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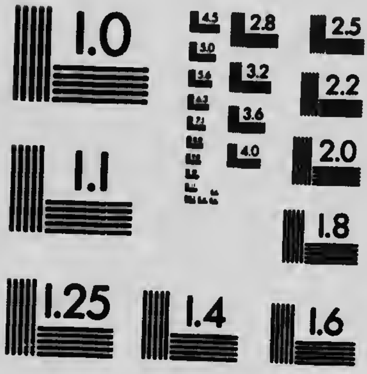

BULLETIN 180.] [APRIL 1910

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE.

Flour and Breadmaking

By R. Harcourt and Miss M. A. Purdy.

INTRODUCTION.

Although flour is one of the most common materials used in the preparation of our foods, very few people have a clear idea of the wide difference between the flour-producing properties of the various varieties of wheat grown in different localities, of the effect of climate, soil, etc., and of the different grades of flour on the market. To many people flour is simply flour, and they know no grades, unless it is simply two kinds—bread and pastry flour. As a matter of fact, there are a great many grades of flour; and, while the millers, particularly those in the larger milling concerns, strive to keep the different grades of flour uniform from year to year, there are wide differences in the quality of the wheat, which is their raw material, that renders this problem a very difficult one, if not impossible. Consequently, the flour got under any one grade is very likely to vary somewhat in strength, or in some of the conditions which would affect the baking. By blending wheats of different grades and varieties of different qualities the miller may be able to produce a uniform sample of flour, but in certain seasons this may be a very difficult problem. Very often the millers are blamed for producing poor flour when the circumstances that effect this are beyond their control.

Circumstances Influencing the Quality of Wheat.

There is abundance of evidence to prove that the composition of wheat is influenced by its environment. Millers are quite familiar with the fact that some districts in Ontario will produce a better quailty of wheat than others, and that the spring wheat of the Western Provinces is superior to the best Ontario can produce. Possibly climate (including variations due to season) and soil, or, rather, the condition of the soil, have the greatest influence on the composition of the wheat. To obtain a good quality of wheat for milling purposes we require bright, warm days, with an abundance of sunshine and an absence of an excess of moisture; or, in other words, the conditions which would cause rapid, though normal, ripening of the grain. Wheat that has ripened slowly, or that is over-ripe, is usually somewhat low in protein, and, consequently, in gluten, and rich in starch. Chemical investigations seem to show that at the time of blossoming the plant has taken up nearly all the nitrogen and ash constituents that it will have in the matured plant, while it continues to take up carbon as long as the plant is green. This means that the longer the time from blossoming to maturity the greater the opportunity for the plant to take up carbon and convert it into starch and store it in the grain. Consequently, slowly matured grain will be plump. The amount of protein, or gluten, is determined by the amount of nitrogen taken into the plant in the early stages of growth, and the completeness with which this is transferred to the seed.

A comparatively high temperature, long, bright days, an absence of an excess of moisture, are the conditions which prevail throughout our Western Provinces, and these are, doubtless, some of the conditions that account for the high quality of wheat produced there.

The researches of Laws and Gilbert at the Rothamsted Institution, in England, and of the Central Experimental Farm at Ottawa, show that manures have very little influence on the composition of the wheat. Recent investigations by F. T. Shutt, Central Experimental Farm, Ottawa, show that the amount of moisture in the soil is a greater factor than the amount of nitrogen available to the plant. These investigations indicate that when wheat is grown on two different soils, one of which contains more moisture than the other, the moist soil will produce grain with low gluten and high starch content. This is probably due to the fact that in this case maturity is retarded. It will thus be seen that the wheat from the same localities and of the same variety may be quite different in composition and in milling qualities. Furthermore, it is well known that the wheat from some localities in our own Province is very much superior to the same variety of wheat grown in another locality. Thus, without going too deeply into this point, it will be seen that wheat is not of a constant composition, but that it varies from season to season and in different localities. The composition also varies very widely with different varieties.

Varieties of Wheat.

Wheats are commonly divided into two great classes—those sown in the autumn and harvested the next summer, known as fall or winter wheats, and those sown in the spring and reaped the same season, known as spring wheats. As a rule, the spring wheats are harder, and make a superior flour for breadmaking purposes. There are a great number of varieties of these two different classes of wheats, which vary very much, not only in the yield of grain and straw per acre, but also in milling and baking qualities.

Some of these varieties are very soft, and yield a poor quality of flour. Unfortunately, these soft wheats usually produce more bushels per acre than the harder, better wheats; and, as the buyer makes very little difference in the price, it naturally follows that the softer, heavy-yielding varieties are grown in largest quantity. We have milled and baked over sixty varieties of fall wheats grown on the college experimental plots in each of the seasons of 1907, 1908, and 1909, and also over forty varieties of spring wheats, grown the same seasons. The results of these tests are too voluminous to incorporate here, but they may be found in the Ontario Agricultural College Reports for 1908 and 1909.

To the Ontario miller the question of the varieties grown in his own district is a very important one, for the greater part of this wheat will probably be delivered at his own mill; and, if the varieties are poor ones, his difficulties in manufacturing a strong flour are increased. Fortunately, there are not a great number of varieties grown in the Western Provinces, and the mixing in transit makes the wheat of more uniform grades than could possibly be done in this Province.

MILLING OF FLOUR.

The roller mill process of making flour is a gradual one. In the old days, when all the flour was ground by the stone process, the whole of the flour was left in one grade, and the germ and some of the bran layers of the wheat were not removed in the bolting process. The consumers' demand for a whiter flour than could be made by this process was partly instrumental in bringing in the roller process of milling, although the introduction of harder varieties of wheat, closer milling, and the division of flour into a number of grades were some of the other reasons for its introduction.

By the roller process the miller has it in his power to separate the flour into as many grades as he chooses, and in the larger mills as many as six grades of flour are made from one stream of wheat. The process is, briefly, as follows:

After being thoroughly winnowed and scoured, the wheat is passed between a pair of corrugated rollers, revolving towards one another, but one travelling slower than the other. In this first "break" the wheat is simply broken open along the crease; the whole of the broken-up material is then separated according to fineness into a number of products. The coarse, main part of the grain is returned to another pair of corrugated rolls, and is ground a little closer; the product is again sifted and the branny part returned to other rolls. This is repeated a fourth, fifth, or even a sixth time, or until practically all the starchy materials are removed from the flat particles of bran. With each sifting some material fine enough for flour is obtained, but the greater part of the endosperm, or central part of the wheat, is left in a coarse, granular condition, which, when purified, forms the wheat farinas that are sold as breakfast foods under a great number of fanciful names, such as Meat of Wheat, Hearts of Wheat, Wheat Crystals, etc. It is from this same part of the wheat that the whitest and strongest flours are made. The germ is the richest part of the grain in protein and fat; the inner bran layers are the next richest, and the starchy endosperm contains the least of these constituents. It naturally follows that if flour is made from the endosperm it will be whiter, and lower in protein, fat, and crude fibre than if the whole grain was included, or somewhat poorer than if all the flour made from the wheat was left in one grade, as was done in the old stone process, or as is done to-day in making a straight-grade flour.

The names assigned to the various grades of flour are very numerous, as practically every flour miller has special names for his products. But, while there are a number of variations, nearly all flour may be graded as "patent," "bakers'," or "straight." The well known flours, Royal Household, Five Roses, and Purity, are patents which probably form about 35 per cent. of the total flour. Sometimes, however, the term "standard patent" or "long patent" is used to designate a flour which forms about 90 to 95 per cent. of the total flour, and is, consequently, only a little better than a "straight." The "bakers'" grade, or "clears," usually represents about 55 per cent. of the flour after the patents have been taken off. A good bakers' grade of flour will yield about as much bread as a "patent," but the bread is not of so good a colour. The low grade is got by grinding still closer to the bran layers, and represents the remainder of the flour, or about 10 to 15 per cent. of a total flour. The "straight" grade is the whole, or 100 per cent., of the flour from the wheat left in one grade. Of course, the percentage amount of the flour left in the various grades are not fixed, but are varied by every miller, according to the quality of the wheat he is using and the strength and colour of the flour he wishes to produce.

To show the difference in the composition of these different grades of flour the following figures, taken from Bulletin No. [illegible] part 9, of the Bureau of Chemistry, Department of Agriculture, Washington, are given:

PERCENTAGE COMPOSITION OF WHEAT AND THREE GRADES OF FLOUR MADE FROM IT.

	Moisture	Fat	Carbo-hydrates	C. Fibre	Ash	Proteids	Gluten	
							Wet	Dry
Wheat	9.07	2.74	70.37	1.68	1.79	14.35	32.31	11.88
Patent	11.48	1.45	73.55	.18	.39	12.95	36.14	10.85
Bakers'	12.18	2.00	69.99	.33	.62	14.88	[illegible]	16.97
Low grade	12.01	3.86	63.26	.93	1.99	17.95	10.01	4.26

It will be noticed that the low-grade flour contains the most fat, fibre, ash, and proteids, and the least starch and gluten, while the patent flour has the least of the first four named constituents—in every case very much less than the wheat from which it was prepared—and the largest percentage amounts of carbohydrates, or starchy material, and a much larger quantity of gluten, although not so much as the bakers' grade. When we remember that there is more fat, ash, fibre, and proteids in the bran layers than in the endosperm, and that the patent flour is kept as clear as possible of bran particles, we are not surprised that this flour is low in these materials and that it is particularly rich in starch. Because of these facts it is lighter in colour than the other grades; and, because consumers of bread attach so much importance to this question of colour, the patent flours sell for more money than any of the other grades, while, judging by percentage composition, the low grade would appear to be the most nutritious, although, as we shall see later, this does not necessarily follow.

The above named grades of flour are generally made from the hard Western wheats. The softer Ontario wheat may also be separated into as many grades, but it is more commonly sold as a "straight" grade flour, or as a long patent, *i. e.*, a straight grade flour from which 5, 10, or 15 per cent. of low-grade has been removed. As shown earlier, the soft winter wheats contain less protein and more starch than the spring varieties; consequently, as gluten is a part of the proteins, the flours will be lower in gluten. They will also be more starchy, and are generally whiter in colour; these flours are usually sold as pastry flours. Although good bread can be made from them, it is not so suitable for commercial breadmaking as the stronger spring wheat flour. It is generally thought that the soft flours make a sweeter and more palatable loaf of bread, but it will not produce so much, nor will it make so large a loaf, as the stronger flour. Many millers in Ontario make a blended flour, in which there is 30 or 40 per cent. of spring wheat and the balance made up of winter wheat. Most of the bakers use large quantities of the soft flour; but, usually, they prefer to do their own blending, because the two flours do not "work" evenly in the breadmaking process.

There are other grades of flour on the market. Among these possibly the Graham is the most important. This flour, if true to name, should be the whole wheat, ground fine, with no bolting process. Therefore, it should be of the same composition as the wheat from which it is prepared. It is to be feared that very often the material sold for Graham flour does not come up to this standard. Entire-wheat flour is not [illegible] to any great extent in this country. In preparing it the outer bra[illegible] are practically peeled off by machinery, and then the remainde[illegible] the wheat is reduced to flour.

Gluten flour is a special brand prepared for people troubled with diabetes, or others who cannot use starchy foods.

Quality in Flour.

The various kinds of flour dealt with in the preceding paragraphs comprise all those in general use throughout this country. They vary very much in strength, due to the circumstances which cause variation in the quality or strength of the wheat, the milling, the grade, and the kind of flour. Unfortunately, our knowledge of the ultimate composition of the constituents of flour, or the various intricate changes that take place in the making of bread, is not complete enough to make it possible for us to determine by chemical analyses the best breadmaking flour. Within certain limits it is an easy matter to tell which flour will make the best bread. For instance, the flour from hard spring wheat is usually granular, or gritty; and, when squeezed in the hand, does not readily pack, leaving the imprint of the fingers, whereas the soft flours do. The hard, or strong, flours absorb more water and give a better yield of bread. They also have more gluten, which gives them greater expansive properties. In general, the hard flours are usually spoken of as the bread flours and the soft flours as the pastry flours. But when we come to distinguish between the different kinds of strong flours, the feel, or appearance, alone is not sufficient to base a correct judgment regarding the merits of the two flours, nor will chemical analyses aid us materially.

The baker likes a flour that will absorb a large amount of water, yield a large loaf of a desirable shape, with good colour and texture. Such a flour is usually spoken of as a strong flour, but if we look deeper and attempt to define "strength" in flour, we find many conflicting views. Jago defines strength as the capacity of a flour for absorbing water, and treats separately the qualities of size, shape, colour, and texture.[1] Humphries' and Biffin's definition of strength is the "capacity for making large well-piled loaves."[2] This definition suggests that the primary factor is the size of the loaf, the other factors being shape and, perhaps, to some extent, texture.

If we try to explain the factors that influence the volume, texture, and shapeliness of a loaf of bread, the conflict of views is even more in evidence. The oldest idea suggested that because of the tenacity of the gluten, the carbon dioxide produced in the dough by the action of yeast was retained, and caused the dough to rise. No doubt a large amount of gluten is frequently associated with large volume and good texture, but there are apparently other factors that influence the result, for there are many cases in which the flour with the highest content of gluten does not give the largest loaf. Attention was called to the fact that some glutens were soft and flabby, while others were firm and tenacious, and attempts were made to ascertain the quality of glutens by determining the relation between the weights of wet and dry glutens.

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[1] Jago, The Science and Art of Breadmaking, London, Simpkin, Marshall & Co., 1895.

[2] Humphries and Biffen, Journ. Agric. Sci., Vol. II., Pt. I., p. 1.

their expansion power under the influence of ..., the proportion of gliadin to glutenin, which together make gluten, etc. But none of these methods have been entirely satisfactory. Recently it has been suggested that it is not the ratio of gliadin and glutenin, but the absolute amount of gliadin which gives strength to a flour. This also has been discredited. Finally, an entirely new theory has been suggested, *i.e.*, that the size of a loaf is not so much dependent upon the quality or quantity of the gluten as upon the amount of s...r con...ned in the flour, together with that formed in the dough by diastatic action, and that shapeliness, and probably gas retention, are dependent on the physical properties of the gluten as modified by the presence of varying proportions of salts.

From what has been said, it is evident that our knowledge, or lack of knowledge, of the chemistry of flour and breadmaking is another instance of the fact that many of the most common materials and everyday operations around us are the least understood. Frankly, we do not know enough about chemistry of flour, or of the changes that the various constituents undergo in the process of breadmaking, to devise any system of chemical analysis that will give conclusive and satisfactory evidence of the strength of flour for breadmaking purposes. Therefore, the only available method of determining the relative value of flour for bread purposes is by actual baking trials.

In all our baking trials nothing but a little sugar, salt and lard, in addition to the yeast and water, was added to the flour. In order to bring out the full expansive power of the flour, a rather large quantity of yeast was used. The conditions were kept as uniform as possible, but each loaf was placed in the oven when it had risen sufficiently and the general appearance indicated that it was ready for baking.

Quality of the Different Kinds of Flour.

It is impossible to bring out here all the differences in quality of the bread of the various kinds of flour. Fig. 1 shows the average size of the loaf of bread made from equal weights of the Western hard spring wheat flour and our soft Ontario winter wheat flour. The former is a good bread flour; it has more and better gluten, greater water absorptive power, greater expansion, and, in every respect but that of flavor, produces a more desirable loaf than the latter. Good bread can be and is being made every day from the soft wheat flour; but, while it may be preferred by some people, it will not make bread that will supply the demand of the bakers' customers so well as the stronger flour.

Fig. 2 shows loaves of bread from several of the grades of flour made from one stream of the Manitoba wheat, while the accompanying table gives the figures showing the percentage of gluten and the water absorption of the flours, the weight and size of the several loaves, and the quality of the bread. Exactly 12 ounces of flour was used in making each loaf. To secure figures showing the comparative quality of the bread, that made from the patent flour was taken as a standard and given 100 points for color, texture and appearance, and the other loaves were marked in percentage of the standard. The quality of the bread from the low grade and red dog was so poor that it could not be compared with that from the patent flour.

Flour	Percent of wet Gluten	Percent of water absorbed	Weight of Loaf *Grams	Size of Loaf Cubic in.	Quality of Loaf		
					Color	Texture	Appearance
Patent	32.16	66.5	522	162.26	100.0	100.0	100.0
Bakers'	34.46	65.6	515	160.43	97.0	99.0	100.0
Straight Grade	34.09	65.9	517	160.43	96.0	99.0	100.0
Low Grade	41.13	72.4	530	145.18			
Red Dog	30.68	78.2	524	145.18			

*28.34 grams in 1 ounce.

The first three loaves are very similar in appearance, but, although the patent flour contained the least gluten, it was able to absorb the most water and gave a slightly heavier and larger loaf of bread that was superior in color and texture to that obtained from the bakers' grade. The straight grade is, as might be expected, a fairly strong flour, but darker in color than the patent or bakers' grades. The low grade flour made a loaf of fair size, but in color and texture it was so poor that no strict comparison could really be made with the higher grades. The water absorption of the low grade flours, especially of the red dog, is very high and the weight of the loaf is correspondingly high. The patent flour made the largest loaf, and the red dog the smallest. The dark, branny flours are always high in absorption, but produce a very small, sodden loaf of bread which does not give much surface for evaporation of water, and is, consequently, very heavy and of poor quality.

It is evident that the first three flours are of good quality for making bread, while the fourth, or low grade, is poor in quality, although it contains fully as much food materials as that from the higher grades. The red dog flour may be used in making dog biscuits, or sold for cattle feed, but is seldom manufactured into bread.

In Fig. 3 we have a photograph of seven loaves of bread from seven different varieties of wheat grown on the Experimental plots of the Ontario Agricultural College. This cut illustrates the wide variation in the quality of the bread the different varieties are capable of producing. The comparison is more fully brought out by a study of the figures given in the following table:

Fig. 1. Bread from straight grade flour made from, 1st, Manitoba wheat; and 2nd, Ontario Winter wheat.

Flour	Per cent of Gluten	Percent of water absorbed	Weight of loaf *grams	Size of loaf Cubic in.	Quality of loaf. Color	Texture	Appearance.
Bulgarian	26.87	47.4	458	128.71	97.0	97.0	100.0
Early Red Clawson	25.87	48.8	464	100.04	97.5	96.0	93.0
Kentucky Giant	27.10	48.8	460	120.78	99.0	102.0	95.0
Early Genesee Giant	26.87	48.8	459	132.37	100.0	100.0	100.0
Geneva	28.40	47.4	462	115.90	98.0	97.5	98.0
Dawson's Golden Chaff	22.50	48.8	473	111.63	90.0	94.0	96.0
Egyptian Amber	27.50	48.8	475	127.49	99.0	7.90	100.0

*28.34 grams in 1 ounce.

Fig. 2. Bread from five grades of flour made from one stream of Manitoba wheat. No. 1, Patent; No. 2, Baker's grade; No. 3, Straight grade; No. 4, Low grade; No. 5, Red dog.

Egyptian Amber gave the best yield of bread, the Early Genesee Giant the largest loaf, and the best quality of bread, while Dawson's Golden Chaff and Early Red Clawson gave the smallest loaves and the poorest quality of bread. In Fig. 4 the cut loaves of Nos. 2 to 6, inclusive are shown. Note the coarse, open texture of Dawson's Golden Chaff and the Early Red Clawson, and the nicely rounded shape of the loaves from Early Genesee Giant and Geneva.

Fig. 3. Bread from seven Winter wheats grown on Experimental plots, Ontario Agricultural College.
No. 1, Bulgarian; No. 2, Early Red Clawson; No. 3, Kentucky Giant; No. 4, Early Genesee Giant; No. 5, Geneva; No. 6, Dawson's Golden Chaff; No. 7, Egyptian Amber.

Previous mention was made of the fact that some localities produced a better quality of wheat than others. Fig. 5 shows the difference in size of two loaves of bread made from Ontario winter wheat grown in two different localities. The larger loaf was also much superior in color, texture and general appearance. It is evident that the millers in the locality in which the stronger wheat is grown, or those who buy from this district, have an advantage over the unfortunate ones who have to use the weaker wheat.

Fig. 4. Cut-surface of loaves shown in Fig. 3.
No. 1, Early Red Clawson; No. 2, Kentucky Giant; No. 3, Early Genesee Giant; No. 4, Geneva; No. 5, Dawson's Golden Chaff.

Again, as shown in Figs. 3 and 4, the general quality of the wheat in any section will vary as the predominating varieties are of the stronger or weaker sorts. The miller grinds a mixture of varieties, usually striving to use enough of the stronger varieties with the weaker sorts to keep up a good quality of flour; but, unless he is catering to some special trade, he does not pay so much attention to uniformity of grade as when the stronger and usually more expensive flours are being made. In the case of the Western wheats, the same difference exist between varieties, localities in which it is grown, and the condition of the soil producing it, etc.; but most of this wheat is graded and passes through the elevators where all the wheat of the same grade is mixed together; consequently, unless the miller can buy from desired districts and ship by car directly to his own mill, he cannot control the selection of the wheat very much.

Fig. 5. Bread from Ontario Winter wheat grown in different localities.

Blended Flour.

This mixing of varieties of wheat from different localities is blending to secure certain results; but, what is commonly known as blended flour is made by grinding some of the soft Ontario wheats with the harder wheats from the West.

The object of blending flours is partly for economy, as the soft wheat is usually cheaper than the hard, and partially to secure the flavour of the one and the expansion and texture of the other. They are usually spoken of as "general purpose" flours, or as "household" flours.

In Fig. 6 we have an illustration of the effect of blending different proportions of the hard with the soft. Loaf No. 1 is made from an 85 per cent. Manitoba flour, and No. 7 is made from an 85 per cent. soft flour. No. 6 contains 20 per cent. of the Manitoba flour and 80 per cent. of the Ontario flour. No. 5 contains 30 per cent. of the Manitoba and 70 per cent. of the Ontario flour, and Nos. 4, 3 and 2 contain 40, 50 and 60 per cent., respectively, of the strong flour. Note the increase in size with the increased proportion of the stronger flour.

Fig. 6. Loaves of bread made from Manitoba and Ontario flours blended in following proportions:

No. 1	100% of Manitoba	and 40% Ontario soft flour.
No. 2	60% " "	" 50% " " "
No. 3	50% " "	" 60% " " "
No. 4	40% " "	" 70% " " "
No. 5	30% " "	" 80% " " "
No. 6	20% " "	" 100% " " "
No. 7		

The following table gives figures showing the change in yield of bread, the size and quality of the loaf of bread produced in each case. Twelve ounces of flour was used in making each loaf.

Flour	Percent of gluten	Percent of water absorbed	Weight of loaf *grams	Size of loaf Cubic in.	Quality of loaf.		
					Color	Texture	Appearance
No. 1	34.09	68.8	523	167.0	100.0	100.0	100.0
No. 2	32.31	66.2	507	162.9	99.0	99.0	98.5
No. 3	31.86	64.6	495	146.4	98.0	98.5	96.0
No. 4	31.41	62.5	496	145.8	97.0	98.0	95.0
No. 5	28.97	61.4	489	125.7	96.0	96.0	92.0
No. 6	30.52	60.9	490	115.9	95.0	95.0	90.0
No. 7	29.63	52.2	477	111.6	94.0	94.0	87.0

*28.34 grams in 1 ounce.

A common blend used by the millers is 40 per cent. of the strong flour and 60 per cent. of the weaker Ontario flour. It will be seen that while the bread from this blend is not equal to that from the all strong flour, it is a good loaf in every respect.

Bleaching.

Every experienced baker knows that newly made flour does not give so satisfactory results in breadmaking as flour that has been aged by storing in a suitable place for two or three months. Why this should be so is not definitely known. There is probably a slight drying out of the flour which would naturally increase its water absorptive capacity. The expansive power is also increased and the flour is improved in colour. Bleaching the flour by chemical means appears to have a somewhat similar effect as that brought about by ageing; but, while a freshly milled bleached flour is better for breadmaking than the fresh unbleached article, the artificial bleaching will never make a flour equal in quality to that obtained under the ordinary conditions of ageing.

The results of bleaching are most plainly seen in the change of colour; the flour becomes whiter or bleached in appearance, but it has not the same desirable creamy shade that is obtained by natural ageing. However, because of the general preference for the whitest bread, a freshly made bleached flour will usually sell for more money than the same flour unbleached. As a general rule, only the better grades of flour are bleached. The cost of treatment is small and the action, while not instantaneous, is rapid.

BREADMAKING.

The object of the miller is to make all the flour that is possible from the wheat at his disposal and to separate this into the grades demanded by his customers. The baker's part is to make from the flour the maximum amount of bread of a good quality. To do this intelligently, he should not only be familiar with the methods of manipulation, but he should also understand the nature of the materials he is working with, and, so far as is possible, the chemical and physical changes brought about during the process.

We have dealt with flour and it now remains for us to discuss some of the more important leavening materials and the changes which these and other agencies cause in the dough.

Leavening Materials

Yeast.

Yeasts are the natural agents which cause the fermentation of bread dough, familiar to every housewife as "raising." This fermentation of bread has been known almost as long as we have any recorded history, for early Bible writers tell of leavened and unleavened bread, the former being raised with leaven (which we now know was yeast), and the latter being baked without previous raising. Although this phenomenon of the fermentation of bread was thus known from very early times, its real cause was not definitely proven until the last century, when between the years 1830 and 1860 German and French scientists showed that different fermentations were caused by living organisms, and among these was the yeast organism, or, as it is commonly called, the yeast plant. Yeasts are also active in a number of other fermentations, viz., the brewing of beers, ales and wines, either commercial or home-made, the making of vinegar, the "spoiling" of canned fruit, and production of gassy curd in cheesemaking, etc.

Yeast plants are always microscopic, no species being large enough to be seen with the naked eye. The individual yeast plants average only 1-3000 of an inch in diameter, hence to see them at all requires a very powerful microscope. Yeast as seen with the naked eye, in a yeast cake or otherwise, is made up of a mass of millions of individual yeast cells or plants. If a bit of yeast is mixed with water, and examined under a high-power lens, there will be seen great numbers of cells such as shown in Fig. 7, some nearly spherical, some oval, and some even quite elongated. They are colourless as seen under the microscope, although in masses they appear of a creamy white colour. The outline or cell wall is regularly and sharply defined. The contents of the cell usually shows one and sometimes two or more rounded clear spots, called vacuoles, and a number of small fat drops besides the slightly granular protoplasm which makes up the remainder of the cell contents.

When a bit of yeast is placed in a solution which contains the proper food, the yeast cells immediately begin to consume the food and grow and multiply by the method known as budding. Upon the side of the cell appears a small swelling or bud. This little bud increases in size until finally it becomes as large as the original cell, when it in turn may begin to bud. This budding continues until there are produced large irregular shaped groups. (Fig. 7.) Later these groups may be broken up and the cells go into a sort of resting stage, each cell remaining by itself. Each of these single cells is capable of growth and multiplication by budding as soon as it is placed in any material that furnishes the proper food for its development. Hence yeasts may be likened to other plants the seeds of which require, among other things, a favourable soil in which to germinate and reproduce the plant.

The most favourable food for the common species of yeasts is sugar, and they will not grow rapidly unless sugar is present in considerable amounts. Bread dough ferments because it contains some sugar. Flour itself contains a large percentage of starch, part of which is changed to sugar, which is then fermented by the yeast present, with the result that there are formed two main products, alcohol and carbonic acid gas. It is the latter product that makes the sponge "raise." When the dough is baked, the alcohol is evaporated by the heat and the gas is expanded, making the loaf still larger and "lighter." Other chemical products

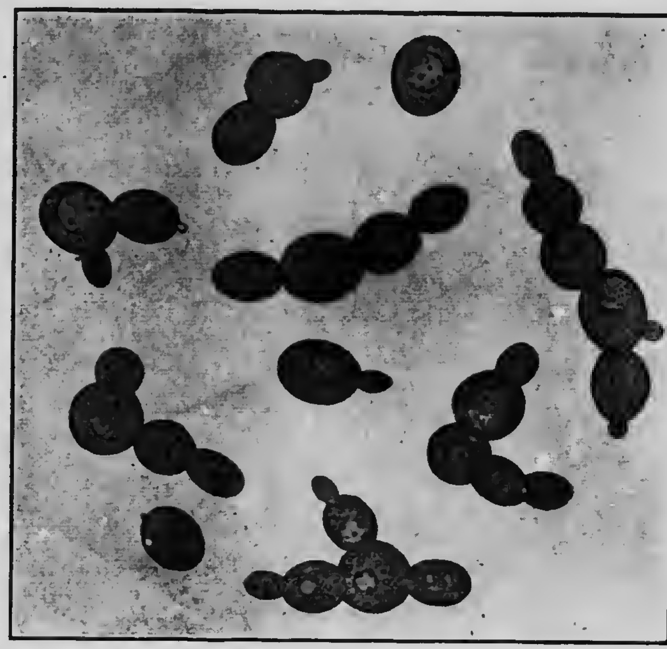

Fig. 7. Yeast cells. Highly magnified. (Sedgwick and Wilson.)

than alcohol and carbonic acid gas are formed in small amounts during the fermentation, and these have some influence in determining the flavour of the bread.

It has been shown that suitable food is essential for favourable growth of yeast. Another essential for the most rapid growth is a favourable temperature, and this factor is one of extreme importance in successful breadmaking. The best temperature for different species of yeasts varies with the species, but the average is about 80° F., or a little below blood heat. At low temperature the growth of the yeast is checked, and, consequently, fermentation does not proceed so rapidly. Cold temperatures do not kill the yeast, and when a favourable temperature is again furnished, growth proceeds as before. At temperatures above 100° F., or body heat, the vitality of the yeast is weakened proportionately as the temperature increases, until at the boiling point it is entirely destroyed.

Although yeast is not killed or injured by low temperatures, yet, there is a disadvantage in allowing the temperature to get too low in preparing the sponge for bread. Flour frequently contains other organisms than yeasts (bacteria and molds), some of which are able to grow rapidly in the dough at temperatures lower than the optimum for yeasts, and form products which impart an undesirable flavour to the bread. Even the commercial yeasts may contain such undesirable organisms.

The two types of trouble most commonly met with are sour bread and slimy bread.

Dough may sometimes appear to rise well, but after the bread is baked it is found to have an unpleasant sour taste. This is due to the development in the dough before baking of acids produced in the growth of bacteria which were present in the flour, in old, or impure yeast, or in unclean utensils used in the process.

In the case of slimy bread, the sliminess is not usually apparent when the bread is freshly baked, but appears in a few hours, caused by the growth of bacteria that were not killed in the baking process. These slime-producing bacteria may arise from the same sources as the acid-producing bacteria. The remedy in either case is to use clean high-grade flour, fresh, pure yeast, and to see that all utensils are scrupulously clean. In addition to these precautions, it should be remembered that correct temperature is most essential for the normal development of yeast.

Other Methods of Leavening Bread.

Many attempts have been made to prepare materials that will replace yeast in breadmaking. It is evident that if a compound or mixture of compounds could be prepared that would give off carbon dioxide regularly, it might take the place of yeast as a leavening material. But nothing has been devised that has proved a success. Baking powders act well for biscuits and such work, but they have not given good results in the large mass of dough prepared in breadmaking. The "self rising" flour sometimes advertised is really flour mixed with materials of this nature. The chief objection to the use of any of these yeast substitutes is that they may be inefficient or harmful; that they are easily adulterated, and that the bread made from them is lacking in the flavour and aroma good yeast fermentation produces.

In some places "ærated bread" is made. The details of the process are kept more or less secret, but the dough is made to "rise" by means of carbon dioxide injected into the dough in various ways. Sometimes a little fermented barley infusion from a brewery is put into the water used in making the dough. This appears to render the gluten more elastic and imparts some of the same flavor resulting from yeast fermentation.

The leavening of "salt rising" bread is dependent upon ferments originally present or acquired from the air. A common method of making it is to prepare a slack batter of milk and flour and allow it to stand at a temperature of about 100° F., until the ferments permeate the whole mass, or until it becomes sour. This is then mixed with a sponge prepared with hot water and flour, to which a little salt has been added. After thoroughly kneading the batter and the sponge together, it is put away in a warm place and the leavening action started in the batter spreads through the whole mass and produces a light, porous loaf of bread. It is an illustration of a self-raised bread, but as it is dependent upon the natural ferment content of the flour and the ferments that may get into it from the air, the method is uncertain.

Some Chemical Changes that Take Place in the Process of Making Bread.

The object of making bread is to convert flour into a form in which it is convenient for use, palatable, nutritious and easily digested. This is accomplished by somewhat separating the particles of flour through the agency of yeast, by moulding the dough into shapes that are convenient to handle, and by baking it when in the raised condition so that the porous structure may be maintained, in order that when eaten the digestive juices of the body may readily penetrate the mass. Every step in the process of making bread produces changes in the composition of the raw materials, and the baker's success depends upon his ability to control these changes. Some of the more important changes are: (1) the change of insoluble carbohydrates into soluble forms; (2) the fermentation of sugars and the production of carbon dioxide and alcohol; (3) the formation of acids; (4) a change in the solubility of the proteid compounds; and (5) the volatilization or oxidation of some of the fat. These and many other changes take place, and, as some of the products are gases, a loss of materials must result.

The insoluble carbohydrates of flour are composed of starch and small quantities of other substances with which we are less familiar. The soluble forms, which do not exceed .3 to .5 per cent. of the flour, are made up of sugar and dextrin. The amount of the germ left in the flour influences the percentage of these soluble substances.

When the flour is made into a dough, diastase, a ferment native to the wheat, probably changes some starch into dextrins and sugars; the acids formed during the fermentation process and the heat of the oven will also account for the formation of some of these soluble compounds. According to Snyder, not more than 6 or 8 per cent. of the insoluble carbohydrates originally present in the flour are changed in this way, (1). But in addition to these chemical changes, the combined actions involved in the breadmaking process change the physical appearance of the starch cells. Some of them are partially disintegrated, while others are ruptured, thus rendering them more susceptible to the action of the digestive juices.

During the process of fermentation, the yeast changes some of the sugar of the dough into carbon dioxide and alcohol. The free escape of the carbon dioxide gas is prevented by the tenacity of the gluten, and thus it causes the dough to rise. The volatilization of the alcohol by the heat of the oven probably aids in the expansion of the dough; but. apparently most of the alcohol is changed to other compounds, as very little of it can be recovered from the oven and none of it is left in the bread.

Along with the alcohol fermentation, there is also some acid fermentation taking place. The extent of this action probably depends on the purity of the yeast, the temperature of the dough, and the length of time the fermentation is allowed to proceed. The result, of course, of too much acid fermentation is the production of sour bread. The acid, however, does not all remain in the free state, for some of it combines with the insoluble proteids, producing soluble forms. If this action proceeds far enough it may materially alter the size of the loaf by destroying the gluten, and it darkens the colour of the bread. It has been frequently noticed that some flours require a longer period of fermentation than others. Snyder states that probably this is due to the fact that gliadin, the gluey part of the gluten, is more readily acted upon by the acid than the glutenin, and that in these flours the prolonged fermentation causes the acid to dissolve more of the gliadin and thus bring these two constituents into the proper relationship to give the best results.

The influence of breadmaking on the fat has not been fully studied, but it appears to be changed in some way, for not more than about one-half of the fat in the flour can be extracted from the bread made from it. Evidently there has been some change affecting the composition of the fat which has changed its solubility.

The total loss of material in making bread by other than mechanical means has been stated by different investigators to vary from 1.5 to 6 per cent. The loss is made up principally of the volatile products of carbon and nitrogen. One investigator states that "in good breadmaking the losses are equivalent to about 3 pounds per barrel of flour, while with poor breadmaking the losses may exceed 12 pounds per barrel."

Influence of Temperature.

In the yeast discussion, page 15, it was pointed out that one of the most important essentials for the rapid growth of yeast germs was a

(1) Bulletin No. 67, Office of Experiment Station, Dept. of Agriculture, Washington, D.C.

favourable temperature, and the temperature recommended was 80° F. This means that to secure the best results the dough should be kept at about this temperature during the time the yeast is working. A low temperature—about 70° F.—will suffice when the long fermentation process is allowed, *i. e.*, when the dough is allowed to rise over night. The difficulty in many households is to properly control the temperature. Frequently the dough is made without any definite determination of the temperature of the materials, and it is placed to "rise" where it is *hoped* the conditions will be satisfactory. The commercial baker does not take any such risks. He determines the temperature of the flour and then makes the water warm enough to raise the whole dough mass to the desired point, and then seeks to control the temperature during the fermentation period. He recognizes that temperature is one of the factors he must control in order that he may get uniform results.

Some years ago butter was made without the use of a thermometer; but, butter makers in the home and factory have long since recognized that they cannot depend upon "feel" to get the correct conditions. There is the same need of the thermometer in breadmaking, and when the breadmaker brings the dough to at least approximately the right temperature to start with, and places the dough to rise where the temperature can be controlled, a great advance will be made in the making of bread in the home. The difficulty has always been that the home breadmaker has no means of controlling the temperature, and has been forced to cover the dough and allow it to stand over or beside a radiator, register, or stove, and trust to luck that the temperature required would be maintained. It may become too hot or too cold, but it would not be known, unless the baker has sufficient experience to tell from the appearance and feel of the dough, and "luck" is blamed for the failure.

Dough will recover from a very severe chilling if it is brought back to the proper temperature and is allowed to stand long enough to rise properly. Chilling does not destroy the yeast germs, but it retards their development, and time must be given them to do their work. An experienced baker has an advantage over an inexperienced one in knowing when the dough has risen sufficiently. Too high temperature may destroy the germs altogether and thus prevent the dough rising.

A simple cabinet for controlling temperature during the dough stage has been devised by the Household Economics Department of this College. The cabinet is illustrated in Fig. 8. It is 2 feet 8 inches high, by 2 feet 2 inches broad, by 2 feet deep, outside measurements. The whole is lined with asbestos, and divided into upper and lower compartments. The partition is placed high enough to allow a small coal oil lamp to be placed in the bottom compartment. The lamp is used as the source of heat, and the heat is transmitted through water contained in a shallow covered galvanized iron pan placed in the centre of the partition. The fumes from the lamp are allowed to escape through small holes in the wooden frame below the partition. The top compartment may be used with or without slatted shelves and may be kept at any desired temperature by raising or lowering the flame of the lamp, thus influencing the temperature of the water, and consequently, that of the compartment. A very small lamp with the wick turned as low as possible is usually sufficient to maintain the temperature at from 70° to 80° F. It is hardly necessary to say that the thermometer should be left in the cabinet and the temperature noted from time to time, and the flame of the lamp so regulated as to give a constant desired temperature.

Fig. 8. Cabinet for controlling temperature in bread-making, showing shallow watertank standing at one side.

The cabinet may be made any desired size, and may be so arranged that the top will answer as a kneading board, and pans and other utensils may be kept in it between baking days.

Fig. 9 shows a simple form of cabinet made out of a packing box. The inside is lined with builder's asbestos paper and arranged very much as the one shown in Fig. 8.

By the use of such a cabinet it is possible to maintain the dough throughout the fermentation period at any desired temperature, and thus render it possible to control one of the main sources of worry and uncertainty in breadmaking.

The asbestos is used to reduce the danger of the case taking fire if anything happened to the lamp, and also to check any draft through the cracks of the box. If the box is tight, and the danger from the lamp overlooked, there would be no necessity for lining the box.

METHODS OF MAKING BREAD.

There are various methods of making bread in the home. A few of the methods and their uses are discussed below.

Fig. 9. Cabinet for controlling temperature in bread-making made out of packing-box.

1. *The ferment, sponge and dough method* is one of the most common methods in use, consisting of a ferment, sponge and dough stage. (*a*) *Ferment*: A thin batter made up of potato or plain water, a little sugar, and enough flour to make a pour batter, placed in a temperature of from 70 to 80° F., until it is light and spongy. This method is best suited to the use of dry compressed yeast, which is in a dry, dormant state, and needs the food, moisture, and warmth to bring it

into a healthy, vigorous ferment. (*b*) *Sponge*: At the stage the sugar, salt, shortening and sufficient liquid to make the desired amount of bread is added to the ferment, and flour added to make a thick batter, and this sponge is allowed to rise from 8 to 10 hours. (*c*) *Dough*. The dough is then made by the addition of all the flour needed to make the mass of the desired consistency.

2. *Sponge and dough,* probably the most widely used in the home, and the best adapted to the uses of the soft and hard flours. Sponge may be made with hard Manitoba flour and fermented from 6 to 10 hours. The hard flours take a much longer time to ripen, hence the reason for giving them the longer time in the sponge. Potato water and a little mashed potato improves this sponge. This is a desirable method where the home-made yeast is used, or the moist compressed yeast. The dough is made from this sponge with either hard or soft flour, either giving good results when properly used. The soft flour gives a loaf of very close texture, but a characteristic sweet flavour that is very much liked by some people, and can only be obtained where Ontario winter wheat flour is used.

3. *Offhand dough* is that method in which the dough is made direct without any preceding stages of ferment and sponge, and it is the best method to use when it is desirable to make bread in a short time. Because of the short fermentation period, it is necessary to use a much larger amount of yeast in proportion to the amount of liquid, and flavour must to some extent be sacrificed, but, if rightly manipulated, this method makes very nice bread and one in which a good grade of soft flour may be used. It is also a good method to follow in winter when there is no means of controlling temperature. The following recipes, typical of each process, are used in our flour testing laboratories with satisfactory results.

The beginner is advised to start with the first method and become thoroughly familiar with its successful use before proceeding to the others. She is also urged to use a thermometer in order to become sensitive to correct temperature as soon as possible. After these typical recipes are mastered the beginner should be able to follow the variations of any good cook book.

The following are the detailed directions for making bread by each of the above methods. When the recipe does not provide sufficient materials to make the desired quantity of bread, the amount of the various ingredients may be halved, doubled or changed in any way provided their relative proportion remains the same.

I. Ferment, Sponge and Dough Method.

1 dry yeast cake.
2 quarts liquid.
2 level tablespoons salt.
2 level tablespoons sugar.
2 level tablespoons lard.
Flour.

Preparation of Ferment. Put a pint of water at a temperature of about 90° F. into a bowl, drop the dry yeast cake into it and soak for half an hour, then stir in enough flour to make a thin batter, add one tablespoon sugar, and beat with a dover beater until well mixed and full of bubbles. Stand in a temperature of 70° to 80° F. until light, which will take from four to five hours.

Preparation of Sponge. When the ferment is ready, put the rest of the sugar, salt and lard into a kneading-pan, bring the rest of the liquid to 90° F. and add it to the ingredients in the pan. Add enough strong flour to make a batter that will beat without spattering; add the ferment and beat until it looks smooth and elastic. This will probably take 15 or 20 minutes. Cover closely, and keep at a temperature of 70° F., until light and spongy. This will take from 9 to 10 hours.

Preparation of Dough. When the sponge is ready stir in strong flour until too stiff to use the spoon, then mix in more with a stiff-bladed knife, or the hand, until the dough no longer sticks to the fingers. Turn the dough out on the moulding-board to knead, leaving the pan quite clean. The dough should knead without flour being put on the board or hands; if it proves sticky return it to the pan and mix in more flour, remembering that while too slack a dough makes coarse textured bread, too stiff a dough makes slow-rising bread which will dry out quickly. Knead lightly until the mass is elastic and velvety, the surface covered with a film of tiny bubbles, and a cut with a sharp knife shows the inside full of fine even bubbles and free from lumps or unmixed portions. Grease the kneading-pan lightly with lard, warm both pan and cover if they are cold, put in the dough, cover closely, and keep at a temperature of 80° F. until rather more than doubled in volume, or until a gentle slap with the tips of the fingers causes it to fall in. This will take from 2 to 3 hours.

Knead lightly in the pan for a minute to get rid of the larger bubbles and return to rise a second time until double in volume. This will take from 1 to 2 hours.

Divide into loaves that will half fill the bread tins. Knead each piece only enough to get rid of large bubbles and smooth the surface, and put it into a greased tin. Keep at a temperature of 70° to 80° F. until doubled in volume, when they should have a bold, nicely rounded appearance.

Bake an hour in an oven about 350° F. When done, the loaves should give a hollow sound when tapped on the bottom.

When baked remove at once from the pan, and stand on edge or across the top of the pans, that the air may get to all parts and cool it quickly.

Variations.

1. The above calls for strong flour. Soft flour may be used for the dough stage, but must be kneaded down before it has quite doubled

in volume each time. It is not advisable to use soft flour for the ferment and sponge stages, as it does not stand the long fermentation.

2. Home-made yeast may be used instead of the dry yeast. Use one cup home-made yeast and only 3½ pints of liquid.

3. The liquid may be part milk (scalded) and part water. The latter may be potato water; *i.e*, water in which two or three potatoes have been boiled, removed and finely mashed and returned to the liquid.

4. The potato water may form the liquid for the ferment stage, and the mashed potatoes added when the sponge is made. Potatoes give that silkyness of texture so much desired by good breadmakers.

5. If the dough is kept covered while rising it will not form a crust. If it seems inclined to form a crust, moisten it with warm milk and water. A crust is to be avoided as it makes a streak through the loaf if kneaded in at the early stage, and an unsightly crust on the baked loaf if allowed to form in the last stages.

6. The second rising of the dough may be omitted, although the extra rising makes the loaf a rather finer texture.

7. The bread-mixer may be used to knead the dough after it is known exactly how much flour the liquid will need to make dough of the right stiffness.

II. Sponge and Dough Method.

1 cake compressed yeast.
2 quarts liquid at 90° F.
2 level tablespoons salt.
2 level tablespoons sugar.
2 level tablespoons lard or butter.
Flour.

Mix the yeast and half of the sugar in 1-4 cup of warm water, and let it stand at a temperature of 80° F. for 15 or 20 minutes to start fermentation.

Measure the shortening, salt, and rest of sugar, into kneading-pan, stir in the rest of the liquid, and mix in flour enough to beat without spattering. Then add the well-fermented yeast and beat with a wooden spoon until it looks smooth and elastic.

From this point treat just the same as in the ferment, sponge and dough method.

Variations.

1. The above calls for strong flour. Soft flour may be used for the dough stage, but must then be kneaded down before it has quite doubled in volume each time.

2. The second rising of the dough may be omitted, but the extra rising makes a loaf of rather finer texture. When a large batch is being

made, this may be taken advantage of to delay the baking of part until the first part is out of the oven.

3. The liquid may be all water, part water and part milk, or part potato-water and part milk.

4. Home-made yeast may replace the compressed yeast. Use one cup home-made yeast and only 3½ pints liquid.

5. If the flour is taken from a cold place in the winter, it should be brought to a temperature of 80° F. before mixing it into either sponge or dough. When one has learned by experience what quantity of flour the liquid will take up, it is a good plan to measure the whole quantity into a kneading-pan, mix the sponge in another dish, make a well in the rest of the flour in the kneading-pan, pour in the sponge and stand the whole in a warm place to rise; then when the sponge is risen the rest of the flour can be kneaded in.

III. Quick Method.

½ cup milk.
¾ cup water.
1 cake compressed yeast.
1 teaspoon salt.
1 teaspoon sugar.
1 teaspoon lard or butter.
Flour.

Put the sugar and yeast into a cup, add 1-4 cup of the water warmed to 90° F., mix until the whole is smooth and the sugar dissolved, and stand in a temperature of 80° F. for 15 or 20 minutes to begin fermenting. Put the milk on to scald. Measure the salt and shortening into the kneading-pan, pour in the scalded milk, add the rest of the water and bring the temperature to about 90° F. Add strong flour enough at the same temperature to make a batter that will beat without spattering; add the yeast, now fermenting vigorously, and beat with a wooden spoon until it looks smooth and elastic. Mix in at once enough warm flour to make a dough that will not stick to the fingers, turn out on the moulding board and knead as usual. Return to the warm greased kneading-pan, cover closely and stand in a temperature of 70° to 80° F. until risen to rather more than double in volume. This will take 2 to 3 hours.

Knead lightly in the pan for a minute to get rid of the larger bubbles, and stand back in the warm place to rise again until double in volume. This will take 1 to 2 hours.

Shape into loaves that will half fill the bread tins, kneading only to get rid of large bubbles, and smooth the surface. Let rise until doubled in volume, then bake and cool as usual.

Variations:

1. Soft flours may be used for the whole process in this method, but care must be taken to knead it down at the proper time. It should be allowed to rise the first time to a little less than double in volume, and succeeding times still a little less. Once over-risen, soft flour dough is very hard to make into a good bread.

2. This process may be used for setting over night, using 1 cake of yeast to six times the quantity of all the other ingredients, and allowing it to rise 9 to 10 hours the first time. The longer time will develop a delicious flavour which can never be attained by the short process.

3. Home-made yeast may be used omitting the water. Bring the yeast to 80° F., add the sugar, and allow it to stand 10 to 20 minutes to begin working before adding it to the sponge.

Home-Made Yeast.

4 medium sized potatoes.
½ cup hops.
1 quart boiling water.
½ cup sugar.
1 cup flour.
2 level tablespoons salt.
1 compressed yeast cake.

Boil the potatoes, drain away the water, and mash the potatoes until free from lumps. Pour the boiling water, which may contain the water drained from the potatoes, over the hops and simmer 15 minutes. Measure into a three-quart bowl, or crock, the flour, sugar and salt, and mix them thoroughly. Strain the hop water, and add at once to the crock, stirring rapidly all the time. Add the mashed potatoes and give the whole a thorough beating. Cool to 70° or 80° F., and add one compressed yeast cake or one dry yeast cake soaked in ½ cup of warm water for half an hour. Keep at a temperature of 70° F. for 3 or 4 hours, stirring down as often as it comes to the top. Bottle and keep in a cool place. Do not cork it tightly at first.

One cup of yeast is equal to one compressed or one dry yeast cake.

Rolls.

1½ cup milk.
½ cup water.
1 cake compressed yeast.
2 level teaspoons salt.
2 level tablespoons sugar.
2 level tablespoons butter.
1 level tablespoon lard.
Flour.

Put the yeast cake and one tablespoonful of the sugar in a cup, add 1-4 cup of the water warmed to 90° F., mix until smooth and the sugar is dissolved, and stand in a temperature of 80° F. for 20 minutes. Put the milk on to scald. Measure the butter, lard, salt, and the rest of the sugar into a kneading-pan, pour in the scalding milk, add the remaining 1-4 cup of cold water, and allow it to come to 90° F.

Add enough flour to make a batter that will not spatter when beaten, stir in the fermenting yeast, and beat until it looks smooth and elastic.

Mix in enough more flour to make a dough that will not stick to the hands. Turn out on the board and knead until smooth, velvety and even textured. Return to the warm, greased bread-tin, cover closely, and keep at 80° F. until nearly tripled in volume.

Knead down in the pan, and let rise again at 80° F. until double in volume.

Shape into small rolls, remembering that they will increase greatly in size, put them into greased pans, and stand in a temperature of 80° F. until doubled in volume. Take care that the surface does not dry. If it is not possible to keep them covered closely, it will be necessary to moisten the top occasionally with warm milk or water.

Bake in a little hotter oven than used for bread for from 20 to 35 minutes, depending on the size of the rolls and the heat of the oven. The oven must not be too hot at first or it will prevent the expansion of the rolls, and may result in doughy centres.

Cool quickly by exposing as much surface as possible to the air.

Summary.

The essentials of successful home breadmaking are:

1. Good bread flour.
2. Good yeast.
3. Dough of the right consistency.
4. Control of the temperature at all stages.
5. To remember that soft flour has not the expansive power of strong flour, and that soft flour doughs must never be allowed to rise longer than necessary. If it rises to the point of falling back, results will not be good.
6. To avoid drying out of the surface at all stages, as this makes a dark streak through the baked loaf.

Macdonald Institute Recipe for Baking Powder Biscuits.

4 level cups flour.
1 level teaspoon salt.
2 level tablespoons shortening.
2½ level tablespoons baking powder.
About 1½ cups milk.

The shortening may be sweet lard, or dripping, or butter, or a mixture.

See that the shortening is soft enough to rub easily. Place the board, mixing knife, rolling pin, cutter, and pan ready, and see that the oven is hot.

Sift the salt and flour into a bowl; rub the shortening into it with the fingers; sift in the baking powder, and mix well. Mix into a soft dough with the milk, using a broad-bladed, flexible knife, in order to cut and mix it quickly. Flour the board lightly, turn the dough out, and roll it round to coat it with flour. Knead just enough to make the dough smooth, roll out about an inch thick, and cut into small biscuits.

Place them in the pan, wet the tops only with milk or water, and bake in a hot oven about 20 minutes.

The secret of success is a slack dough, quick mixing, and little handling.

Strong vs. Weak Flour for Baking Powder Biscuits.

It is the opinion of some bakers that the strong spring wheat flours are better for making baking powder biscuits than the softer and weaker flour from the winter wheats. The opposite view is just as strongly held by others. To secure definite data on this point some experimental work was done in the Macdonald Institute with six different kinds of flour, including both strong and soft flours and also blended flour. We quote from the report of the work given in the Ontario Agricultural Report for 1908:

"The flours used were obtained from the manufacturers for other purposes, but were regular brands, which might have been bought in the open maket, and were chosen as likely to yield decisive information. They were:

"A. Strong—A high patent flour, made wholly of Manitoba wheat.

"B. Strong—A high patent flour, made wholly of Manitoba wheat.

"C. Soft—A nearly straight grade flour, made wholly of Ontario wheat.

"D. Blend—A combination of 20 per cent. B strong and 80 per cent. C soft.

"E. Soft—An 85 per cent. soft wheat flour, made wholly from Ontario wheat.

"F. Soft—A 35 per cent. soft wheat flour, made wholly from Ontario wheat.

"The Macdonald Institute recipe for milk biscuits was taken as the starting point, and a series of experiments carried out to determine various points before making the final test. In every baking each ingredient was carefully weighed, the biscuits compared with others, and results recorded to guide the procedure of the next experiment. When rolling out the dough before cutting the biscuits flat sticks of equal thickness were laid on either side for the rolling-pin to travel on, so that the biscuits of all bakings were as nearly alike in thickness before baking as was possible with dough of such slackness. Only the biscuits cut from the first rolling were baked, so that no biscuits were made from dough that had been worked over."

Experimental bakings were made to determine what proportion of fat, baking powder, and what oven temperature would yield the best results. Experimental bakings were also made to determine the proportion of milk needed for each flour, in order to have each dough of the same slackness, the effect of doughs of different slackness, etc. Finally, making use of the experience gained with each flour, a concluding baking was made.

"The ingredients for each batch (except the milk) were weighed and kept carefully separate before any mixing was done. The mixing and baking were done as rapidly as possible. Nine biscuits of each flour were baked; when sufficiently cooled the best six of each were numbered and placed in a covered wooden box to prevent drying out before they were judged. The following table gives the weight of each ingredient used in making the biscuits and the weights recovered after baking.

Baking No.	Flour	Weight in grams of					Biscuits		Oven Temp. Fah.	Per cent loss in baking
		Flour	Butter	Bak. Pow.	Milk	Dough	Raw	Baked		
24.	A. Strong	300	24	16	252	592	308	257	450°	16
25.	B. "	300	24	16	248	583	307	257	450°	16
26.	C. Soft	300	24	16	212	552	323	260	450°	19
27.	D. Blend	300	24	16	221	561	306	259	430°	15
28.	E. 85% Soft	300	24	16	222	562	302	257	450°	14
29.	F. 35% "	300	24	16	218	558	295	247	450°	16

"When baked, these biscuits were much alike in general appearance, owing to the care taken in proportioning ingredients, maintaining oven temperature, and in manipulation; but the experimenter judged the first two about equal; C soft, rather better; 85 per cent. decidedly best, with 35 per cent. a close second.

"The Dominion Millers' district meeting was held in Guelph, December 12, 1907. One session was held in the O. A. C. Chemical Building, about twelve hours after the biscuits were finished. All the numbered biscuits were carried over, the meeting informed of the uniformity of manipulation, quantities of flour, fat, and baking powder, but not told the names of the flour or quantities of milk used, and the meeting asked to judge which were best. A committee of three was appointed, which reported Nos. 28 and 29 as best, but declined to rank one above the other. The committee stated that there was so little difference between the other lots that judgment between them was very difficult.

"*Conclusion.*—Soft wheat flours yield the tenderest biscuits when conditions are uniform.

"*Remarks.*—When strong and weak flours are made slack enough for biscuits, and both [illegible] the same slackness, the difference in 'handling' quality is [illegible] noticeable. The strong flour dough has a stickiness like glue, while the soft flour has a silky smoothness, which is much easier to handle.

"*Summary.*—1. Other things being equal, soft wheat flours make more tender milk biscuits than strong wheat flour.

"2. Given a strong wheat flour dough and a soft wheat flour dough of equal slackness and suitable for milk biscuits, the soft wheat flour dough is the easier to handle.

"3. At the present prices of the different flours the strong wheat flour biscuits cost more than soft wheat flour biscuits.

"4. It is possible that a larger proportion of fat used with the strong wheat flour would yield biscuits of tenderness equal to those of soft wheat flour, but the cost of fat makes that method of improvement a disadvantage."

PASTRY.

The soft flours are generally used for making pastry, and are, consequently, called pastry flour. It does not follow, however, that good pastry cannot be made from the stronger flours. In fact, experiments made in Macdonald Institute have clearly shown that it is possible; but more shortening must be used to get results obtainable from the softer winter wheat flour. The greater gluten content, expansive powers, and good colour of the stronger flours are not necessary requisites for pastry purposes; and, consequently, it would not appear to be good practice to purchase these more expensive flours and then use larger quantities of shortening in order to obtain the same results that may be secured by the use of the cheaper flours and less shortening. Practically the matter resolves itself into one of cost.

Short Pastry.

1 lb. flour.
½ lb. shortening.
Ice-cold water.

The shortening may be a mixture of butter and sweet lard or sweet dripping.

If the fingers are cool, the shortening may be rubbed into the flour; otherwise, it should be cut into it with two knives until thoroughly mixed with the flour.

Mix into a dough with the ice water, using only enough to hold it together. It should be so dry that it will not stick to the bowl anywhere.

Turn out on the floured board, and knead only enough to make the ball smooth, when it is ready to cut into pieces for rolling out to line pie-plates, etc.

The quantity of shortening may be lessened for a plainer pastry.

FLAKY PASTRY.

1 lb. flour.
½ to ¾ cup butter.
Ice-cold water.

Rub two ounces of the butter into the flour. Cut the remainder into half-inch dice, and stir through the flour. Mix the water in with a broad-bladed knife, using only enough to hold the flour and butter together in shreds. If the quantity is difficult to mix without cutting through the butter lumps, flour the board, lift out the part that mixes first, and proceed to mix the rest. The object is to avoid any further breaking of the butter lumps. Turn the mixture out on the board in a pile, pack it together with the hands, and roll out into a sheet. Use a broad-bladed knife, and fold it into three or four layers, tucking in all the loose shreds about the edges. Be sure it is not sticking to the board, turn it around, and roll out again. Fold and roll out again. Fold in half and set away to chill, if necessary, before rolling it out to line pie-plates, etc.

This requires a hot oven at first to puff it, but a cooler one to complete the baking.

PUFF PASTRY.

½ lb. flour.
½ lb. butter.
Ice-cold water.

Wash the butter, form it into a flat, round cake, and put it away to chill. Make the flour into a stiff dough with ice water, and knead until perfectly smooth. It should be firm enough to roll out without much contraction, but should not be dry. Roll into two pieces a trifle larger than the butter pat; place the butter on one, moisten the edge, place the other on top, and press the edges together. Put aside to chill. Roll it out in one direction only, until about three times as long as broad, fold into three or four layers, turn around and roll again in the other direction, then set aside to chill. Roll and chill twice more in the same way, but fold it in half the last time. It is then ready to roll out and cut into shape for baking.

The oven for baking should be rather hot at first, then cooler, to permit of baking the pastry thoroughly without burning. One-quarter of the butter may be replaced with lard.

The cook books indicate many different ways of making puff pastry, and all of them are good in skilful hands. Skill is attained only through practice and the judgment of experience.

It would seem important to exercise care, as follows.

1. To make the dough of just the right consistency.

2. To prevent any softening of the butter during the rolling operations. If the maker can work in a temperature just above freezing, no special chilling is necessary.

3. To roll lightly, but evenly, to avoid crushing layers together.

4. To regulate the oven carefully to secure the strong heat necessary to puffing the layers and yet avoid burning.

COMPOSITION OF BREAD MADE FROM DIFFERENT KINDS OF FLOUR.

It has been pointed out that many changes take place during the process of breadmaking; but while these changes affect the composition of the various groups of materials, as the proteids and carbohydrates, they do not materially alter their proportion to one another. The increased percentage of water in the bread naturally decreases the percentage of other constituents from what they were in the flour. The following table gives the average results of a number of analyses of bread made from different grades and different kinds of flour. All the breads analyzed, with the exception of that marked baker's bread, were made in our own flour-testing laboratory.

Composition of Bread.

Kind of Flour	Moisture	Protein	Fat	Ash	Soluble Carbohydrates
Patent	36.80	7.60	1.80	1.25	52.53
Baker's grade	36.84	7.82	1.71	1.32	52.30
Standard patent 85%	37.40	7.74	1.71	1.27	51.88
Bakers' bread	38.02	8.23	.43	1.13	51.63
Home-made Spring wheat	37.24	9.28	1.54	.92	51.04
Home-made Winter wheat	33.31	6.17	2.54	1.06	56.91

The strong flours always absorb the most water, consequently a greater weight of bread can be made from them than from the softer and weaker flours. Notice the low moisture content of the home-made bread from soft winter wheat, as compared with the same kind of bread made from spring wheat. With very low grade flour of the red dog type the water absorptive power is greater than it is in the better flours, but the loaf of bread produced is not marketable.

Some of the bakers' bread and the home-made bread from spring wheat were made with flour from wheat grown in the season of 1909. This accounts for the high percentage of proteids, as the wheat of the 1908 crop was much lower in this constituent. Incidentally, it may be mentioned that because of this increased proteid content and, consequently, gluten content, the flour from this year's crop of wheat is very much superior to that of last year. Naturally, the bread from the soft winter wheat is low in proteid, as the flour and wheat it is made from are low in this constituent.

The low fat content of the baker's bread is due to the fact that no lard or other fat materials were added to this bread. In all other cases some lard was used. The home-made bread from the winter wheat flour evidently contains the most fat, but this cannot be credited to the flour. It is due to larger amounts of lard being added in the process of making the bread. The high soluble carbohydrate, or starch, content of the bread from winter wheat flour is naturally due to the comparatively low percentage amounts of protein and water.

It is evident that there is not much difference in the composition of the ordinary bread made from the higher grades of the spring wheat flours, but there is considerable difference when we compare this bread with that made from the winter wheat flour. We are frequently asked which of these breads actually furnishes the most nourishment to the body. To answer this question we made bread from four kinds of flour and analyzed it. The flours used in the work were the patent and bakers' grades, from Manitoba spring wheat, an 85 per cent. or standard patent, from the same grade of wheat, and 85 per cent. from all Ontario soft winter wheat. The bread was made in the regular way in our flour-testing laboratory—in fact, the loaves were taken from some of the regular testing work. In this work we used 12 ounces of flour for a loaf, and each lot of flour received exactly the same amount of yeast, salt, etc., and all the water it would absorb. The bread was weighed, dried, and the whole mass ground to an impalpable powder and analyzed. The average results of a number of analyses are given in the following table. As the actual size of the loaves, their colour, texture, etc., do not enter into the problem, these data have been omitted. It may be stated, however, that the bread was all of a good quality. Naturally, the loaves from the Ontario flour were not so large, but the bread was a fair sample of that got from these flours.

Percentage Composition of the Bread.

	Av. wt. of loaf *grams	Water	Protein	Fat	Carbo-hydrates	Ash
Patent	502	36.48	7.29	1.76	53.42	1.05
Bakers'	506	36.75	7.50	1.71	52.81	1.32
85% Manitoba	501	36.10	7.93	1.73	52.92	1.33
85% Ontario	468	32.90	5.74	1.6[illegible]	58.58	1.15

*28.34 grams in 1 ounce.

It will be seen from the above table that the various spring wheat flours produced about an equal weight of bread which was very similar in composition, while the Ontario winter wheat flour gave less bread with a lower water, protein, and fat content, and a considerably greater amount of carbohydrates. This is as expected, as the soft flour is starchy and poor in protein.

In order that we may make a closer comparison of the amounts of the various food constituents furnished by each 12 ounces of flour, the weights of protein, fat and carbohydrates contained in each loaf were calculated and are given in the following table. The fuel, or calorimeter value of each loaf was also calculated and is given in the last column of the table.

Weight in Grams of Food Constituents and Fuel Value of Each Loaf of Bread.

	Protein	Fat	Carbo-hydrates	Ash	Fuel value
Patent	36.60	8.84	268.17	5.27	1399.
Bakers'	37.89	8.65	267.22	6.68	1393.
85% Manitoba	39.73	8.67	265.13	6.66	1388.
85% Ontario	26.91	7.63	274.15	5.38	1351.

It is generally assumed that, provided any given food is consumed as part of a well-balanced dietary, the number of calories of heat it will produce when burned, or, in other words, its fuel value, is the best basis for making a comparison of the nutritive value. Taking this as the basis, we have the figures given in the last column.

It will thus be seen that the soft wheat flour gave bread that contained approximately one-third less protein, or flesh-forming material, a little less fat, but more carbohydrates, and that it would furnish only 3.5 per cent. less energy than the bread from the spring wheat flour.

From these figures we must conclude that, when eaten in the usual way as part of a mixed diet, bread from the soft wheat flour is practically equal in nutritive value to that obtained from the hard spring wheats.

Nutritive Value of White and Brown Bread.

The comparative nutritive value of white and brown bread has always been a subject of controversy. The theory is advanced that in preparing the finer flours much of the most nourishing of the food materials are removed, and, consequently, the whole wheat, or Graham flour, is the most nutritious and healthful. In studying the nutritive value of any food it must always be borne in mind that it is not the flour or bread that contains the highest percentage of the most valuable food constituents that is the most nourishing, but it is the one that contains the most of these constituents in a form that is capable of being absorbed. The coarser flours have a higher percentage of protein, fat, and mineral matters than the finer grades, and so has bran; but, owing to the amount of crude fibre, or cellulose, surrounding these materials, they are not so well assimilated, and they really furnish less nourishment than is obtained from the bread made from the finer grades of flour. The work of Snyder, of Minnesota, Wood and Merrill, of Maine, and others, have clearly shown this. A few figures taken from Bulletin No. 101 of the Office of Experiment Stations, Department of Agriculture, will illustrate the point.

In the work referred to the different grades of flour experimented with were made from one stream of wheat, the flours and the bread made from them were analyzed, and the digestibility of the bread determined. We shall only refer to three grades of flour—*i. e.*, the standard patent, or straight grade, which represented about 96 per cent. of the total flour from the wheat; the entire wheat flour, which is made by removing part of the outer bran layers and then grinding, and a true whole wheat or Graham flour, *i. e.*, a flour made from the clean, scoured wheat without any bolting process. The composition of these three kinds of flours was found to be as follows:

Composition and Heat of Combustion of the Flours.

	Water %	Protein %	Fat %	Carbohydrates %	Ash %	Phosphoric acid %	Heat of combustion	
							Calculated calories	Determin'd calories
Standard patent or Straight	10.54	11.99	1.61	75.36	.50	.20	4.022	4.050
Entire wheat flour	10.81	12.26	2.24	73.67	1.02	.54	4.026	4.032
Graham flour	8.61	12.65	2.44	74.58	1.72	.71	4.123	4.148

No crude fibre is given in the above table, but it would increase as we pass from the finer to the coarser flours. The percentage of protein and fat also increases, but the carbohydrates decrease, and the difference here would be still more pronounced had the crude fibre been separated.

When the bread made from these three flours was submitted to digestion experiments the following results were obtained:

DIGESTIBILITY OF NUTRIENTS AND AVAILABILITY OF ENERGY OF BREAD.

	Protein %	Fat %	Carbohydrates %	Energy %
White Bread	85.8	56.4	97.5	90.1
Entire-wheat bread	80.4	55.8	94.1	85.5
Graham Bread	77.6	58.0	88.4	80.7

This means that in these experiments 85.8 per cent. of the protein in the bread from the straight grade flour was digested and only 77.6 per cent. of that in the Graham bread. Furthermore, while 90.1 per cent. of the total fuel or energy value of the white bread was available, only 80.7 per cent. of the total energy of the Graham flour was of use to the person eating the bread.

The same bulletin shows that the bread from the first patent, which represents about 35 per cent. of the finest of the flour, is even more digestible than that from the straight grade flour.

In 1857 Laws and Gilbert, of the Rothamsted Institution, England,[1] studied this same question; and, in view of the fact that the roller process of making flour was not then in use, their conclusions will be of interest. Writing in 1881, Gilbert summarized their conclusions as follows:[2] "The higher percentage of nitrogen in bran than in fine flour has frequently led to the recommendation of the coarser breads as more nutritious than the finer. We have already seen that the more branny portions of the grain also contain a much larger percentage of mineral matter. . . . It is, however, we think, very questionable whether upon such data alone a valid opinion can be formed of the comparative values as food of bread made from the finer or coarser flours from one and the same grain. . . . Again, it is an indisputable fact that branny particles, when admitted into the flour in the degree of imperfect division in which our ordinary milling processes leave them, very considerably increase the peristaltic action, and hence the alimentary canal is cleared much more rapidly of its contents. It is also well known that the poorer classes almost invariably prefer the whiter bread; and among

[1]Rothamsted Memoirs, Vol. 1.

[2]Rothamsted Memoirs, Vol. 5.

some of them who work the hardest and who, consequently, would soonest appreciate a difference in nutritive quality (navvies, for example), it is distinctly stated that their preference for whiter bread is founded on the fact that the browner breads pass through them too rapidly; consequently, before their systems have extracted from it as much nutritious matter as it ought to yield them. It is freely granted that much useful nutritious matter is, in the first instance, lost as human food in the abandonment of 15 to 20 per cent. of the wheat grain to the lower animals. It should be remembered, however, that the amount of food so applied is by no means entirely wasted. And, further, we think it more than doubtful, even admitting that an increased proportion of mineral and nitrogenous constituents would be an advantage, whether, unless the branny particles could be either excluded or so reduced as to prevent the clearing action above alluded to, more nutriment would not be lost to the system by this action than would be gained by the introduction into the body, coincidentally with it, of a larger actual amount of supposed nutritious matter. In fact, all experience tends to show that the state, as well as the chemical composition of our food, must be considered; in other words, that its digestibility and aptitude for assimilation, are not less important qualities than its ultimate composition.

"Of course, if the branny particles were reduced to a perfect state of fineness, and it were found that this prevented the aperient action, and that other evils were not introduced; or, better still, if more of the food materials can be separated from the bran, and in either case without more cost than the saving would be worth, there might be some advantage. But to suppose that whole wheat meal as ordinarily prepared is, as has generally been assumed, weight for weight, more nutritious than ordinary bread flour is an utter fallacy, founded on theoretical text-book data, not only entirely unsupported by experience, but inconsistent with it. In fact, it is just the poorer fed and the harder working who should have the ordinary flour bread rather than the whole-meal bread as hitherto prepared, and it is the overfed and the sedentary who should have such whole-meal bread. Lastly, if whole grain were finely ground, it is by no means certain that the percentage of real nutritive nitrogenous matters would be higher than in ordinary bread-flour, and it is quite a question whether the excess of earthy phosphates would not then be injurious."

The previously presented results on the digestibility of different kinds of bread confirm the above conclusions of Laws and Gilbert. In concluding the discussions on the nutritive value of bread, we submit the conclusions of a study of the composition and digestibility of white and whole-wheat bread given in the St. Bartholomew's Hospital Report, London, England, 1897:

"From the experiments we are justified in concluding that the higher nutritive value which we might, upon pure chemical grounds, ascribe to brown bread, cannot, with the single exception of fats and mineral constituents, be maintained from the physiological side. On the other hand, distinctly less nutritive materials actually get into the blood in the case of the brown than of the white bread. . . .

"White bread is, weight for weight, more nutritious than brown. Therefore, it appears the preference given by operators in large towns for white bread has to a certain extent a sound physiological basis.

"In the case of people with irritable intestines white bread is to be preferred to brown.

"In the case of people with sluggish intestines brown bread is preferable to white, as it tends to maintain regular peristaltic action and ensure regular evacuation of the bowels, with all its attendant advantages,

"In cases where the proportion of mineral ingredients, and especially of lime salts, in other articles of food or drink is insufficient, brown bread is preferable to white. . . .

"If the dietary is insufficient in fat, or if the patient is unable to readily digest fat in other forms, brown bread may possibly be preferable to white."

In this country, where everyone eats a very varied diet, it is doubtful if a sufficiency of ash materials and fat are not taken into the system without using the bread from the coarser flour for the purpose of obtaining these substances. Moreover, it is evident that the comparative nutritive value of white and brown bread varies with the individual.

COMPARISON OF THE NUTRITIVE VALUE OF BREAD AND SOME OF THE COMMON FOODS.

Bread is often referred to as the "staff of life," presumably because it is so universally used, and because it is one of our cheapest foods, and, at the same time, very nutritious and palatable. It is sometimes spoken of as a complete food, *i. e.*, one that furnishes all the nutrients required to nourish the body and in the proper proportion. It possibly fails somewhat in the latter respect; but, as is well known, the food of man must please the palate as well as satisfy the demands of the body, and to do this we must have a varied and mixed diet. This is not the place to discuss the balancing or cost of diets; but, for purposes of comparison, it may not be out of place to show the amounts of the important food constituents furnished by other common foods. For this purpose we have calculated the weight of protein, fat, and carbohydrates, and the number of calories of heat one dollar's worth of each of the more common foods will furnish. The figures are based on the average composition of the foods as purchased.

Weight of Protein, Fat, and Carbohydrates, and the Fuel Value of $1.00 Worth of Each Food.

	Price per lb.	Refuse %	Protein lbs.	Fat lbs.	Carbo-hydrates lbs.	Fuel Value cal.
Milk	6c. quart	—	1.38	1.69	2.21	13,009
Milk	8c. quart	—	1.04	1.27	1.66	10,402
Skimmed milk	10c. gallon	—	3.4	.30	5.1	17.070
Buttermilk	10c. gallon	—	3.0	.50	4.8	17,362
Butter	25c. pound	—	0.04	3.4	—	14,422
Cheese	17c. "	—	1.63	2.16	.24	12,593
Beef, fore quarter (wholesale	6c. "	18.7	2.41	2.91	—	16,762
Beef, hind quarter (wholesale	8c. "	15.7	1.92	2.29	—	13,235
Beef, flank	8c. "	10.2	2.12	2.37	—	13,944
Beef, sirloin	18c. "	12.8	.92	.90	—	5,509
Veal, cutlets	15c. "	3.4	1.34	.50	—	4,612
Mutton, chops	16c. "	16.0	.84	1.80	—	9,158
Lamb, hind quarter	18c. "	15.7	.92	.90	—	5,509
Ham, smoked	18c. "	13.6	.79	1.85	—	9.276
Ham, smoked and cooked	30c. "	—	.67	.75	—	4,405
Eggs	25c. dozen	11.2	.79	.56	—	3,853
White bread	2½ lbs. 10c.	—	2.10	.5	12.2	28,710
Rolled oats	7 lbs. 25c.	—	3.5	1.9	20.0	51,730
Farinas	6 lbs. 25c.	—	2.3	.24	18.7	40.070
Potatoes	90c. bag	20.0	2.18	.10	15.6	33,492

In some respects the figures are hardly fair, as some of the foods have to be cooked, whereas the bread is ready for use. If the weight of protein, fat, and carbohydrates furnished by one dollar's worth of flour had been given, they would have been about double that furnished by bread, and much larger than that supplied by oatmeal. However, as the figures stand, it is evident that bread is one of our cheapest foods, and when we take into consideration its palatability and high digestibility, it may well be termed the "staff of life."

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INDEX