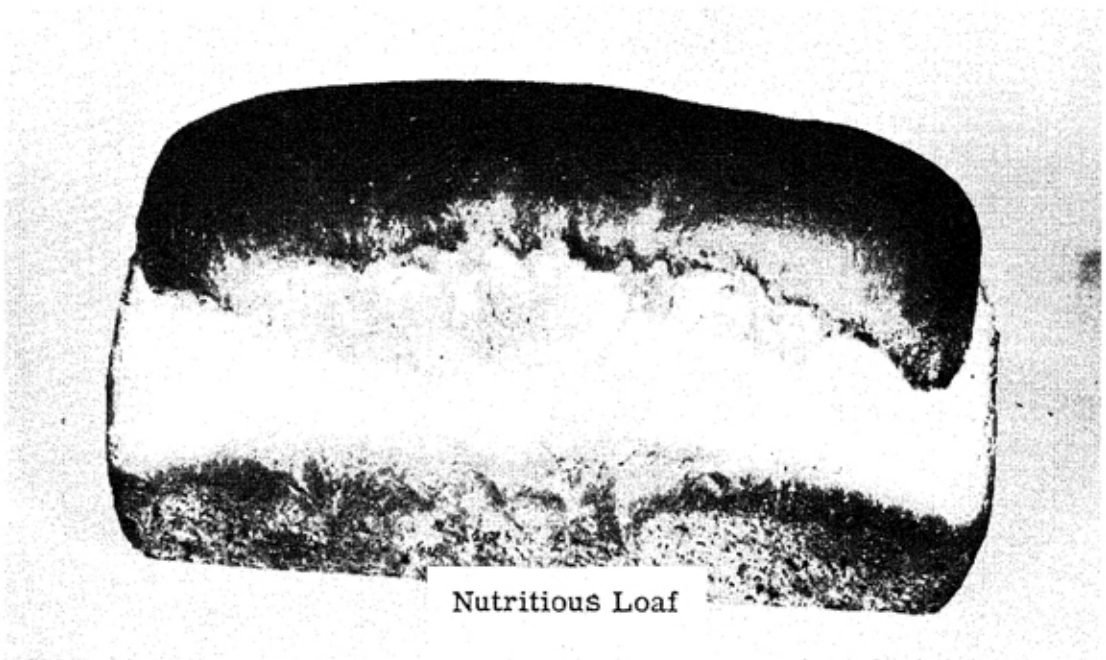

Figure 1.—The loaf as standardized during this experiment.

richness of the dough (Figure 1). The texture of the loaf was fine but the grain tended to be coarse and uneven, though not to an extent to impair the acceptability of the loaf (Figure 2).

Obviously the cost of such bread is more than that of ordinary bread. A rough computation of the cost of the ingredients when a few loaves were baked at a time, using five and ten pound lots of supplies, was 25 cents per loaf (1951). But if these supplies were bought in large quantities, the cost would be reduced appreciably. Actually, however, the practicability of this loaf depends upon whether the nutritional value is commensurate with the cost.

Biological Assay. There were no significant differences in the growth records of the rats receiving the nutritious bread as affected by preparation and handling. None of the rats gave evidence of nutritional deficiencies. Their coats were sleek, their eyes clear, and the autopsies did not reveal any impairment of the organs generally susceptible to marked deficiencies.

When whole milk powder supplied one-fourth of the loaf diet the growth was comparable to that of the rats on the stock diet, 23.6 and 25.3 grams per week, respectively. To confirm this result three parallel groups of rats were fed (1) the stock diet, (2) the plain loaf diet, and (3) the supplemented loaf diet for a period of five weeks. The relative efficiency of the three diets is shown in Table 2 and Figure 3. The statistical treatment of the data shows no significant differences in the growth of the rats on the stock diet and those on the supplemented loaf diet (Table 3). The autopsies revealed no abnormalities.

Reproduction Study. All the females bore young within five weeks of the

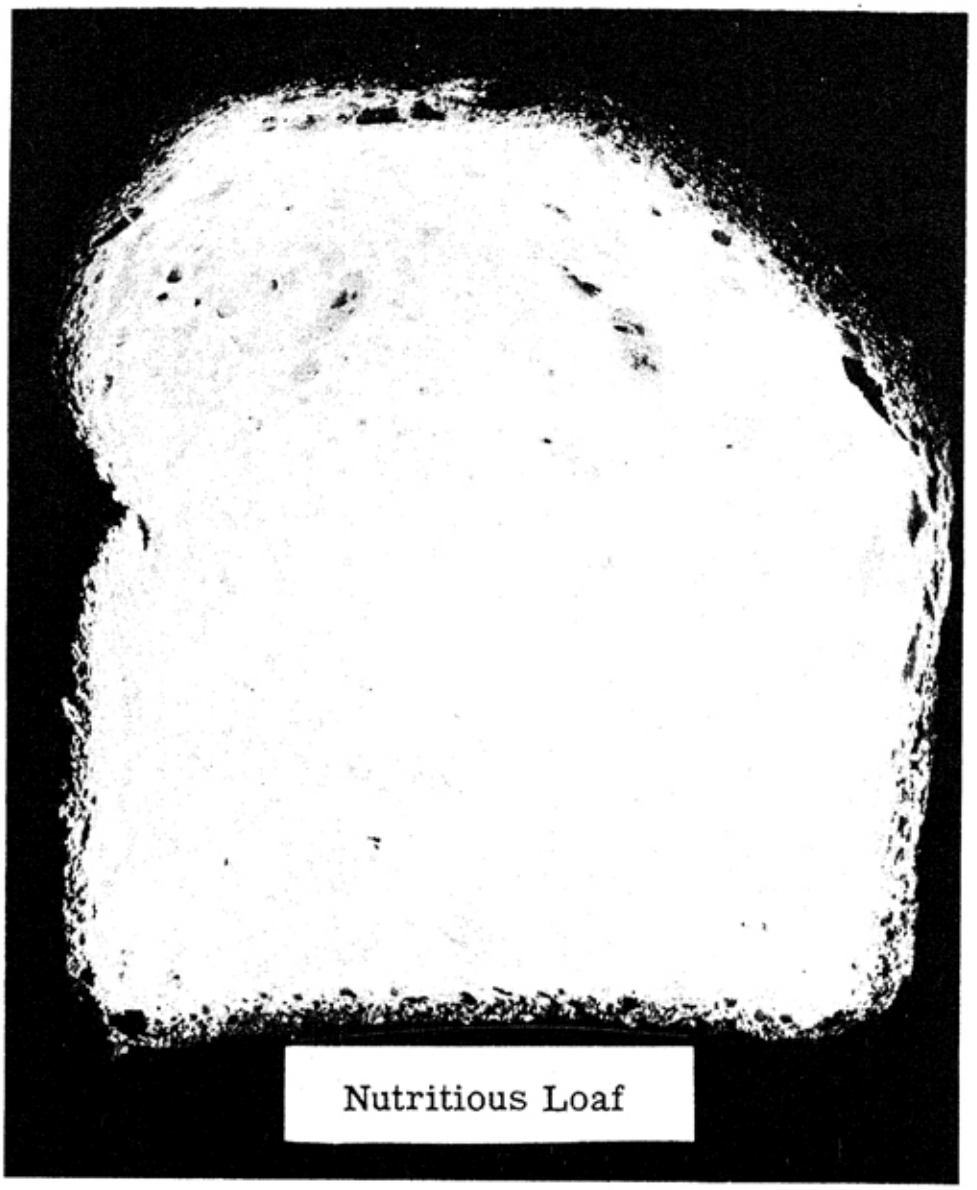

Figure 2.—A slice from the center of the loaf.

TABLE 2--COMPARATIVE EFFICIENCY OF THE THREE DIETS

Diet	Number of rats	Experimental period (days)	Average food intake per rat per week (gm.)	Average gain per rat per week (gm.)	Gain per gram of food consumed (gm.)
Stock	11	35	68.95	25.3	0.37
Plain loaf	11	35	49.76	14.1	0.28
Loaf supplemented	26	35	59.95	23.6	0.39

TABLE 3--STATISTICAL ANALYSIS OF DATA

Diet	Number of rats	Gain in 5 weeks Mean (gm.)	S.D.M. (gm.)	Critical ratio
Stock	11	126.3 ± 5.76	28.36	
Loaf, baked and dried	11	70.4 ± 1.56	7.69	8.8
Stock	11	126.3 ± 5.76	28.36	
Loaf plus supplement	26	118.2 ± 2.72	20.59	1.4
Loaf, baked and dried	11	70.4 ± 1.56	7.69	
Loaf,plus supplement	26	118.2 ± 2.72	20.59	10.8

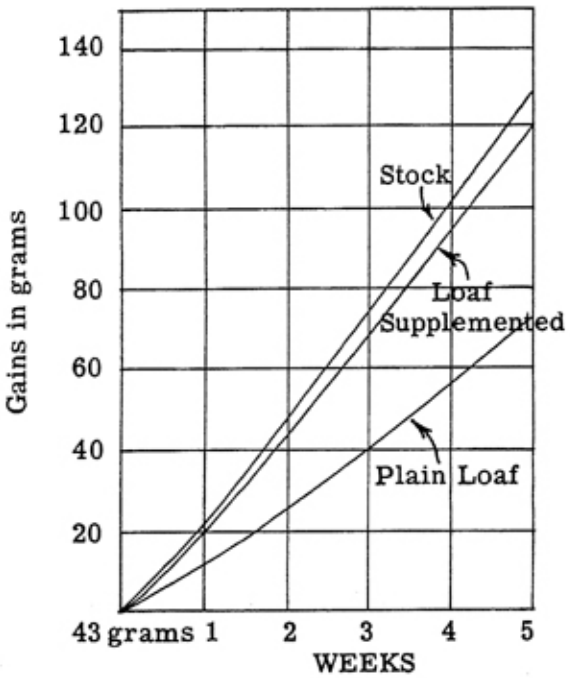

Figure 3.—Growth curves of young rats fed diets as indicated on the graph.

TABLE 4--LITTER RECORD OF RATS ON REPRODUCTION EXPERIMENT

Diet	Number of females	Age at first mating (weeks)	First litter Born (No.)	First litter Weaned (No.)	Second litter Born (No.)	Second litter Weaned (No.)	Third litter Born (No.)	Third litter Weaned (No.)
Stock	2	9	23	7	26	19	20	16
Loaf	2	9	21	0	21	0	25	22

mating date. Tables 4 and 5 give a summary of the reproduction performance and of the growth record of the two groups of rats during the reproduction study. It will be noted that the weight of the two groups of rats levels off to the same figure at the twenty-sixth week. The fact that the female rats on the loaf diet had a longer wait between matings, since they did not raise their young, and possibly, that their diets were enhanced by their own litters

TABLE 5--WEIGHT RECORD OF RATS ON REPRODUCTION EXPERIMENT

Rat No.	Diet	Weight in grams at periods indicated: Weaned (age 3 weeks)	End of growth experiment (age 9 weeks)	First litter weaned (age 18 weeks)	Second litter weaned (age 26 weeks)	Third litter weaned (age 34 weeks)
15097♀	Stock	43	170	259	262	266
15108♀	Stock	49	177	237	244	265
15107♂	Stock	48	237	374	403	416
Total		140	584	870	909	947
Average		46.7	194.7	290.0	303.0	315.7
15098♀	Loaf	42	133	214	250	240
15104♀	Loaf	50	159	246	287	270
15106♂	Loaf	53	151	295	371	406
Total		145	443	755	908	916
Average		48.3	147.7	251.7	302.7	305.2

accounts for some of this trend. However, the records of the male rats show the same tendency.

It is conjectured that though the loaf produced a slower growth, it is, nevertheless, an adequate though not an optimum diet. The points in support of this belief are: (1) they raised healthy litters two months later than the rats on the stock diet, and (2) they tend to equal the weight record of the rats on the stock diet, by the end of the twenty-sixth week of life. It is the opinion of some scientists that a relatively slower growth may have some advantages over rapid growth (McCay, Crowell and Maynard, 1935).

Summary

A palatable and good appearing loaf of nutritious bread was devised which theoretically, with the exception of vitamin C, carried its quota of vitamins and minerals in proportion to its caloric value. These nutritive values were incorporated largely through the use of enriched flour, dried whole milk, and dried whole eggs. No synthetic vitamins or mineral salts, as such, were used.

The bread fed, as the sole diet, to young rats will support growth but at a slower rate than a diet of one-third by weight whole milk and two-thirds whole wheat.

The bread, plus a supplement of whole milk powder to bring the total amount to one-fourth by weight of the diet as fed, will induce growth at a rate comparable to that of the whole wheat and milk diet.

There were no significant differences in the growth of rats receiving the nutritious bread as affected by preparation and handling.

The results, both in growth and reproduction experiments, indicate that rats on the nutritious bread, as their sole diet, tend to mature slowly.

PART II. NUTRITIONAL INVESTIGATION

The study herein reported was designed to extend and clarify the results obtained in the investigation, reported in Part I. The experiments were planned with the following objectives:

(1) To determine if calcium and vitamin A are the significant factors in dried whole milk, which when added to the nutritious bread, increased the rate of growth in young rats.

(2) To compare the nutritive value of the baked with that of the unbaked bread.

(3) To continue the reproduction study.

(4) To assay the bread for calcium, protein, thiamine, riboflavin, niacin and vitamin A.

Experimental

Biological Assay. Young, growing white rats from mothers reared on Sherman's Diet 13 were used in the experiments. They were weaned at 21 days of age, divided into representative groups and fed one of the following diets:

(1) The stock diet; (2) the nutritious loaf, which was prepared from bread baked under standard conditions, dried and ground as described in Part I, page 5; (3) the nutritious loaf plus calcium lactate (17.46 grams of calcium lactate per 1000 grams of loaf), making the total calcium in the diet equivalent to that in the control diet; (4) the nutritious loaf, supplemented with calcium lactate and cod liver oil (1000 grams loaf, 17.46 grams calcium lactate, 10 grams cod liver oil); and (5) the unbaked nutritious loaf.

Reproduction Study. A second generation of young rats reared, after weaning, on the nutritious bread as their sole diet, (Part I), was used in starting this study. A group of one male and two females was reserved from each succeeding generation. The mating procedure followed that described in Part I, page 7.

Analysis of the Bread. A composite of six loaves of the nutritious bread was prepared for these analyses. The bread was sliced into one-fourth inch slices, dried in an electric oven for two hours at a temperature of 60°C., ground fine, and stored in the refrigerator in covered metal containers. A representative portion of the finely ground bread was dried to constant weight in a vacuum oven at 98°C., at the time the analyses were made.

Methods used to determine the amount of the various constituents present in the bread were as follows:

Calcium—McCrudden (1911) with modifications by Sherman and MacLeod (1925).

Protein—Kjeldahl-Gunning (A.O.A.C., 1945).

Thiamine—Hennessy and Cerecedo (1939) with modifications by Hennessy (1941).

Riboflavin, fluorometric—Conner and Straub (1941) with an adapta-

tion of the modifications described by Andrews *et al.* (1942), Andrews (1943) and McIntire *et al.* (1939).

Riboflavin, microbiological—Snell and Strong (1939) with modifications by Strong and Carpenter (1942).

Niacin—Krehl, Strong and Elvehjem (1943) a modification of the procedure of Snell and Wright (1941).

Vitamin A—A modification of the Sherman-Munsell (1925) procedure.

Results and Discussion

Biological Assay. The average gain in grams and the probable error of the mean for each of the five diets were: stock, 129.6 ± 4.6; loaf alone, 76.5 ± 1.3; loaf plus calcium lactate, 75.2 ± 1.0; loaf plus calcium lactate and cod liver oil, 74.3 ± 1.6; and unbaked loaf, 82.3 ± 3.6. The results are shown in Table 6 and Figure 4.

TABLE 6--SUMMARY OF THE AVERAGE GROWTH RECORDS OF RATS ON FIVE DIETS

Diet and supplement	No. of rats	Initial weight (gm.)	Gains at end of successive weeks 1 (gm.)	2 (gm.)	3 (gm.)	4 (gm.)	5 (gm.)	Final weight (gm.)	Total gain (gm.)	Total food intake (gm.)
Nutritious loaf	15	43.6	13.1	15.7	15.6	17.1	15.0	120.1	76.5±1.3	263.7
Nutritious loaf* + calcium lactate	15	43.7	13.8	15.7	14.3	18.3	13.1	118.9	75.2±1.0	278.2
Nutritious loaf** + calcium lactate + cod liver oil	15	43.5	14.6	15.4	15.1	17.3	12.0	117.8	74.3±1.6	274.1
Nutritious loaf, Unbaked	6	41.9	16.0	18.0	20.8	18.5	9.0	124.2	82.3±3.6	298.5
Stock diet	12	44.2	21.0	25.8	29.8	28.1	25.0	173.8	129.6±4.6	326.4

* 1.75 grams of calcium lactate per 100 grams of loaf.
** 1.75 grams of calcium lactate + 0.5 grams of cod liver oil per 100 grams of loaf.

It will be observed that there are no significant differences in the growth records of the rats on the loaf diet alone and the two supplemented loaf diets. Also, whereas the rats on the unbaked loaf gained somewhat more than those on the baked dried loaf, the difference was not significant. This finding confirms the results reported in Part I and indicates that there are no appreciable losses in the processes of baking and drying the loaf. Average gains in grams per gram of food eaten as calculated from the food consumption records were: stock, 0.397; unbaked loaf, 0.276; nutritious loaf plus calcium lactate, 0.270; nutritious loaf plus calcium lactate and cod liver oil, 0.271; and nutritious loaf alone, 0.290.

It is thus apparent that the enrichment of the loaf diet with a liberal supply of calcium lactate or with additional fat soluble vitamin A was of no benefit in promoting a rate of growth comparable to that of the stock diet.

All of the rats on the five diets appeared to be in excellent condition and autopsies did not reveal any nutritional deficiencies.

Sherman observed that the improvement in growth, longevity and nutritional well-being obtained, by doubling the amount of milk in the diet of rats,

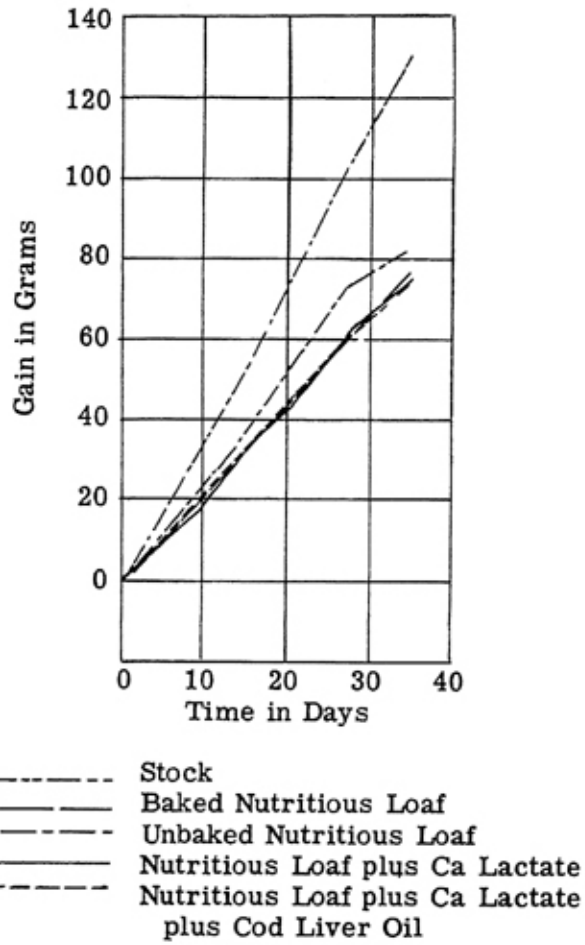

Figure 4.—Average growth curves of rats on the five diets fed in the biological assay.

was due to a combination of the factors in the milk. Results of the present investigation and those reported in Part I substantiate the assumption that possible unknown factors in milk contributed to the increased rate of growth of rats fed a diet containing a higher proportion of milk.

Reproduction Study. The success of the nutritious loaf diet for reproduction was judged by the number and weight of litters as well as by the number of young born and reared through four successive generations of rats fed the loaf as the sole diet.

The complete reproduction records of the first generation of rats, two females on the loaf diet and two on the stock diet, are summarized in Table 7 and Figure 5. The total number of young born (seven matings) was similar for rats on both the loaf and the stock diets, 115 and 113 respectively; however, only 37 per cent of the young on the nutritious bread diet survived as compared to 64 per cent on the stock diet.

It was noted that the weight of the rats on the loaf diet did not decrease

TABLE 7--SUMMARY OF THE REPRODUCTION PERIOD OF FIRST GENERATION RATS ON LOAF AND STOCK DIETS (SEVEN MATINGS)

Diet and rat number	Number of young Born	Reared
Loaf diet --		
15104♀	59	25
15098♀	56	18
Total	115	43
		37%
Stock diet --		
15097♀	63	40
15108♀	50	33
Total	113	73
		64%

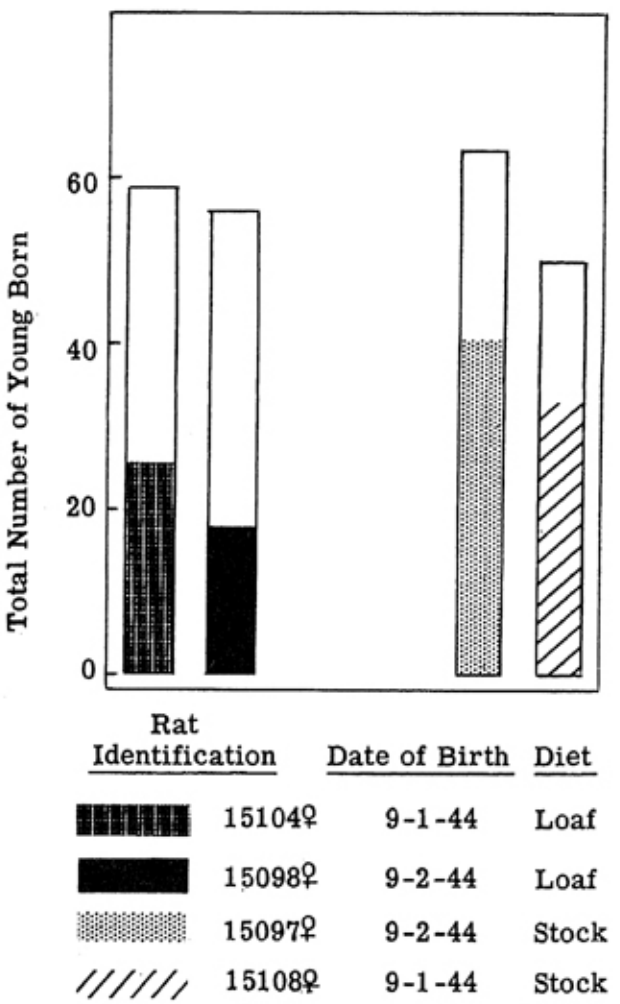

Figure 5.—Column diagram. Comparison of total young born and reared during entire reproduction period of two rats on the nutritious loaf diet and two rats on the stock diet.

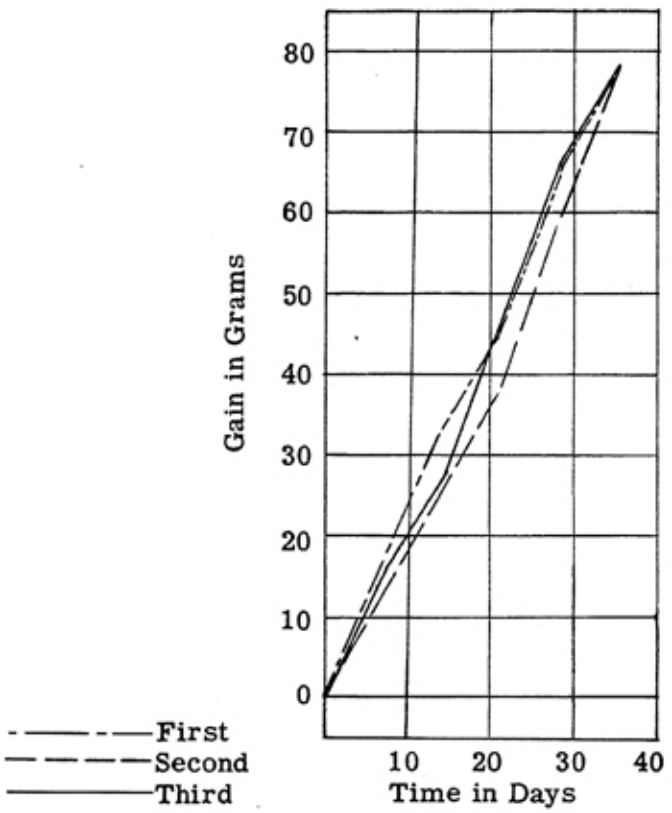

Figure 6.—Crowth curves for five successive weeks of three generations of rats receiving nutritious loaf diet.

progressively with each succeeding generation. During the period of most rapid growth, three successive generations of rats, gained an average of 79 grams each, in a five-week period (Figure 6). Also at the time this experiment was terminated, a rat of the third generation weighed more (361 gms.) at nine months of age than one of the second generation of the same sex and at the same age (310 gms).

A rat of the third generation, on the nutritious bread diet, with her five young is shown in Figure 7. Two of the rats used in starting the reproduction study in Part I, one on the stock diet and one on the loaf diet are shown in Figure 8. They were 604 days of age at the time the photograph was taken.

Only a limited number of rats were maintained in the reproduction study. Before definite conclusions can be drawn in regard to the efficiency of this diet for reproduction it would be necessary to have a larger number of rats represented.

Analysis of the Bread. Results of the analyses, given in the table below show: (1) that the bread, with the exception of riboflavin, contains as much or more than the values calculated from tables for the constituents of the loaf and (2) that the various nutrients are present in amounts above the recommended allowances for a moderately active man (Table 1, page 6).

Figure 7.—A rat of the third generation loaf diet and her five young, 28 days old.

Figure 8.—Rat No. 15108 F, stock diet, age 604 days, weight 258 grams. Rat No. 15104 F, loaf diet, age 604 days, weight 217 grams.

NUTRITIVE VALUE PER 100 GRAMS OF NUTRITIOUS LOAF
(moisture-free basis)

Values	Protein	Ca	Thiamine	Riboflavin		Niacin	Vitamin A
				fluoro-metric	micro-biologi-cal		
	gm.	gm.	mg.	mg.	mg.	mg.	I.U.
Analyzed	15.7	0.15	0.44	0.47	0.48	4.19	1064
Calculated	14.0	0.11	0.43		0.51	3.22	667*

*In Part I, the loaf contained 580 I.U. of vitamin A per 100 grams. Due to the larger amount of vitamin A added to the margarine by the manufacturers in 1946, the amount of vitamin A per 100 grams of loaf in Part II was 667 I.U.

Summary

The study of the nutritive value of the nutritious bread has been extended to include the following: a biological assay to determine if calcium and vitamin A are the factors in dried whole milk, which when added to the loaf diet, contributed to the increased growth of young rats; a comparison of the growth promoting efficiency of the baked versus the unbaked loaf; a continuation of the reproduction study; and a chemical analysis of the loaf.

The nutritious bread, fed as the sole diet to young rats, will support growth and reproduction.

The loaf diet promotes a slower rate of growth than Sherman's Diet 13.

There were no significant differences in the growth increments of rats fed the nutritious loaf, the loaf plus calcium lactate, the loaf plus calcium lactate and cod liver oil, or the unbaked loaf.

It appears that possible unknown factors in dried whole milk may contribute to the increased rate of growth noted when the diet of the rat is supplemented with whole milk powder.

The nutritious bread carries the recommended allowances of nutrients in proportion to its caloric value.

PART III.

The nutritious bread as described in the preceding studies was prepared in the Foods Research Laboratory. The ingredients were weighed. The equipment used in combining, proofing and baking was designed for carefully controlled experiments and would not be available or practical for ordinary use.

It might be more convenient and economical to use fresh eggs and fresh milk in place of the dried products. Other changes were indicated for modifying the preparation and the choice of ingredients to prepare a product for common use in the diet.

The purpose of this part of the study was to produce the nutritious bread, adapting the preparation to the facilities available in an average home kitchen.

To accomplish the purpose it was planned to (1) measure the weighed ingredients and convert each to the nearest practical measure; (2) substitute fresh eggs and fresh milk for dried eggs and dried milk, and dried yeast for compressed yeast; (3) formulate directions for combining ingredients by hand-mixing; and (4) determine a satisfactory length of time for fermentation and for baking temperature.

Procedure

The basis for this study was the formula developed as described in Part I, namely:

	grams
Flour	290
Dried whole milk	36
Dried whole eggs	30
Margarine	26

	grams
Sucrose	12.5
Yeast (compressed)	12.5
Salt	4.5
Water, dist.	188 ml.

The Measured Loaf (dried whole milk and eggs). For the practical adaptation of the formula to home use, the ingredients were weighed, then measured, using standard measuring cups and spoons. The weighed quantities were increased slightly, where necessary, to make the measurements practical. After weighing, the flour was sifted and then measured.

The milk and eggs were measured without sifting. The eggs were pressed down into the measuring cup, so that when removed they retained the shape of the cup.

The formula is as follows:

3 c enriched flour
½ c dried whole milk
⅔ c dried whole eggs
3 T margarine or butter
2 T sugar
1 cake compressed yeast
1 t salt
1 c water

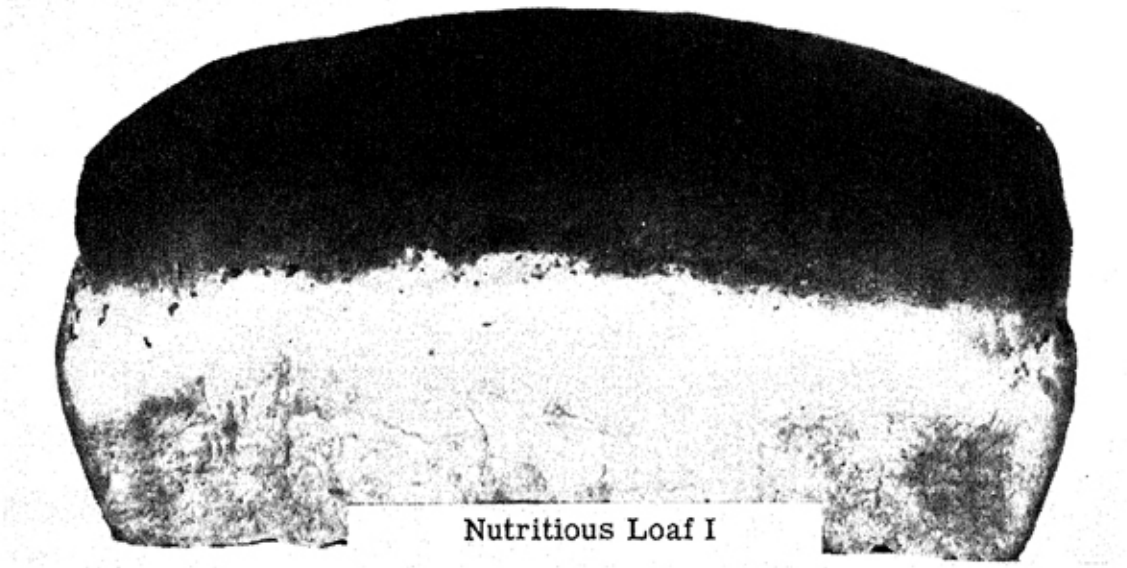

Figure 9.—The measured loaf (dried whole milk and eggs).

Combining the Ingredients. Sift two cups of the flour with the dried milk. Reconstitute the dried eggs by adding one-half cup of water and beating slowly with a rotary beater until of a smooth consistency. Dissolve the sugar and salt in one-fourth cup of water. Soften the yeast by crumbling it in the remaining one-fourth cup of water.* Melt the butter or margarine in a bowl placed over hot water. Combine the eggs, sugar, salt, yeast and butter or margarine. Add one-half the flour-milk mixture and beat about three minutes. Add the remainder of the flour-milk mixture and stir. Finally add the last cup of flour, one-half at a time, and stir after each addition. See directions given below for kneading, shaping and baking.

*One cake of dried yeast may be substituted for the compressed yeast. Soften it in the same manner.

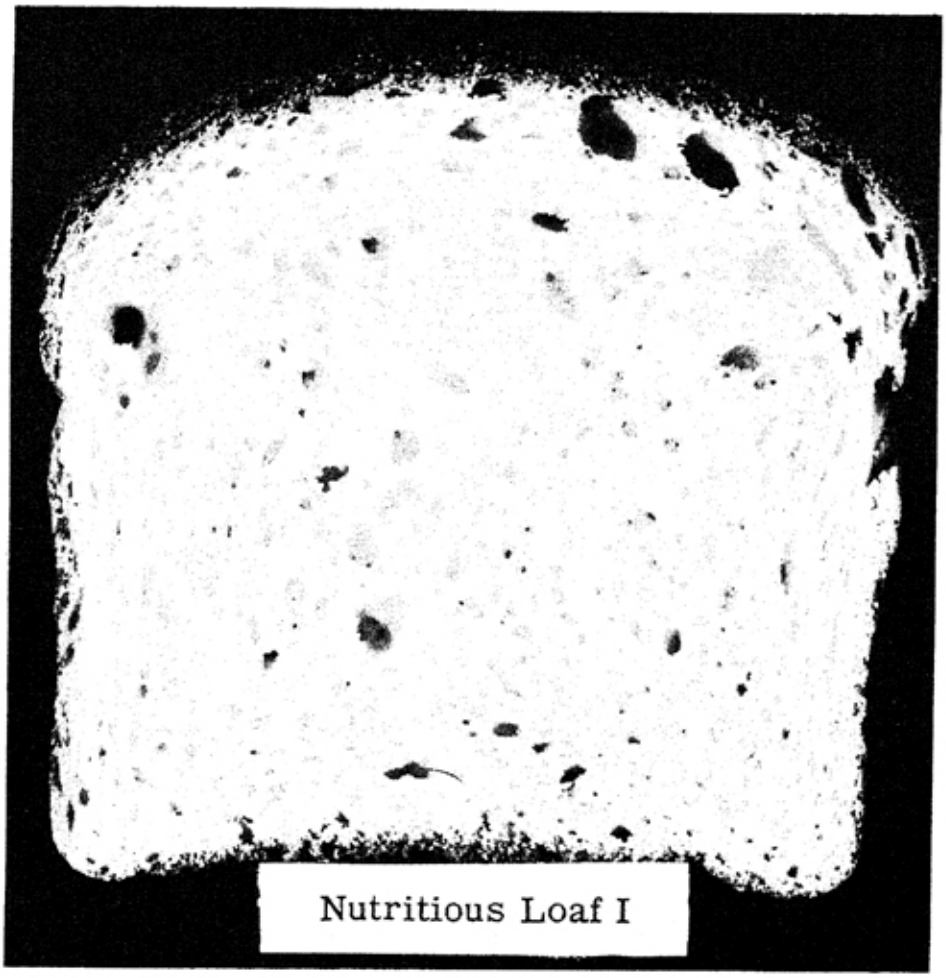

Figure 10.—A slice from the center of measured loaf (dried whole milk and eggs).

The Measured Loaf (fresh whole milk and eggs). Recognizing that it may be more convenient and more economical to use fresh milk and fresh eggs, when available, the formula has been adapted to such use, as follows:

4 c enriched white flour	2 T sugar
¾ c fresh whole milk	1 cake compressed yeast
3 fresh whole eggs	1 t salt
3 T butter or margarine	No water

Combining Ingredients. Sift flour before measuring. Scald the milk, add sugar, salt and butter or margarine. Allow to cool to lukewarm temperature, about 80° to 85°F., add yeast and the beaten eggs. Add one-half the flour and beat three minutes. Add the remainder of the flour, about one-half cup at a time, and stir after each addition.

Kneading. Remove the dough from the bowl to a pastry cloth or bread board and knead until smooth, elastic and satiny. Place the dough in a bowl which has a volume about two and one-half times as large as the unfermented dough. Grease the top of the dough lightly, cover with a plate, cloth or

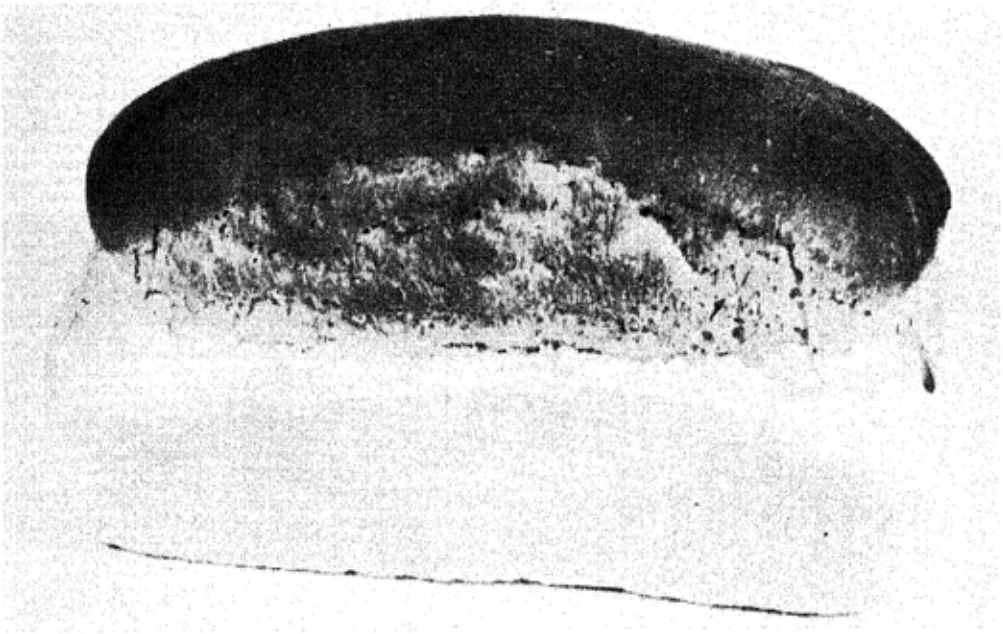

Figure 11.—The measured loaf (fresh whole milk and eggs).

Figure 12.—A slice from the center of the measured loaf (fresh whole milk and eggs).

waxed paper and set in a warm place, 80° to 85°F., to rise. When doubled in bulk, in about two hours, punch down, folding the edges toward the center. Turn the dough in the bowl so that the smooth side is up and allow to rise again until doubled in bulk.

Shaping and Baking. Remove the dough to the pastry cloth or bread board and proceed as follows:

1. Beat the dough into an oblong shape with the heel of the hand.
2. Fold the dough lengthwise through the center and pound from the fold outward.
3. Fold one-third of the way from both ends toward the center and pound from the folds.
4. Repeat step three.
5. Gently roll the dough until the length is equal to the length of the loaf pan, (size of pan 4½ x 8½ x 2¾ inches). Place the dough in the pan with the seam underneath. Cover with a cloth or wax paper and let rise, in a warm place, 45 to 50 minutes.
6. At the end of the rising period, bake in a preheated oven at 380°F. for 40 to 45 minutes.

Remove the baked bread from the pan immediately after baking and place on a wire rack or across the edges of the pan to cool. When thoroughly cooled it may be stored. Photographs of the bread are shown in Figures 6 to 9.

Discussion

Whereas the ingredients used in the "measured loaf" were weighed, and then measured, the object was to establish a standard of measurement to insure a degree of accuracy that would produce a loaf having an approximate food value to that of the weighed loaf. Although, the measured loaf, containing dried whole milk and dried whole eggs, had slightly larger quantities of ingredients by weight, than the original loaf, the nutritive value was retained in approximately the same proportions.

When fresh whole milk and fresh whole eggs were used the moisture content was so high that it was necessary to use more flour in order to handle the dough. The resulting loaf was larger than that made of dried milk and dried eggs, but with the exception of calcium, the loaf carried its load of nutrients in proportion to its caloric value.

Summary

A loaf comparable to that of the original was prepared by first weighing and then measuring the ingredients.

The bread was equally acceptable when fresh whole milk and fresh eggs were substituted for the dried whole milk and dried whole eggs.

The nutritive value of the measured loaf containing dried whole milk and dried eggs was approximately the same as the original loaf in which the ingredients were weighed.

The bread made with fresh whole milk and fresh eggs, with the exception of calcium, contained the recommended amounts of nutrients in proportion to the caloric value.

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APPENDIX

Procedure for Preparing the Weighed Nutritious Bread

The preliminary baking tests were carried out using the procedure given on page 5. These quantities yielded a loaf weighing approximately one pound.

The flour was sifted, weighed, and sifted again into the mixer bowl. The weighed milk solids were sifted into the bowl with the flour.

The dried egg was reconstituted by combining with 100 ml. of distilled water in the bowl of an electric mixer and beaten at low speed for from five to eight minutes or until well blended.

The margarine was placed in a bowl over warm water until it had melted to a smooth consistency.

The sugar and salt were suspended in 50 ml. of water, and the yeast was softened in 25 ml. of water.

When all ingredients were ready, the egg, margarine, salt, sugar and yeast were combined and added to the flour-milk mixture. The bowl was placed on the electric mixer with the bread hook attached and beaten for two minutes at speed No. 2.

The dough was removed to a bread board and kneaded twenty times by hand. It was then put in a large bowl, covered with wax paper, and placed into the fermentation cabinet maintained at 28° to 30°C.

All told the fermentation period lasted three hours. At the end of 105 minutes, the dough was placed, wet side down, on a pastry cloth for punching. It was firmly folded each of the four ways from the center then inverted and the opposite ends overlapped so that a smooth square shaped mass was formed. It was replaced in the fermentation bowl seam side down, and returned to the cabinet for 50 minutes. Following the second fermentation period, the dough was again punched down using the same methods as before and returned to the cabinet for 25 minutes.

Several panning methods were used but the one finally adopted and found most successful was that demonstrated to the worker by Alma Swenson of The Wheat Flour Institute. It was as follows:

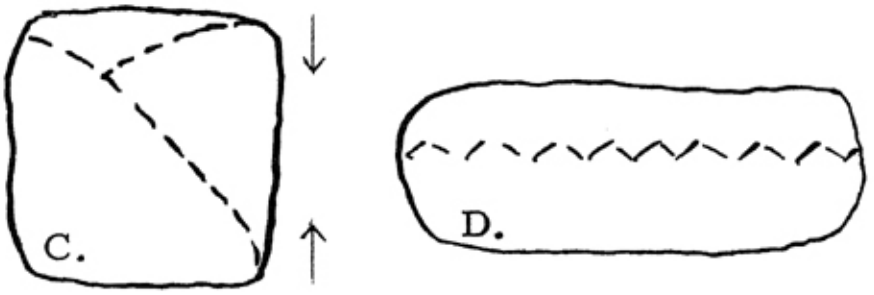
1. The dough was beaten into an oblong shape with the heel of the hand about thirty times and then allowed to rest several minutes.

2. The dough was folded lengthwise through the center and pounded. More air was forced out if the pounding began at the fold and continued outwards (A).

3. It was folded about one-third way from both ends toward the center and pounded again (B).

4. It was then folded each way from the top and bottom and brought to meet at the center, flattened slightly and this same folding from the ends repeated. When the ends were seamed together by gently pinching, the dough was in the shape of a cylinder (C).

5. This cylindrical mass was gently rolled over the board until its length equalled that of the pan in which it was to be baked.* It was placed into the pan seam down using a spatula to smooth out the ends (D).



The pan was covered with wax paper and returned to the fermentation cabinet for proofing time of 55 minutes.

The rotary oven was preheated to a temperature of 204°C. or 399°F. and the pan was placed on the shelf of the oven so that it radiated from the center pole, but did not touch it. A pan the same size as the bread pan but containing water to provide moisture was also placed in the oven. The bread was baked 45 minutes at this temperature. The Cereal Laboratory Methods recommended a temperature 230°C. plus or minus 5° and a shorter baking time. These directions were followed in the first few bakings but the crust was a very dark brown and hard. It was felt that the richness of the nutritious loaf would necessitate slower cooking. The lower temperatures gave much better results.

*Size of pan 8½" x 4½" x 2¾".