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WHEAT FLOUR SUBSTITUTES

An Address by

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INTRODUCTION.

It is needless to announce how highly pleased I am to be able to address this audience of master bakers on the use of flour substitutes, a subject to which a great deal of attention has been given by the Bureau of Chemistry.

I certainly consider it a great honor to have been invited to speak to you on a subject which, to my mind, is of first importance at this time.

I highly appreciate the opportunity to tell you some of our results with the use of flour substitutes in baking for it is evident that the food situation makes it absolutely imperative for the baker and the housewife to use less wheat and more of other products in making bread. It is, therefore, essential to the best interests of this country and that of our allies that we begin an intenstive study of this subject and that we adopt some radical steps leading to a greater conservation of wheat.

We may lend billions of dollars to the allies; we may send even five million men to battle, but unless we follow this tremendous sacrifice with sufficient food, and especially wheat, our exertions will have been in vain.

HISTORY.

This investigation was begun even before the outbreak of the European War. When the European War was declared the work was already under way and at the time of our entering the war it was practically complete. Even at the beginning of this investigation, there was noted a slight tendency for high prices, and it was hoped to be able to find some substitutes which would nullify this tendency. The outbreak and the continuance of the war has only exaggerated these high prices.

It must not be understood, however, that the use of flour substitutes is entirely original, for ever since the Old Testament Prophets there have been periodic occasions when substitutes for flour were advocated. Ezekiel 4:9 reads as follows: "Take thou also unto thee wheat and barley and beans and lentils and fitches (spelt) and put them in one vessel and make thee bread thereof."

In 1765 Saverio Manetti published a pamphlet in which he showed that some 50 or 60 different substances had been used for bread making. In the latter part of the same century a Frenchman by the name of Parmentier advocated the use of a large quantity of potatoes as a part substitute for wheat in bread making.

These investigations, however which have been conducted in the Bureau of Chemistry are the first, to our knowledge, which have been carried on on such an extensive scale, and which have been supplemented by a chemical analysis of the flour substitutes themselves and of the bread made therefrom in order to determine the relative food values of the different breads.

FOOD SITUATION.

Statistics published by Mr. Hoover showed that there was a deficit of about 580 million bushels of wheat in the allied countries of Western Europe, and that the excess of production over requirements in the United States and Canada was about 210 million bushels, leaving an actual deficit of about 370 million bushels. It is well known that the countries of Europe have been milling a large proportion of the wheat into flour, and that they have been using more or less of flour substitutes. These two facts coupled with the further fact that the United States and Canada could supply 210 million bushels reduced the actual deficit to about 125 million bushels. This shortage was due to a large extent to the bad weather conditions, and to a lack of labor and of farm animals. For example, in France alone, in normal times 8 million men, women and children are engaged in agriculture. Of these 3 million men have been taken away and placed in the ranks. In all Europe some 30 million men, formerly engaged in agriculture, are now in arms.

According to Mr. Hoover, in a statement made last fall, in order to overcome this shortage of wheat in Europe, a saving of at least 20 per cent in our wheat crop was imperative. That was the statement he made last fall. However, the time is now past when a saving of 20 per cent on our wheat crop could suffice to give the allies all the wheat they require. Already fully one-half of the 1917 crop has been milled and consumed and any saving which must now be done (and it is more imperative now than ever before that it should be done) must be based on the fact that only one-half of the 1917 crop is available. Taking into consideration the fact that a considerable amount of wheat has already been saved by the volunteer movement on the part of the housewives, it would seem that approximately 35 per cent of our present supply must be saved instead of 20 per cent which it would have been necessary to save had we begun last fall to save our 1917 crop.

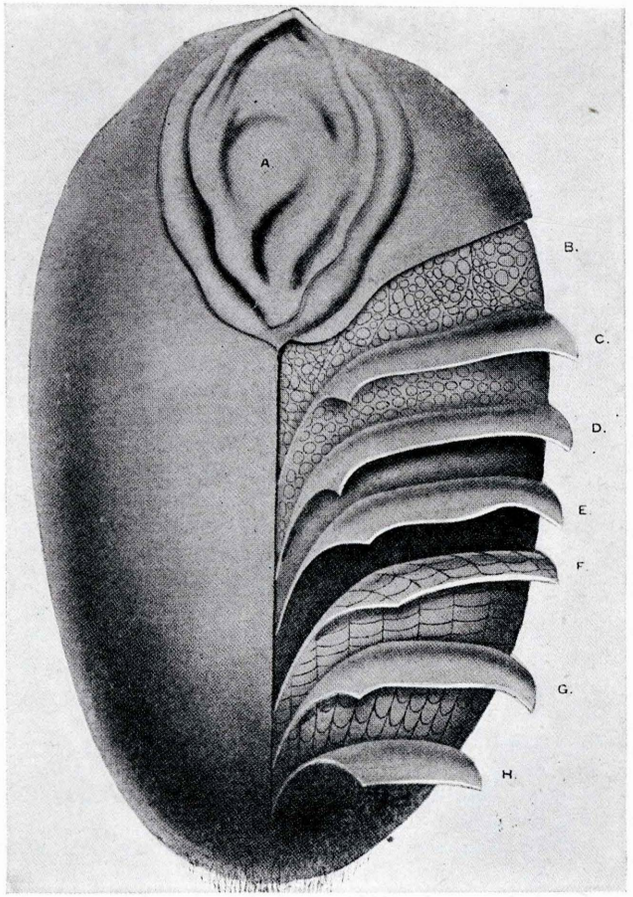
How is all of this wheat to be saved? It can be done in one or all of the following ways:

1. By the volunteer saving, as advocated by the Food Administration of the United States and of the several states. Much wheat has already been conserved by our so-called wheatless days and the "no-wheat bread days," advised and advocated by the Food Controllers of New England and other states and by other volunteer methods.

2. By milling more of the wheat into flour. The recent order of the Food Administration making the extraction of 74 per cent instead of an average of 70 per cent will bring about a saving of approximately 12 million bushels. Had this order been promulgated at the beginning of the 1917 crop approximately 20 million bushels of wheat would have been saved.

The milling of more of the wheat into flour has been adopted

by every fighting nation of Europe, only it has been done to a larger extent than here. In England the milling is carried on on the basis of 81 per cent extraction. The French people require that 85 pounds of flour shall be produced from every 100 pounds of wheat. In Italy 90 pounds of flour must be milled



Dissected Kernel of Wheat: a. Germ; b. Starch cells predominate; c. Gluten cells predominate; d. Interior coat of bran; e. Testa, coloring matter of bran; f. Endocarp; g. Epicarp; h. Epidermis.

from every 100 pounds of wheat and in Germany practically nothing is removed except that which comes off in the scouring process. This means that approximately 97 or 98 per cent of the wheat is milled into flour. If we had adopted the English standard at the beginning of the 1917 crop, the saving in wheat would have been approximately 78 million bushels. The French standard of milling would have conserved 105 million bushels, or almost enough to have supplied the allies with all their needs. In

fact, this amount would have been quite sufficient when taken into conjunction with wheatless days and other volunteer conservation. If, however, any such order should now be promulgated by the Food Administration as is at present in vogue in England or France, the saving, from today on, would be only half what it would have been had such an order been made in July or August last, namely, 39 to 52 million bushels, respectively, instead of 78 and 105 million bushels. Even if such an order should now be issued, we would be compelled, moreover, to bring about a saving of another 50 million bushels before the allies could be supplied with all the wheat they need.

Before I leave this subject let me call your attention to the picture of a kernel of wheat and show you just where the flour comes from and what is the general composition of the principal components of the wheat kernel.

TABLE A.

Composition of the Various Parts of the Wheat Kernel. (Per Cent.)

Parts Wheat Kernel	Wheat	Protein	Fat	Fiber	Ash	Water
Pericarp	4.2	7.0	2.5	18.0	2.9	11.3
Aleurone	9.3	23.9	5.5	11.0	6.6	13.4
Germ	1.5	35.9	12.5	2.0	5.7	11.5
Endosperm	85.0	10.5	1.20	.5	0.9	13.0

The wheat kernel (Table A) is really a fruit surrounded by the pericarp (from the Greek "around the fruit"), which consists of the three outer layers of bran. Within these three layers is the seed proper, consisting of the germ and the endosperm, which are inclosed and protected by three other layers, which together with the three outer layers form the entire bran of the wheat. The pericarp, which makes up about 3 or 4 per cent of the wheat, has relatively little food value. It contains approximately 3 per cent of ash, 3 per cent of fat, 20 per cent of fiber and 7 per cent of protein. The ash constituents are lower in phosphoric acid, lime and magnesium than are the ash constituents of the other portions of the wheat kernel.

The seed coats or the three innermost layers of the bran, which include the aleurone layer, and the germ, on the other hand, make up about 12 to 14 per cent of the wheat, and are extremely rich in fats, protein and ash. Furthermore, the ash constituents are rich in phosphoric acid, calcium, magnesium and potash, all valuable food constituents. These three bran layers and the germ likewise contain relatively large amounts of the water-soluble vitamines which have been found to be absolutely essential for body growth.

The endosperm, which makes up 80 to 85 per cent of the wheat, is the part from which flour is made. If it were possible to extract the endosperm entirely from the seed proper, leaving nothing but the seed coat and germ behind, we would get 83 to 85 pounds of flour from every 100 pounds of wheat. In olden days

(and not so long ago either, for the system has been in vogue in country mills up to within a very few years, and it may still be in use in some localities) the farmer obtained from the miller 100 pounds of flour for every 2 bushels of wheat he took to the mill; that is exactly an 83 or 85 per cent extraction. While such flour contained most of the endosperm of the wheat, it also contained a certain proportion of the germ and inner coat or aleurone layer, because of the impossibility of making a clean separation. In our modern process of milling, 70 per cent of the wheat only is extracted and this is entirely from the endosperm. The result is a white flour containing approximately 11 per cent of protein, 0.2 per cent fiber, 1 per cent of fat, over 73 per cent starch, but less than one-half per cent of mineral ingredients. i. e., only one-fourth as much as is present in the wheat itself. Milling in order to include the germ and aleurone layer with the flour, but without also including the pericarp with our present equipment is impossible. It is also impossible, according to our present system of milling, to remove the pericarp without also removing the germ and aleurone layer.

TABLE B.
Composition of Wheat and Flour. (Per Cent.)

	Water	Fat	Protein	Carbo-hydrates	Ash	Fiber	Potash	P_2O_5	CaO	MgO	Fe, SiO_2, Cl, Na_2O
Wheat	12.0	2.0	12.0	70.0	2.00	2.00	.62	1.00	.07	.24	.07
Flour	12.0	1.0	10.5	75.8	.50	.20	.18	.25	.03	.03	.01
Losses due to milling. (Per cent.)											
29	65.	30.	22.3	82.5	93.0	79.0	82.0	71.4	91.3	90.0	

Table B shows the losses which take place in the process of milling. This chart gives the composition of the wheat and likewise the composition of the flour. It likewise gives the percentage amount of the wheat which is lost as a result of milling. It shows that 65 per cent of the fat, 30 per cent of the protein, 22 per cent of the carbohydrates and over 80 per cent of the ash ingredients go into the offal. It is also seen that the constituents of the ash are lost to the extent of 71 to 91 per cent. The result of milling wheat which has been in vogue in this country is a white flour, which, according to McCollum, formerly of the University of Wisconsin, is low in one of the essential vitamines, as are almost all of the so-called purified foods.

According to Mr. Hoover, we have already shipped all the wheat available over and above our normal needs and any and all wheat which we may hereafter be able to export must be as a result of conservation. The Food Controller Rhondda of England has within the past week cabled to this country to the effect

that he considers the situation of the allies most serious. Recent newspaper advices indicate that a large part of the civilian population of France has been put on a daily ration of 7 ounces of bread. When we know that bread is the great staple food of the French, consisting of over 50 per cent of the diet of the nation, and a much larger proportion of the food of the poorer people, the seriousness of the situation must dawn upon us. Every American with any patriotism in him will be glad to do everything and anything to help in a crisis like ths.

(3) The third method of wheat conservation lies in the use of flour substitutes.

Probably no class of people of this country, except the millers, is in a better position to alleviate the sufferings of the European than is the baker class. The baker handles 35,000,000 barrels of flour annually. He is, therefore, able to bring about a very large share of wheat and flour conservation. The use of 15 to 20 per cent of flour substitutes is practicable and has been found successful in France and elsewhere. If the use of this amount of flour substitutes had been begun last fall there would have been brought about a saving of 5 to 7 million barrels of flour, equivalent to 22½ to 31½ million bushels of wheat. Inasmuch as approximately one-half of the wheat crop is already exhausted, the actual saving from now on will be nearer 11 to 16 million bushels. This is an amount equivalent to the saving which the millers are now making by extracting the wheat on a 74 per cent basis.

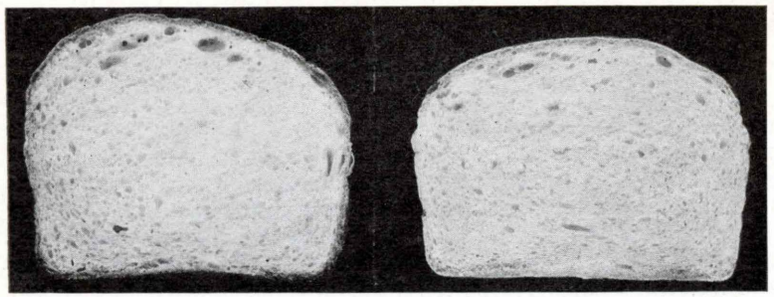
The Bureau of Chemistry has already done a great deal of research work on flour substitutes. The object in undertaking this work was four-fold, viz:

1. To show how the excess of certain foodstuffs which may be found in various localities may be used.
2. To offer variety in our so-called "staff of life."
3. To show how the wheat supply of the world may be conserved by making a bread containing more of the natural food elements of the wheat than is found in the highly refined white flour of today.
4. To show how the wheat supply may be converted by utilizing a certain percentage of other material in place of a part of the wheat.

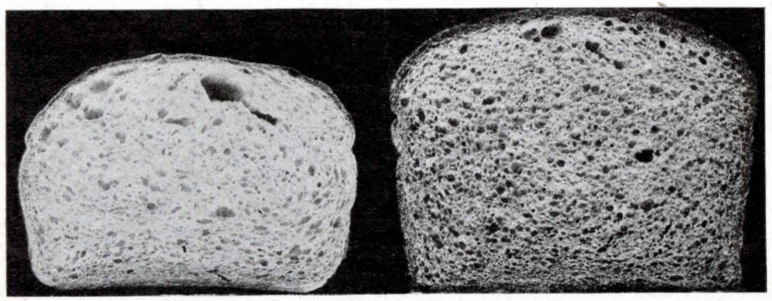
The substitutes used were divided into four general groups:

(a) Those substitutes which were low in protein or high in carbohydrates, as for exampe, the starches from the different sources: fruit such as the banana; roots such as the cassava; or tubers such as the potato and dasheen; and nuts rich in carbohydrates, such as the chestnut.

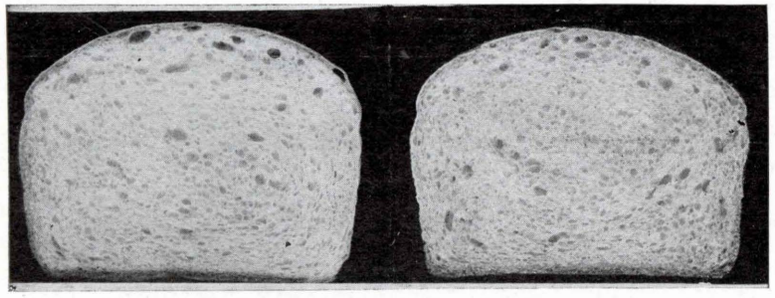
(b) Those substitutes which belong to the cereals or grains other than wheat. Among these may be named corn, rye, oats, barley, buckwheat, sorghums and millet.



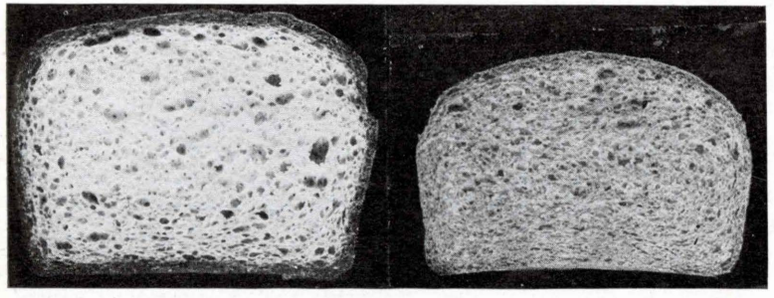
Standard all-white flour. Oats.



Rye. Barley.

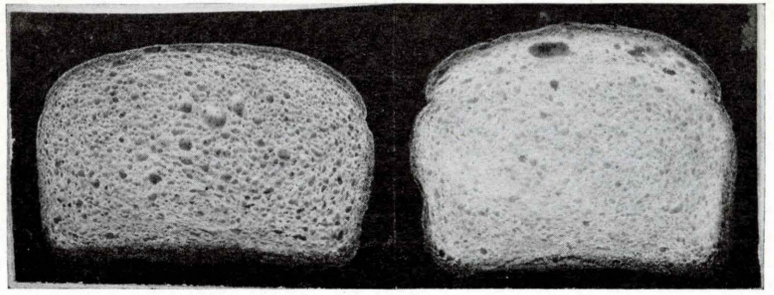


Corn Flour. Corn Meal.

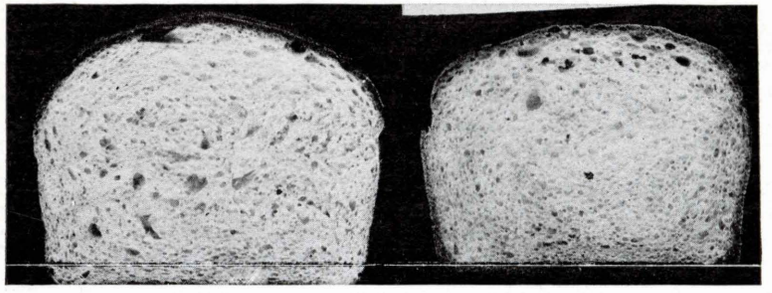


Buckwheat. Bran.

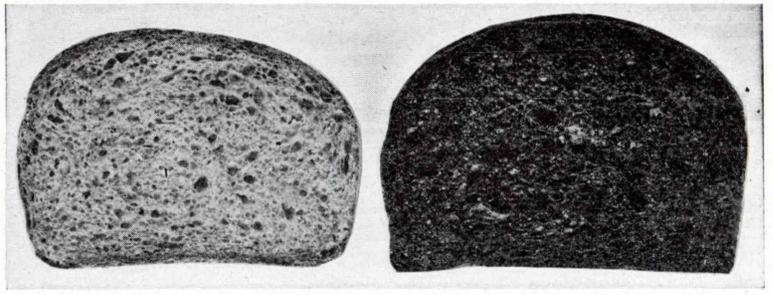
Loaves of bread baked with 75% white flour and 25% flour substitute. The pictures represent cross-section of loaf and show the correct relative size compared with standard 100% white flour) and also the color and grain.



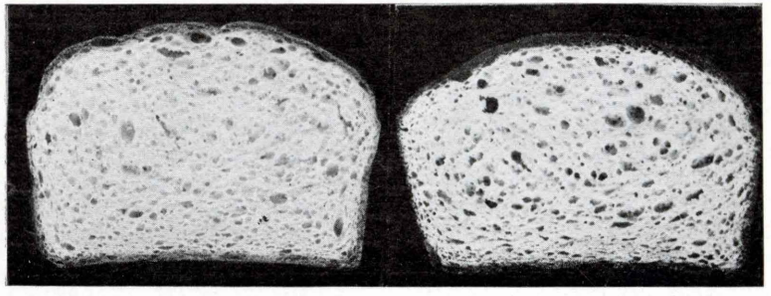
Millet. Milo.



Boiled Potato. **Kafir.**



Feterita. Cottonseed.



Dried Bean. Soy Bean.

(c) Those substitutes obtained from the legumes, e. g. peas beans, soybeans, etc. including the peanut.

(d) Substitues obtained as a byproduct of industries, such as bran, cottonseed flour, soybean oil cake, peanut oil cake, etc.

It was found in our labortory experiments that a mixture of 25 per cent of these flour substitutes with 75 per cent of wheat flour, made a good palatable and pleasing loaf of bread. On a large scale it might be better to use from 15 to 20 per cent of such substitutes, though there is no reason whatever why the housewife in baking her own bread should not use the maximum amount. As a result of all of our experiments we have come to the conclusion that almost any foodstuff which can be suitably prepared can be utilized as a flour substitute and we advise the use of all such substitutes which are to be found in sufficient abundance in any locality to be of any economic importance.

For all practical purposes, however, I shall mention and discuss here only a few which I deem to be of greatest importance to this region, namely oats, barley, sorghum, corn, bran, buckwheat and possibly soybean and bean.

TABLE C.

Composition of Flour Substitutes.

Kind of Flour	Moisture	Protein	Fat	Carbohydrates	Ash	Calories
White	12.00	12.50	1.00	74.08	.42	1647
Bran	7.86	18.00	2.90	65.98	5.26	1550
Cottonseed	4.57	50.56	9.68	29.63	5.56	1818
Peanut	2.82	29.31	49.40	16.29	2.18	2905
Soy Bean	6.14	39.56	20.71	28.35	5.24	2105
Oat Meal	8.00	16.80	7.00	66.30	1.90	1815
Barley	11.47	8.69	1.16	77.60	1.05	1469
Feterita	8.00	9.96	1.87	78.38	1.04	1725
Corn Meal	7.21	8.25	2.73	80.86	.95	1758

It is not my purpose to give formulae for making these breads. As a general rule, the addition of a substitute decreases the amount of gluten in the whole mixture and weakens the flour by just that much. The mixture of flours should be, therefore, handled more or less like a weak flour. Every baker will find it necessary to modify his methods of baking to a more or less extent before he may be expected to bake the best loaf.

I shall show you the composition of these flour substitutes and of the breads made with them and compare these breads with white bread, in food values.

Our attempt to compare the value of flour substitute bread with white bread should be considered as in line with a patriotic duty and not in itself as an attack on the value of white bread. We all know to what extent white bread is being made and consumed and we all recognize the value of such bread in its place and that it may have a rightful place in every well rounded diet.

It may well be expected that the bakers are going to be required to use flour substitutes or mixtures of flours. It is up to

them to make as good a bread as possible. It is their patriotic duty to do so, in order that the people generally may have no real cause for complaint, because of their being denied white bread. It should make no material difference to the baker whether he makes white bread or bread containing a flour substitute, so long as he makes the bread. It being, however, necessary to use substitutes for flour, and it being absolutely incumbent upon the bakers to make and to sell bread made with substitutes, the people generally should be shown and taught that flour substitute bread is really a good bread. It will be easier for all concerned if the public can be convinced that flour substitute bread, as a food, is in many respects equal to and in some respects superior to white bread.

Table C gives the composition of flour and flour substitutes. A good bread flour may contain 12 per cent of water, 12 per cent of protein*, 1 per cent of fat. 0.4 per cent of ash. Wheat bran contains a considerably larger amount of protein than does white flour and from 12 to 15 times as much mineral ingredients. Cottonseed flour contains 4 to 5 times as much protein as is found in ordinary flour, twelve times as much ash material and 9 times as much fat. The peanut flour meal made from the whole peanut kernel contains 29 per cent of protein, 49 per cent of fat and a little over 5 times as much ash material as is found in wheat flour. The soybean meal made from the whole soybeans is also one of the richest flour substitutes that we have, in protein and fat, containing almost 40 per cent of protein and 20 per cent of fat, besides 12 times as much mineral constituents as is found in wheat flour. The oatmeal contains, as a rule, considerably more protein than the white flour does and a great deal more fat (5 to 7 times as much as does the white flour) and considerably more mineral ingredients. Barley flour contains, in the sample here shown, somewhat less protein than does the wheat flour. However, it contains considerably more mineral ingredients.

In this connection, I should say that the composition of flour depends to a large extent upon the composition of wheat and this, in turn, is affected by the environment in which the wheat is grown. As a rule, wheats grown East of the Mississippi are low in gluten. Those grown in the dryer regions of the West are very high in gluten. That is due to climatic conditions. The same thing applies not only to wheat, but to barley and to other plants. Environment exerts a great influence upon the composition of plants.

Feterita flour contains approximately the same amount of protein as white flour, but considerably more ash. Feterita is one of the sorghum grains. These are grown to a very large

* The factor N x 6.25 was used in order to simplify matters, inasmuch as this same factor was employed to obtain the protein of the other samples.

extent in Western Kansas, Oklahoma and northern Texas. In fact, this year the sorghum crop of the state of Oklahoma was larger than the wheat crop. For Oklahoma and for the people who live near there, ferterita should prove a splendid flour substitute.

Corn meal contains somewhat less protein, but more ash than does wheat flour. Corn flour, on the other hand, is somewhat poorer in both protein and ash.

Table D gives the composition of breads. In no case shown here is the bread produced inferior in nutritional qualities to white bread. As a matter of fact the use of every flour substitute suggested by the Bureau of Chemistry, with the exception of the starches, improve the food value of the bread in some particular or other. To be sure these breads are inferior in color, texture and volume. As to the color, however, it should no longer be considered as the criterion of superiority. In this connection I believe that, inasmuch as flour substitutes must be used by the baker and housewife, it is a patriotic duty to show our people that these breads are in food value equal to and in many respects superior to white bread.

TABLE D.

Composition of Breads Made With 75% Flour and 25% Flour Substitute. (Per Cent.)

Substitute 25%	Moisture	Protein	Fat	Carbohydrates	Ash	NaCl free Ash	Nutritive Ratio	Calories
Bran	35	9.92	1.64	51.46	1.96	1.17	5.5	1186
Cottonseed	35	15.87	2.64	44.34	2.15	1.25	3.2	1211
Peanut	35	12.25	9.45	41.68	1.61	.62	5.3	1394
Soy Bean	35	13.70	5.31	43.82	2.17	1.17	4.1	1283
Oat Meal .	35	9.78	2.87	50.84	1.51	.57	5.9	1242
Barley	35	7.97	2.25	53.34	1.44	.42	7.3	1232
Feterita ...	35	8.74	1.38	53.54	1.35	.40	6.5	1212
Corn Meal .	35	8.17	2.15	53.29	1.39	.40	7.1	1247
Wheat Bread	35	8.74	2.08	52.90	1.30	.30	6.6	1223

The protein content of most of these breads, with the exception of corn and barley breads, compares with that of wheat bread. Bran bread contains somewhat more protein; so does the oatmeal bread. Feterita bread contains approximately the same amount of protein as white bread does. On the other hand cottonseed bread, peanut bread and soybean bread are much richer in protein than is white bread.

According to the investigtions of Osborne and Mendel, the protein of soybean is a more complete protein than that of wheat flour, inasmuch as it contains a relatively large amount of lysine one of the necessary amino acids. Investigations by Johns and Jones of the Bureau of Chemistry on peanut protein have shown it to be richer in amino acids, and capable of supplementing to a marked degree the proteins of wheat which are relatively deficient in these amino acids. In a general way it is found that the proteins of a mixture of grains such as has been used in these experiments are an improvement in food value over the proteins

of wheat alone. Breads made from a mixture of flours would therefore seem to be a better food for man than bread made from wheat flour alone.

The analysis of these breads show that wheat bread contains a much smaller amount of salt-(sodium chloride)- free mineral ingredients than is found in any of the other breads reported here. The highest amount of the natural mineral ingredients is found in bran, cottonseed and soybean breads. The consumption of these breads every day to the extent of one-half pound instead of the same amount of white bread will give to the system an opportunity to assimilate over 1½ pounds of mineral ingredients per year more than would be supplied by white bread. That this is an important factor is apparent without further discussion. When white bread is the sole "staff of life" this amount of mineral ingredients can be made up only by consuming other foods rich in minerals and such foods are not always accessible. The poorer classes, moreover, whose diet is made up for the most part of white bread, would feel the effect of a deficiency in mineral constituents most seriously. To show you the importance of a liberal amount of mineral ingredients, let me call your attention to the fact that a child during the first year of its life, consumes about 1000 pounds of milk, (often a mixture of mother's and cow's milk) and in this milk the child may take into its system as much as five pounds of mineral ingredients. In the form of white bread, a somewhat older child sonsuming one-half pound per day, takes into its system less than three-fourth of a pound of mineral ingredients per year. The question may be well asked how is the poor mother's child going to obtain enough mineral ingredients to form bones and teeth and supply every cell in its body with the proper amount of lime and other salts when bread which is recognized as the chief article of food of these poor people, is so lacking in mineral ingredients. The use of 25 per cent bran bread, soybean bread or cottonseed bread will supply four times as much mineral ingredients as will white bread. The use of bread made with 25 per cent of beans, peas or oat meal will give 2 to 3 times as much mineral ingredients as are found in white bread. Graham bread would also supply approximately this same amount of mineral ingredients. There is, therefore, a certain compensation for the loss of the people's nice white bread.

The calorific values of these breads do not present any appreciable differences. The calorie is a unit of measure just as the yard stick is a unit of measure, and it simply represents the amount of heat that is required to raise the temperature of one pound of water 4 degress Fahrenheit. Except in the case of soybeans and peanut there is very little difference in the amount of calories in one pound of bread made from these substitutes. Peanut and soybeans are very rich in fat.

THE NUTRITIVE RATIO.

The nutritive ratio is the relative amount of protein compared to the non-protein foods. According to Hutchinson, while bread itself is one of our most important and nutritious foods, it is not a perfect single food, because the nutritive ratio is too wide. According to this table the nutritive ratio of white bread is as 1 is to 6.6, whereas that of peanut bread is as 1 is to 5.3, soybean bread is as 1 is to 4.1 and bran bread is as 1 is to 5.5.

The flavor and taste of all of these breads are distinct and agreeable, and are characteristic more or less of the flavor and taste of the materials used. Where only 5 to 10 per cent of the substitutes are added there is very little effect in flavor, taste or even texture, but the use of only 5 to 10 per cent substitute would be of comparatively slight economic importance. In order to make any considerable impression in our conservation program, 15 to 20 per cent flour substitiue at least should be employed.

In Table E, your attention should be drawn to the amount of the more common substitutes which are available. I have calculated the amount, not in bushels, but in millions of tons. Assuming that flour should be milled on an 85 per cent basis, we would have 16,600,000 tons of available food. Our corn crop consisting, as it does, of considerably over 3,000,000,000 bushels and milled so that we could get 90 pounds of corn meal from every 100 pounds of corn, would give us 79.5 million tons of available meal. From the oats we would obtain about 17,700,000 tons. That is asuming that we would remove the hulls, which constitute 27 per cent to 30 per cent of the oats and that we could use the oat groat almost entirely. The barley being milled on a 70 per cent basis, would give about 3,500,000 tons of avaiable flour; the rye

TABLE E.

Crop	Yield in million tons	Per cent flour	Flour available million tons
Wheat	19.5	85	16.6
Corn	88.4	90	79.5
Oats	25.3	70	17.7
Barley	5.0	70	3.5
Rice	1.0	75	.7
Rye	1.7	85	1.4
Sorghums	2.2	80	1.7
Buckwheat	0.4	75	0.3
Peanut	0.6	35	0.2
Cottonseed Oil Cake	2.5	50	1.2
Beans	.5	80	.4

something over 1,000,000 tons. If sorghum were milled on an 80 per cent basis, it would give us something over 1,000,000 tons of available sorghum flour or meal. Buckwheat would supply 300,000 tons and peanuts 200,000 tons of available meal. This table shows that while we have only 16.6 million tons of available wheat flour, we have enough raw material to furnish 6 to 7 times

as much flour or meal from other sources, provided of course, it were all available for human consumption.

TABLE F.

Food Value of 100 Pounds of Wheat Milled Into

	Graham Flour	White Flour	+	Bran
Pounds flour	100	70		30
Per cent protein	12	10.8		14.8
Pounds protein	12	7.56		4.44
Coefficient of digestion	77	90		17*
Pounds digestible protein	9.24	6.80		.75
Total pounds digestible protein	9.24		7.55	

in favor of graham flour { 1.69 lbs. or 22%

*When food materials are fed to animals first, only 15% of the energy and 17% of the protein are realized as human food. Report by Commission on "Economy in Food Which Might be Effected by Prohibition." Jr. Inst. Brew. 1917 **23** 98.

I want to call your attention to the last table, Table F, which compares the food value of 100 pounds of wheat milled in the form of graham flour with that obtained from the same amount of wheat milled in the form of white flour and bran. Assuming the percentage digestibility of the protein of graham flour as 77 (Office Exp. Station Bull. 156) there would be in 100 pounds of wheat milled into graham flour 9.24 pounds of digestible protein. If the 100 pounds of wheat are milled into patent flour and bran, the miller will obtain approximately 70 pounds of flour and 30 pounds of bran and offal. Again, assuming the percentage of digestible protein in the flour as 90. (Office of Exp. Sta. Bull. 156) the total amount of digestible protein in the 30 pounds of white flour would be 6.80 pounds. When food materials are fed to animals first and then the animals are fed to man only 17 per cent* of the protein of the food is realized as human food. Therefore, the amount of digestible protein obtained from 30 pounds of bran is approximately 0.75 pounds. The total amount of digestible protein obtained from 100 pounds of wheat milled into white flour and bran would be 6.80 plus .75 equals 7.55 pounds or 1.69 pounds less than the amount obtained from 100 pounds of wheat when milled into graham flour. This means that 22 per cent more protein would be obtained from 100 pounds of wheat milled into graham flour than when milled into white flour and bran. In other words, if the 500,000,000 bushels of wheat annually milled by the millers of this country should be milled into graham flour the people would obtain the same amount of digestible protein as would be obtained from 610,000,000 bushels of wheat milled into white flour and bran.

CONCLUSIONS.

1. Good, palatable, and nutritious yeast risen bread can be

* When the bran is fed to dairy cows, 30% of the protein is recovered, instead of 17%, as noted above. Even when bran is fed to dairy cows, however, the milling of wheat into graham flour would show a gain in digestible protein of 13% over and above the amount obtained by milling the same quantity of wheat into white flour and bran. This would mean a saving of 65 million bushels of wheat.

made by using as much as one fifth of flour substitute and four-fifths of bread flour. The flour substitute may be any food material grown anywhere in sufficient quanity to render it cheap and which may be suitably prepared. To make the best appearing bread and yet one which would be effective in wheat conservation no more than 20 per cent of flour substitute should be used.

2. The use of 20 per cent substitute in the place of wheat flour during the whole period of the 1917 crop would have permitted the saving of nearly 100,000,000 bushels of wheat.

3. Almost every part of the country produces a flour substitute of some kind. The South has cassava, dasheen, banana, rice, soybean, peanut and cottonseed, and in this respect is the most fortunate section of the country. The Southwest has sorghum grains. In the far West, e. g. in the Sacramento Valley, there is a superabundance of potatoes. The same applies to certain parts of Maine, Minnesota and Colorado and other states. Besides these, cereals other than wheat are grown in abundance in very many of the states of the Union. In this section oats, barley, and corn are the most abundant substitutes.

4. Recent researches regarding the value of the protein of flour for body building purposes seem to indicate that a mixture of wheat and some other substances might for certain individuals be an improvement over the use of white flour alone.

5. One of the most important problems in the country today is the maintenance and increase of our bread supply. This can to a large extent be brought about by the use of flour substitutes or by milling a greater portion of the wheat into the flour.

Now do not let us forget that the bakers are in a position to lend the greatest amount of assistance to the country and to the world in this crisis. Economy in wheat is a patriotic duty. Waste is a crime against the country. The use of white bread at this particular time is being recognized as an unnecessary waste. The making of a good, satisfactory flour substitute bread will soon be looked upon as a great patriotic privilege and duty and one which the American baker will not be slow to adopt and carry out. To practice such economy would insure a sufficient amount of food for all the allied countries as well as for ourselves. The sacrifice to the baker is comparatively little. Instead of making a white bread of the same general character, day after day, there are open to him ways innumerable of making delicious bread with flour substitutes. Room for every baker to exercise his ingenuity is here. Every section of the country has substitutes which can be used and the bakers of America will not be slow to find some suitable substitute to make a salable and popular bread. To the public the deprivation of white bread is a sacrifice more apparent than real. It may even prove a blessing in disguise. Certainly the eating of flour substitute bread will be considered by the general public as far more agreeable and far more preferable than trench warfare.