THE

THEORY AND ART

OF

BREAD-MAKING.

A NEW PROCESS

WITHOUT THE USE OF FERMENT.

BY

E. N. HORSFORD,

RUMFORD PROFESSOR IN HARVARD UNIVERSITY, CAMBRIDGE.

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THE

THEORY AND ART OF BREAD-MAKING.

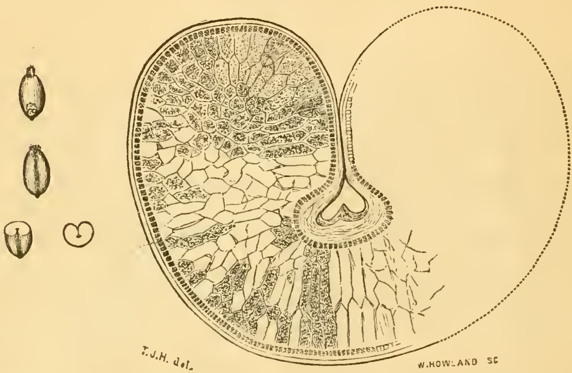
BREAD-MAKING, in its widest sense, consists in giving to the flour of certain grains convenient form for the purposes of food. What the form shall be is determined by several considerations, the most important of which is the adaptation of the food to the requirements of digestion. In order to this adaptation, the most essential quality of the bread is surface for the action of the digesting fluids. Bread presenting great surface, so as to yield promptly to the agents of digestion, is healthy, while that which presents little surface, so as to overtask the powers of digestion, as in the case of heavy bread, is not healthy. Surface is gained most conveniently by giving to the mass of flour the cellular structure of raised or light bread. This cellular structure permits the fluids of the mouth and stomach to pass in by capillary action, and by endosmosis and exosmosis to penetrate every part of the mass and accomplish the office of digestion.

As experience has shown wheat to contain the elements of nutritious food in the best proportions for the wants of the human organism, the discussion which follows will be devoted to the art of making bread from wheaten flour. In the broadest acceptation, bread-making might include the preparation of crackers, cake, and all the forms of light and heavy pastry in use; but it is proposed to omit all these, and limit the application of the word *bread* to the plain, light, or raised *wheaten flour loaf*, into which, beside the principle of leaven, only salt and water enter as component parts. The great essential process of such bread-making is the production from flour of a permanent cellular structure of convenient size and form, — to wit, the raised loaf, with but inconsiderable changes of the original flour. If the loaf is made sweet by addition of sugar, or aromatic by addition of flavoring extracts, or rich by addition of eggs or butter or fruit, it is cake or pudding or pastry, but not bread.

Let us consider the material out of which this loaf is to be produced.

Composition of the Wheat-Grain.

Fig. 1.



The crushed grain of wheat is a mixture of reddish-brown and white portions. By bolting or sifting, most of the brown portion is removed. Of this the coarser part is called bran. Bran is commonly though not universally supposed to contain but little of the nutritious part of the wheat. Careful examination shows it to contain much of the interior portion of the berry. The outer *true* bran, or bark, may be partially removed by moistening the grains and rubbing them lightly between the folds of a coarse towel. This hull or bark so separated is chiefly composed of woody fibre, and contains little nutritious matter. Investigations made elsewhere, and confirmed in my laboratory, have shown the amount of the outer bran that may be so detached to be less than three and a half per cent of the weight of the un-

Fig. 1 exhibits the wheat-grain or kernel of the natural size, presenting the grooved side and reverse, and cross section; also a cross section magnified to 18 diameters, and displaying the bran-coats, gluten-coat, and starch-cells.

branned berry. Within this bark, and constituting a continuous inner wrapper, is the most important constituent of the wheat, as it contains the phosphates and nitrogenous ingredients out of which the digesting and assimilating apparatus elaborate all the important tissues and organs of the body. It is the gluten. Within this envelope of gluten, and extending to the centre of the berry, is a mass of starch. There are then three portions, — the bran proper or outer envelope, the gluten or inner envelope, and the starch.

They are exhibited in Fig. 1. The bark envelope, including also the portion next the gluten, consists of several layers, the outermost of which much resembles very thin straw. The gluten is not fibrous, like the hull or bran proper, but is in cells, and cuts like the rind of cheese. The starch is granular and loosely held together by a coarse network of cellular tissue.

The starch belongs to a class of bodies specially related to the respiratory organs. Its consumption, and that of the gum, sugar, and oil also present in small quantities in wheat-meal, contribute to maintain the temperature of the body necessary to the fulfilment of its various functions.

Gluten is the name under which the chief nitrogenous constituents of the flour are grouped. In it there have been recognized an insoluble portion, the fibrine; a smaller, soluble portion, the albumen; and a portion not so well known, which is said to expedite certain kinds of fermentation, and is called cerealine. As these bodies have substantially the same chemical constitution, it is conceivable that they differ from each other chiefly in the degree of degradation which the latter two have experienced, or in the degree in which they are susceptible of decomposition by the action of ferment, the fibrine being the most stable, and the cerealine the least stable of the group. Besides the gluten in the envelope, there is, according to Mayer,[1] a small amount of a soluble nitrogenous compound distributed throughout the starch.

The gluten and starch may be separated from each other by kneading in a current of water. The former is a tenacious, slightly elastic substance. The latter is granular and loosely coherent.

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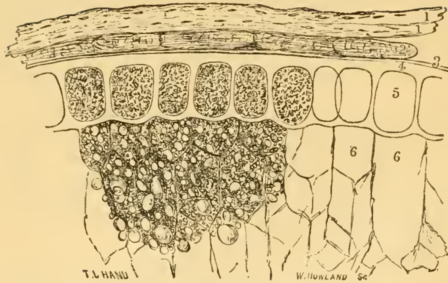
[1] Ann. d. Chem. u. Pharm., CI. Bd. 2, p. 163.

Fig. 2.



If a cross section of wheat be exposed for a short time to the action of a solution of ammonio-sulphate of copper, the gluten will be impregnated with a green compound. The extent of the green compound, which is coincident with that of the gluten, will be found to be limited to a thin envelope immediately within the bran proper. If another cross section be exposed for an instant to the action of a solution of iodide of potassium to which a few drops of nitric acid have been added, it will become deep violet wherever the starch granules occur, and the extent of the starch will be found to include the entire space within the thin envelope of gluten. Microscopic examination shows the gluten to be disposed in one continuous layer of cells with no intervening starch granules, and the chemical tests show that the gluten cells penetrate the starch but slightly, if at all.

Fig. 3. *Miller's Bran.*

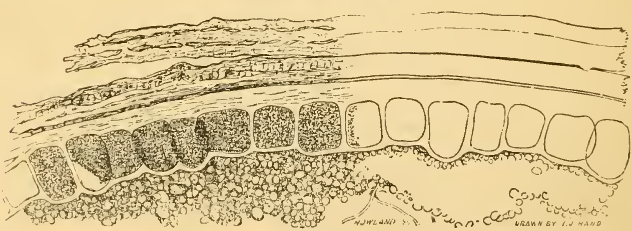


Fig. 2 presents a portion of a transverse section of white wheat, magnified to 150 diameters. 1, 1 are the coats of outer true bran; 2 is the inner coat of true bran; 3 is a thin filmy coat covering the gluten cells; 4, cellulose containing gluten; 5, sacks of gluten; 6, starch-cells.

Fig. 3 is a transverse section of commercial bran, upon the same scale as the last. The layer of starch is sometimes twice or three times as thick as is here exhibited.

Loss of Phosphates with the Bran.

A glance at these figures will explain why Mayer[1] found fourteen times as much phosphoric acid in commercial bran as he found in commercial superfine flour. The bran carried with it most of the layer of gluten in which the phosphates and the companion nitrogenous compounds — the sources of living tissue — are lodged; while the superfine flour consisted chiefly of starch, but little of the gluten having been detached from the bran. Mège-Mouriès[2] found the gluten coat to contain ten per cent of nitrogen, while the average of the whole berry is from two to three per cent.

A glance at these figures will also show why the bread made from Graham flour, and the Pumpernickel of Westphalia, which is also made from unbolted meal, and the black bread of like origin found in the sacks of Russian soldiers in the Crimea, are so nutritious, in spite of their heaviness and sourness. They contain *all* the gluten as well as starch of the grain. All the phosphates and nitrogenous compounds of the grain enter into the bread when the bran is not separated from the flour, instead of a small fraction only, as in bread made from superfine flour.

Fig. 4.

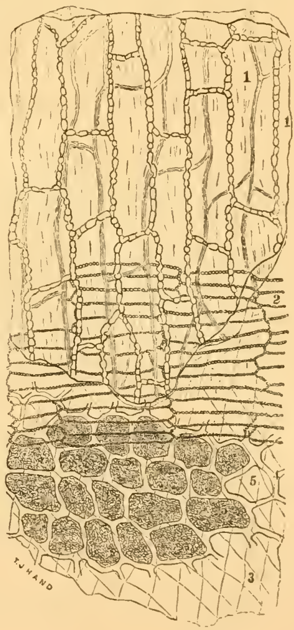


Fig. 4 exhibits the arrangement of the successive coats, including the gluten and gluten-cells, more or less of each coat being removed, so as to display the order of succession. It is also on a scale of 150 diameters. The coats 1, 1 are readily separated with a moist cloth.[3]

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[1] Ann. d. Chem. u. Pharm., CI. Bd. 2, p. 146.

[2] Compt. Rendus, XLVIII. 431.

[3] Mr. Thos. J. Hand, of New York, to whom I am indebted for these most detailed and elaborate original drawings, and who has in numerous ways aided

Difficulties of Bread-making.

It is well known that the best bread-makers find great difficulty in the production of uniformly good bread. This is true of household cooks and of bakers employed in the shops. The bread is sometimes good, more frequently indifferent, and oftentimes positively bad. Sometimes the objectionable qualities of the bread are apparent to the touch, sometimes to the senses of smell and taste, and more frequently in their effects upon health through inferior assimilation.

The sources of this difficulty are various. Some of them may be mentioned. The flour which is employed is variable in excellence as well as in composition. Some of it is made from winter wheat, some from spring wheat; sometimes the

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me in my researches upon bread, is about to give to the public the results of his fresh microscopic examination of the structure of the kernel of wheat.

The parts which Mr. Hand has so successfully individualized under the microscope, may be separated to some extent by chemical processes. If the berry, deprived of the two outer coats of true bran by friction with a moistened cloth, be treated with alum solution, then opened along the side opposite the groove, digested with warm water, and carefully pressed, the starch may be quite successfully separated. The residue, consisting of gluten and the immediate investing coats, constitutes some twelve per cent of the whole berry. If the gluten coat be treated with acetic acid, it may, with care, be separated from the layers without.

The extreme outer coats separated by friction with the moistened cloth, contain phosphate of iron and phosphate of magnesia, besides silica and potassa. The ash which has been analyzed by my assistant, Mr. Brooks, is 6.64 per cent, of which 7.70 per cent is phosphoric acid.

The coats next to the gluten contain also phosphates and alkalies. But the great magazine of phosphates, as well as of nitrogenous compounds, is in the gluten layer.

The ash of wheat as a whole contains, —

Potassa	29.97
Soda	3.90
Magnesia	12.20
Lime	3.44
Phosphoric acid	46.02
Sulphuric acid	.33
Silica	3.35
Oxide of iron	.79
Chloride of sodium	trace
	100.00

flour is made from "grown" wheat; oftentimes it is heated in grinding, frequently it is damp and granular, and occasionally it is sour.

The ingredients of the leaven or yeast with which the fermented "batch" bread is prepared are not only variable, but the changes which take place in the yeast itself are influenced by the quality and condition of the ingredients, by the volume of water employed, by the temperature to which the mixture is subjected from without, by the heat which is developed in the process of fermentation within, by the species of ferment which are added, by the degree of cleanliness maintained, and by the time during which the various changes are protracted.

Effects of Fermentation.

Among the effects which ferment produces in flour, — some of which are beneficial, and others of which are more or less hurtful, — there are the conversion of starch into dextrine (a body nearly allied to gum arabic), and this dextrine into sugar, and the changing of a portion of the sugar into alcohol and carbonic acid, the production of lactic, acetic, butyric, succinic, and formic acids, the greater or less liquefaction of the gluten, the formation of ammonia, the production of a dark coloring matter, the development of microscopic vegetable organisms of various kinds, and, through the breaking down of the gluten, the greater or less deterioration of the nutritive properties of the flour. In the use of recently prepared leaven there is sometimes produced an ethereal oil which adds to the pleasant taste of the bread. In the use of old leaven the production of offensive ethereal oil is uniform.

Of all these effects, it is now generally conceded that the most important, if not the only essential office of ferment in the making of bread, is to give to it the requisite porosity, or to make it "*light.*" This porosity is necessary, as already intimated, that the fluids taking part in digestion may have surface to act upon. It is accomplished by the evolution of carbonic acid from sugar, the alcohol from which exhales with the surplus moisture in the process of baking.

The production of all other acids than carbonic acid can scarcely be other than hurtful. The liquefaction of the gluten, due to their presence in excess, tends to deprive the bread of porosity. This extreme change causes the dough once distended to collapse and fall, leaving the bread heavy, or displaying here and there great cavities.

Liebig proposed the use of lime-water in mixing the dough, — a suggestion that met with great acceptance. Its office was obvious. It neutralized the acid which was liquefying the gluten. The lime also combined with the liquefied gluten (albumen) giving it firmness. The use of alum and sulphate of copper for the same end may be said to be, in some districts, quite universal. Dr. Hassall examined twenty-four samples of London bread, and found alum in all. Dr. Muspratt remarks that what is true of London may be said of Liverpool and all the larger towns of England. Dumas found that sulphate of copper (blue vitriol) had been in use in Belgium from an indefinitely early period. The quantity employed, however, was very small. Kuhlmann found that one baker employed only a pipe-bowl full of the solution for 250 lbs. of bread. It was observed to have the effect to make inferior flour produce a bread that sold as well as bread from a better quality of flour, and, besides, the bread retained more water and was whiter. Alum produced the same results. The action of the alum, by virtue of its qualities as a mordant, is readily understood. It combines with albumen and renders it less soluble, so far arresting the action of the ferment, and thus in a twofold way lessening the liquefaction of the gluten. The action of sulphate of copper is much the same as that of alum, in so far as combining with the albumen, to form a compound less influenced by the ferment, is concerned, and it may have a separate specific effect. It is said to increase the activity of the ferment, but this may be apparent only, as the effect may be simply to stiffen the gluten, and thus increase its capacity to hold all the bubbles which the ferment produces. It is conceivable that it acts somewhat, though inferior in degree, as corrosive sublimate does to destroy some of the species of the yeast-plants.

The excessive production of dextrine, with extreme porosity, makes the bread dry too rapidly, and gives rise to the brittleness and hardness which characterize the slice of most bakers' loaves when left a short time exposed to the air.

Mould poisonous.

The mould, or the organic germs from which it arises, can only be hurtful. To this, it is well known, some of the most painful forms of dyspepsia are ascribed. The significance of this statement may not at first glance be fully appreciated. The existence of microscopic organisms in the various forms of yeast has been established. Whether they be regarded as having an essential office to fulfil in the process of fermentation, as many maintain, or whether the more philosophical view of Liebig be accepted, that they are the incidental concomitants of decay, — the yeast germs everywhere present in the atmosphere finding a fit soil in decaying vegetable organisms, — whether the one view or the other be adopted, it is admitted that the phenomena of fermentation are accompanied by the growth of microscopic vegetable organisms.[1] It is well known that each kind of ferment is capable of reproducing itself, and communicates to the new substance the tendency to break up into bodies of the same character as those into which it is itself resolved. This is true of lactic, acetic, and putrefactive fermentation, as well as of those attending the successive changes of starch into dextrine, sugar, and alcohol and carbonic acid. When now we take into account these doctrines, it is not difficult to conceive that the ferments and their yeast-plants, having escaped destruction by the heat of baking, may produce ill effects when they reach the general circulation.

As a class, microscopic fungi are poisonous. Some of the forms of mould in carelessly dried chestnuts are well known to be poisonous. The form of mould that appears on cheese has long been recognized as a malignant poison. The fungus[2] that appears on rye, and its ill effects, are well known. The wheat-bread distributed among the troops in Paris in 1841 was found to contain in all its crevices a minute red lichen. The rust of wheat and smut of corn are varieties of these poisonous fungi.

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[1] Blondeau has indicated the particular fungi that attend the different kinds of fermentation. With the alcoholic is the *Torvula cerevisiæ;* with the lactic acid, the *Penicillium glaucum;* and with the acetic, *Torvula aceti.*

[2] Ergot.

Dr. Mitchel of Philadelphia long since called attention to the influence of these microscopic organisms on health, and the subject in this immediate connection has been discussed at considerable length; among others, by an English author on hygiene, Dr. Lobb, in a series of articles in the Medical Circular of London, in which he advocates the aerated bread of Dr. Dauglish, made without ferment, to the exclusion of all fermented batch-bread; and in an able paper by Dr. Hunt in the North American Journal of Homœopathy.

These effects of ferment and the incidental deterioration of the flour by the incipient disintegration of the gluten are undesired concomitants, which, to a greater or less extent, we must accept if we produce the cellular structure by means of ferment.

Why Flour is mixed with Water and Yeast, and kneaded and baked, &c.

The great fact, as already remarked, in the art of bread-making, is the production of surface for the action of the digesting fluids. It is the accomplishment of a permanent cellular structure. Let us trace the series of processes.

The flour is thoroughly mixed with water for what? That the gluten, which, when moistened with water, possesses elasticity and tenacity, may be intimately mixed with the starch, so that when bubbles of gas appear in the midst of the loaf they may everywhere have an elastic and tenacious coat.

The yeast is kneaded thoroughly with the flour for what? That, when the gas-bubbles are produced, their walls may be thin enough to dry, by exhalation of the water, to the consistency required for self-support before the outside burns in the process of baking.

The dough is placed in the oven to be baked for what? That the surface, by extreme drying, may become hard at the moment when the dough has attained its greatest porosity, and hold up the spongy interior while the surplus water is exhaled. The browning of the crust gives rise, by destructive distillation, to some essential oils, kindred with those produced in the roasting of corn or coffee, and agreeable to the senses of smell and taste.

The coagulation of the albumen, and the increased solubility of some of the starch produced by baking, may be considered steps in the direction of disintegration.

Are there other effects accomplished in ordinary bread-making? Knapp remarks, that the starch is for the most part unchanged. Any one may satisfy himself on this point by adding a drop of iodine water to a crumb of bread, which will become blue. The starch and gluten may be separated by kneading with cold water. They have been simply mixed together, and the change produced in them has been inconsiderable.

But is there not something mysterious in the action of ferment which gives the fermented bread decided superiority? Let us consider this inquiry.

The Ideal Loaf.

Every baker has in his mind an ideal loaf, — a loaf the ferment of which was quite fresh, and almost neutral or but slightly acid, and that with volatile acid; the flour of which was not heated in grinding, nor moistened just before nor after grinding, and made from choice winter wheat containing a large proportion of gluten, which gluten was not all removed with the bran, the mixing of which was with rich milk instead of water, the rising of which was carefully watched so that the loaf might be placed in the oven when the temperature of the latter and the distension of the former were precisely what they should be, — and now and then some of the numerous staff have had a loaf approaching that ideal. But the testimony of all is that the task of attaining it is one beset with innumerable difficulties, and that no one would be safe in prophesying with regard to a given trial as to its result; so that whatever the careful baker may occasionally rejoice in, the world cannot have this ideal loaf. If there were no other reasons, there is not good flour enough for it. The intrinsic difficulties of the problem lie in the number of unknown quantities in the yeast and flour, and the varying skill of the cook. These difficulties are so great that the baker speaks of the vagaries of the yeast, — its fitfulness, inconsistency, and untrustworthiness, as if they were almost entitled to the rank of moral qualities. It is known, for example, that a sample of yeast that sometimes refuses to work well on a lower floor will work admirably in the fourth story, and that a yeast working well at one bakery, when carried with its containing vessels to a neighboring bakery, refuses to fulfil its office. These phenomena find some explanation when it is considered that the germs of the yeast-plants are carried readily in the air.

All attempts at establishing a method of making fermented batch-bread that shall be invariably good, from the days when unleavened bread was prescribed for use at sacred ceremonials, have resulted in but inconsiderable advancement. The process of Rollan, which attracted considerable attention in France, and the ingenious processes of Berdan, apply only to the mechanical arrangements connected with kneading and baking. Neither made the slightest advance in the most essential part of the process, — to wit, the production of the cellular structure.

Mège-Mouriès's Process.

The most considerable contribution in recent times to our scientific knowledge on this subject has been made by Mège-Mouriès. This experimenter divides wheaten meal into three portions, — *flour*, *groats*, and *bran*. He steeps the groats with water, in the proportion of one of groats to four of water acidulated with tartaric acid, and lets it run through the alcoholic fermentation. It is then strained, to separate any bran-flakes, and mixed with the flour which is to be made into dough. The alleged gain is that the loaf does not become dark-colored, as wheaten meal more frequently does, and as other bread occasionally does when made in the ordinary way, and that all the nitrogenous constituents of the flour are saved. Mouriès's theory is, that there is a nitrogenous body in the groats, the first action of which is to produce a dark-colored compound as a result of disintegration. This function of the nitrogenous body having been fulfilled by letting it run through the alcoholic fermentation, it is in condition to perform the office of leaven upon the flour. Mouriès's process is doubtless good; though, in careful hands, it has not invariably succeeded, and his reading of the results is imperfect. Bakers are familiar with the fact that dough which is made with *brewers'* yeast, set aside to rise one hour, for example, and then baked, yields a dark-colored loaf, while, if permitted to remain two hours before baking, it yields a white loaf. The coloring matter is, then, obviously a passing phase accompanying certain changes. The bread of the darker loaf is uniformly sweeter than that of the whiter loaf. The baking arrests the changes in the dough. In the first case the changes stop in the dextrine and sugar stage; in the second, they stop in the alcoholic stage.

To comprehend this fully, let it be remembered that the best researches made in this direction, from Schwann and Liebig to Pasteur, go to prove that each change in the fermenting mass has its own special attendant ferment, that each ferment is capable of reproducing itself, and that the transforming power of each ferment is proportioned to the quantity present. When Mouriès sets the groats aside to steep in water, he sets aside a great excess of gluten and a moderate amount of starch; when he adds tartaric acid, or starch sugar already in ferment, he introduces an agent which liquefies the gluten. Exposure to the air is followed by the absorption of oxygen and the breaking down of the gluten compound. With this comes the formation of the ferment that is to change the starch to dextrine; further disintegration of the gluten gives the body that is to convert the dextrine into sugar, and still further disintegration, and perhaps oxidation, the body that is to transform the sugar into alcohol and carbonic acid. Each of these transforming agents not only produces the change in starch or dextrine or sugar which is its immediate office, but it reproduces itself, as already remarked, from the stock of nitrogenous matters at hand. Thus, when the decoction of the groats has run its course through the alcoholic fermentation, it has left behind — no starch, no dextrine, no sugar, — but it has left the particular ferments that are essential to the production of the dextrine, sugar, and alcohol. And when this magazine of ferments is mixed with flour to be wrought into bread, and a portion of the starch is transformed into dextrine by the aid of the appropriate ferment, another ferment is at hand to convert the dextrine into sugar, and still another ferment to convert the sugar into alcohol. These several ferments were produced from the groats by the preliminary process.

Conceive now the supply of ferment required to effect any of the changes in the series to be inadequate, — for example, the ferment necessary to produce the change from dextrine to sugar. Suppose the baking to take place when this stage has been reached. The bread will be characterized by the presence of dextrine and sugar. It will be dark-colored, and sweet and heavy. But give time for new ferment to be produced and to act, and the change will be complete. The ferment that converts the sugar into alcohol and carbonic acid being present in adequate quantity, the dark color and extreme sweetness and heaviness will disappear.

The saving of the gluten of commercial bran or groats, or "fine feed," if only as a ferment to spare the disintegration of the gluten of the flour, is desirable, but the certainty of obtaining good fermented batch-bread by the process of Mouriès, beside consuming much time, requires the same close attention that the ordinary process with brewers' yeast requires. Moreover, the usage of this country does not contemplate the joint purchase of flour and bran for home supplies.

Can Fermentation be avoided?

Since then fermented batch-bread is liable to these uncertainties, and since the cellular structure is the only important good result attained by fermentation, the inquiry suggests itself whether this desirable effect of ferment may not be attained without the hazard of making the bread hurtful, — without the sustained care and watchfulness, and without the consumption of so much time. May it not be attained without the use of decaying gluten, starch, and sugar? This is manifestly the great problem of household supplies. It has been so recognized. This inquiry was made by Henry[1] at the close of the last century, when he proposed the use of a carbonated alkali and muriatic acid, that, when mixed with the flour and moistened, gives, by the evolution of carbonic acid, the requisite porosity, and produces common salt throughout the loaf at the same time.

The mixture of saleratus (carbonate of potassa) and sour milk

[1] This plan is ordinarily ascribed to Dr. R. Thompson. Dr. Whiting, in 1837, and Sewall, in 1848, took out English patents for modifications of the process.

(lactic acid) with flour was another answer, and this method of making biscuit and short-cake is still practised to some extent; but the imperfect distribution of the saleratus throughout, and the imperfect neutralization of the potassa, because of the variable acidity of the sour milk employed, and the consequent free alkali in the bread, both discoloring it and making it bitter, have brought this method into general disrepute. Bicarbonate of soda with sour milk has found more favor, the less causticity of this alkali, if any remains without being neutralized by the lactic acid, being less objectionable to the palate and less marked in its effects on the bread.

The mixture of dry tartaric acid and bicarbonate of soda with flour is well known to produce a light and palatable bread. Substituting cream of tartar — an acid tartrate of potassa — in place of pure tartaric acid, to be mixed with the bicarbonate of soda, is another and popular expedient for escaping the prolonged and variously objectionable process of bread-making in the use of yeast or sour dough.

Dr. Dauglish has devised a method, recognizing — indeed, based upon — the idea that the only desirable office of all ferments in bread-making is to give to the loaf a certain cellular structure. He works into the flour a solution of carbonic acid in water, employing a closed kneading apparatus, so as to conduct the process under pressure. To this plan, which results in most excellent and acceptable bread, there can be no objection except that, although suited to the wants of extensive public bakeries, it does not meet the wants of private families.

The use of bicarbonate of soda and sour milk has this objection, that the proper adjustment of acid and soda is rarely if ever attained, and the bread is frequently bitter and portions of it brown, from the excess of alkali.

The use of cream of tartar and bicarbonate of soda in equivalent proportions, resulting in tartrate of soda and tartrate of potassa, is generally regarded as harmless, because these substances are present in much of the most healthful fruit we eat; but there are eminent physicians who regard the bread made by the use of these ingredients as injurious to the alimentary organs.

In all these processes nothing useful is added to the dough, except the cellular texture. However deficient any of the normal constituents of the flour may be, none of its wants are supplied by any of these methods.

THE NEW METHOD.

In view of the foregoing, the question naturally suggests itself, May it not be possible to return a wanting ingredient, or add a nutritive constituent to the bread, at the same time that the raising of the loaf is accomplished as an incidental effect?

This problem has been subjected to experimental solution.

The idea which directed the research was the production, each by itself, of the two ingredients, the acid and the base of a normal salt, present in the cereals and all healthful food, and essential to the production of all the important organs of the body, in such form that the two mixed with flour would remain inert till the addition of water or the application of heat, and then unite to establish the normal salt, evolving incidentally carbonic acid from the midst of the dough, to make the bread porous.

Of all the salts taking part in vital processes, the most important are the phosphates. They enter into the composition of the bones, the muscles, the nerves, the brain, and indeed of every higher tissue; and wherever an important function is to be performed there nature has supplied a store of phosphates. They are present in all the forms of substantial food. Aside from the great prominence now given by the medical world to the use of the various forms of soluble hypophosphites, it is well known that finely prepared phosphate of lime, eaten as such, greatly aids the growth and firmness of bones and teeth. Fractured bones are reunited much more promptly upon a diet into which pulverized bone enters as a prominent constituent. The excess of phosphates in the secretions of the kidneys consequent upon extreme mental exhaustion has led to the use of some form of phosphorus to renew the cerebral and nervous fibre.[1]

Food otherwise unobjectionable is frequently deficient in these ingredients, and the effect of living too exclusively upon such imperfect diet is conceived to lower the tone and diminish the

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[1] Sir Benjamin Brodie.

vigor of the system as a whole. On the other hand, it has been suggested that pioneers and early settlers owe the prominence of the osseous system, and the accompanying hardihood they so uniformly display, in no small degree to the abundant phosphates supplied by the virgin soil to the cereals and meats that constitute their food. This suggestion derives strength from the circumstance that the effeminacy of many Oriental nations is the concomitant of a diet which is relatively deficient in phosphates.

This demand of the system for phosphates is illustrated in the well-known relish of many inferior animals for bones. Cattle, grazing in inferior pastures, eat ground bones with avidity.

Superfine Wheat Flour is deficient in Phosphates.

In the preparation of ordinary superfine wheaten flour we lessen the quantity of normal phosphates by all that are contained

Fig. 5.

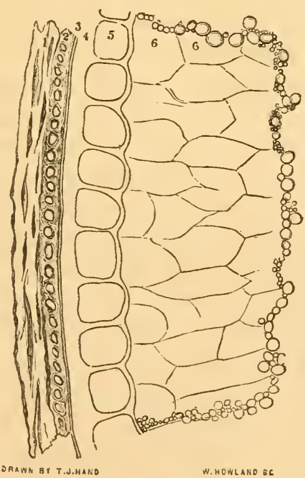

Fig. 5. Outline drawing of a portion of a *longitudinal* section of *Miller's Bran*, upon a scale of 150 diameters. This is the companion drawing to Fig. 3, which presents a *transverse* section of miller's bran. This is an accurate drawing, under a camera lucida, and shows the great loss of nutritious matters in ordinary *Miller's Bran.*

1, outer true bran; 2, inner true bran; 3, thin membranous coat; 4, coat containing gluten cells; 5, gluten sacks, in outline; 6, 6, starch cells, in outline.

in the gluten which is separated with the bran. Mayer, who has made upon this subject the most detailed and comprehensive research, finds the percentage of phosphoric acid in bran to be 2.82, while the percentage in superfine flour is only 0.20; that is, the *bran* contains, weight for weight, as already remarked, more than *fourteen times* as much phosphoric acid as the *superfine flour* that is separated from it.

The gluten which contains the phosphates is for the most part distributed, as already remarked, immediately within the bran coat of the berry. It is easy to see, therefore, why the gluten should be so largely removed with the bran, — why also more proportionally of the nutritious portion of the grain is withdrawn, when a large part of it is separated as bran, in the effort to obtain a white superfine flour. Mègé-Mouriès recovered in part the nutritious matter when he employed the bran or groats extract as a ferment. He at least spared the gluten present in the flour, that would otherwise have been sacrificed to the wants of fermentation. But as the process of Mouriès, for reasons already mentioned, is impracticable, even if it promised good bread with greater certainty of fulfilment than the ordinary processes of fermented batch-bread, there remains, as the next best thing, the restoration of the phosphates. They are, moreover, the salts, which, with the gluten, are sometimes deficient. It is known that the wheat-grain, grown under certain circumstances, has contained no gluten whatever.[1] In many cases it is imperfectly supplied with gluten, especially when it has been grown upon impoverished soil. Thus, in introducing phosphates into bread, we shall fulfil the double office of restoring an ingredient sometimes deficient even if the whole berry is employed, and always deficient in superfine flour. These deficient phosphates are the phosphates of the alkalies, and of the alkaline earths, lime and magnesia.

To secure the more important of these in the bread, with the incidental evolution of carbonic acid, it is only necessary to mix together with the flour a dry, highly acid phosphate of lime,

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[1] This was the case with a sample of Algerian wheat analyzed by Millon. It contained soluble nitrogenous compounds. Compt. Rend., XXXVIII. 12. Mayer found less phosphoric acid with the soluble nitrogenous compounds of the interior than with the gluten of the envelope.

which is phosphoric acid and neutral phosphate of lime, and dry bicarbonate of soda, in such proportions as shall leave a neutral phosphate of lime and phosphate of soda after the dough has been thoroughly kneaded and baked.

Preparation of the Acid.

The phosphoric acid is prepared from the only practicable source of it, the bones of beef and mutton. They are boiled, then calcined, after which the lime is in great measure withdrawn by the action of a stronger acid, and the phosphoric acid, as an exceedingly acid phosphate of lime, extracted by leaching. The extract is then concentrated by boiling, and in this condition mixed with simple farinaceous matters, dried at a low heat to render it brittle, and pulverized. When now this pulverulent acid is mixed with dry flour, and to this mixture bicarbonate of soda added in such quantity as exactly to neutralize the free phosphoric acid, and in such quantity of both acid and carbonate that the carbonic acid evolved shall give to the loaf the requisite porosity, then it remains only intimately to incorporate these ingredients with water and a little salt, and bake, in order to the production of bread. The addition of the water to the mixture of flour, acid phosphate of lime, and carbonate of soda, and especially the application of heat, causes the phosphoric acid to decompose the carbonate of soda, with the evolution of carbonic acid, forming cavities throughout the dough, and producing at the same time phosphate of lime and phosphate of soda.

Instead of mixing the acid separately with the flour and then this mixture with the bicarbonate of soda, the acid phosphate and the bicarbonate, thoroughly dried, may be mixed together, and in this condition preserved until the occasion for preparing the dough arises. The mixture may then be incorporated with the flour, and thoroughly kneaded with an adequate quantity of cold water.

Scientific Precision in Bread-making.

By this process, bread-making and most of the forms of pastry-preparation may be reduced to scientific precision. The production of cellular structure will be a thing by itself. Other qualities may be added as taste or fancy suggests. Sugar or acids, aromatic fluids or fruits, butter or eggs, any or all, may be incorporated in specified quantities, without interfering with the agent which is to produce cellular structure. None of the constituents of the flour, derived from its starch or its gluten, are to be sacrificed in order to gain porosity, as in the ordinary process of fermentation.

This method has enabled the writer to insulate, and impart at will to the loaf, the peculiar properties of the baker's fermented batch-bread. By adding a little wine to the water with which the flour containing the cell-producing powder (the mixed pulverulent phosphoric acid and bicarbonate of soda, or yeast-powder) is mixed, the baked loaf acquired some of the peculiar aroma of the wine, and a certain peculiar feel of the pile (cellular structure) recognized in good fermented bread, and due to to the presence of alcohol. By adding British gum (roasted starch or dextrine), the baked loaf acquired a certain leathery toughness, recalling this common property of fermented bread. By adding sugar, the peculiar sweetness of a loaf baked in the sugar stage of its fermentation was recognized. By adding weak vinegar, the peculiar objectionable acidity of bread made from ferment passed into the acetic fermentation was imparted to the loaf.

By adding to the mixture of yeast-powder, flour, and salt, before kneading, instead of water or milk wholly, a part of good ale, there were imparted all the desired qualities of the choicest loaf of fermented bread made from brewers' yeast. This process insured the aroma and faint, agreeable bitter of the hop,— the dextrine, alcohol, and sugar of the beer,— in addition to the cellular structure; and to those who relish these qualities, due to beer, the method leaves nothing to desire. A few experiments will satisfy any baker or cook that the qualities he covets in bread or pastry may be imparted to it with certainty upon the principle here laid down.

Is Bread made by the New Method Healthy?

Let us consider whether any ill can result to health from the use of bread containing phosphates of lime and soda. Practically this question has been settled in two ways. Bread has always contained phosphate of lime and phosphate of potassa (nearly allied to phosphate of soda), and the article of phosphatic bread has been in extensive use for a series of years, to the great satisfaction of those who have employed it. But it may be asked, — Does the question admit of a theoretical doubt?

Both the articles are essential constituents of healthful food. The phosphate of soda is a normal constituent of the blood, and the phosphate of lime or phosphoric acid, in some form of combination, is present as an indispensable ingredient of every important tissue of the organism. The bread made from superfine wheaten flour is deficient in the phosphates, and this supply fulfils a legitimate want.[1] But it may be asked, Is there provision for the healthful removal of phosphates, if there be a surplus? To this inquiry, the fact that nature has provided for the removal of portions of the osseous system, especially in cases of fracture, is perhaps a sufficient answer; but there is another, more emphatic. The French army was at one time supplied with soup-cakes prepared from bones with the aid of Papin's digester. The cakes prepared from bones liquefied at an elevated temperature and under pressure, supplied phosphates in quantity greatly beyond the normal wants of the soldiers' diet; but nature appropriated such portion of the nutriment offered as she required, and the remainder was rejected. If the digestive system can thus easily dispose of this great surplus, the task which the phosphatic bread may impose is a light one. The superfine wheat-flour, which constitutes generally less than three quarters, and in some instances less than one half, of the wheat from which it is prepared, has according to Mayer, already cited, only one fifteenth of the phosphoric acid of the original wheat. One hundred ounces of bread made from flour of the latter quality contain about three ounces of phosphates less than the whole wheat contained. This quantity greatly exceeds the amount restored in the use of phosphatic yeast-powder.

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[1] See the statement of Mayer, already quoted. Mouriès's analysis of the gluten coat, taken in connection with the correlation of the nitrogenous ingredients and phosphates, amply confirms the truth of this remark.

SUMMARY.

The wheat-grain consists of an outside coat, composed of several layers, and constituting the pericarp or *bran* proper, which contains but little nutritious matter; an inner envelope, the *gluten*, which contains most of the nitrogenous constituents and phosphates, and an interior mass of *starch.*

In the ordinary method of bolting to produce superfine white flour, most of the first two are separated. In Graham flour, so called, or wheaten meal, the constituents are not separated from each other. The Pumpernickel, or sour black bread of Westphalia, is made from flour of the latter kind. It contains, as does bread made from ordinary unbolted wheat-meal, all the nutritious ingredients of the wheat.

Fermented or leavened bread differs from unleavened bread in that the former has derived a porous structure from the gases evolved in the greater or less decay of some of its constituents.

The chief advantage possessed by leavened or porous bread is that it permits the ready admission of the juices of the mouth and stomach employed in digestion. Without this the bread would be unhealthful. The object in kneading is thoroughly to incorporate the starch and gluten of the flour with the leaven and water, so that, when bubbles appear in the dough, they may be surrounded by an elastic and tenacious coat, and not run together, giving rise to large cavities and making the bread heavy.

The object in baking is to arch over the risen dough by sudden drying or conversion of the starch into dextrine, so as to hold up the porous interior while the surplus water exhales, without which the digesting fluids could enter but slowly; and also to render the starch more soluble, while the albuminous portion of the gluten is coagulated.

To make uniformly good fermented bread is well known to be a task beset with numerous difficulties.

The difficulties arise partly from the variable qualities of the yeast employed, and more still from the influence of time and temperature upon the action of the yeast on itself and on the flour.

The yeast, beside conferring the cellular structure upon dough, deteriorates the flour by the greater or less disintegration of the gluten. It frequently makes the bread offensive to the taste and smell. The microscopic plants which attend on fermentation are not all destroyed by baking. Each change of the starch, whether yielding dextrine, sugar, lactic acid, alcohol and carbonic acid, or acetic acid, has its own accompanying ferment and fungus or plant.

These microscopic plants or fungi, as a class, are poisonous. To most persons warm fermented bread is injurious, possibly, it has been suggested, because the vitality of some of the yeast-plants has escaped the destructive action of the oven. These surviving plants, whose office is the disintegration of albuminous compounds, after imperfect digestion, it is maintained, produce their ill effects upon the blood.

In stale bread, the prolonged drying has perhaps deprived the larger portion of the plants, and corresponding ferments, of vitality, or has permitted them to exhaust their action in converting starch into dextrine and sugar, and the latter into lactic acid, so that fermented bread when cold is less injurious. If the fungi and ferment which accompany the changes from starch to dextrine, sugar, alcohol, and carbonic acid, are relatively but slightly injurious to most healthy organisms, it cannot be doubted that the fungi and accompanying ferment that attend upon putrefactive fermentation, which are liable to be present in fermented bread, are objectionable in the last degree.[1]

Numerous attempts have been made to give cellular structure to dough without the aid of ferment. The method of carbonate of soda and hydrochloric acid, — that of carbonate of potassa and sour milk (lactic acid), — that of carbonate of soda and tartaric acid or cream of tartar, — and that of kneading dough under pressure with water charged with carbonic acid, have all had their

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[1] Dr. Lobb (London Medical Circular, Vol. XVI. No. 397, p. 90) remarks, that the vitality of the yeast in the centre of a loaf of fermented batch-bread is never wholly destroyed. I have found that freshly-baked fermented bread, crumbled up and mixed with flour, mashed potatoes, and water, passes into putrefactive fermentation. The reason why warm fermented bread is not healthful to persons whose digestive powers are not in full vigor, while stale bread is less so, invites further observation and experiment.

advocates. Although objections have arisen to all these methods, the last two have met with great acceptance. But not one of them adds a nutritive ingredient to the bread.

The method of Mège-Mouriès, employing the extract of bran or groats as a source of ferment, is commendable, as it tends to save the nutritious constituents of the flour; but it is time-consuming, and, as experiment has shown, does not seem any more certain, without equivalent care and watchfulness, to produce good bread, than the ordinary method of brewers' yeast or sour dough.

The writer proposes a new method of raising bread, which, at the same time that it adds a nutritious ingredient, or restores a wanting constituent of nutrition to the flour, shall incidentally confer cellular structure on the dough; a method by which, while the bread is made light, phosphates of lime and soda shall be produced in the bread, to take the place in some degree of the phosphates withdrawn from the flour with the bran, or deficient in the original wheat.

This method gives to the baker the scientific precision which successful bread-making requires. The cellular structure may be produced by itself, and any other desired qualities may be imparted, each by itself, by employing the necessary agent for the purpose. For example, alcohol, dextrine, sugar, and flavoring extracts may be made to produce their specific effects upon the dough, each by itself. Or they may be employed, several of them together. Or they may be all united, and the most prized qualities of home-made bread conferred on the loaf, by replacing a part of the water required for kneading with ale. Thus the qualities imparted by dextrine, sugar, alcohol, aroma of the hop, the faint trace of pleasant acidity, and slight agreeable bitterness, which are generally so much esteemed in bread, may be given without the hazard of the offensive results that frequently attend ordinary fermentation.

The principle here laid down will make the preparation of all the forms of pastry a task of moderate skill and great certainty.

ADVANTAGES OF THE NEW METHOD.

Among the advantages which the new method of making bread presents, are: —

1. Its saving of the nutritious constituents of the flour from consumption in the process of raising the bread.

2. Its restoration of the phosphates, which are in larger or lesser measure removed with the bran in the preparation of the finer qualities of flour.

3. Its saving of time. While ordinary fermented bread involves as a general thing preparation over night, care for several hours before baking, and dependence on a variable supply of leaven or yeast, the phosphatic bread is prepared from the flour for the oven in a few minutes.

4. It secures a uniformly excellent result, while the result with the process of fermentation is of doubtful issue, and in household production is more frequently indifferent than good.

5. It furnishes a bread that retains its moisture much longer than equally porous fermented bread, and does not mould as readily as fermented bread does.

6. It provides a bread, from the use of which, even by persons of delicate digestive apparatus, none of the ills peculiar to fermented bread follow. It may be eaten warm with impunity, while with most persons it is necessary that fermented bread should lose its freshness, or become stale, in order to the destruction of some objectionable qualities, before it may be eaten with safety.

7. It is a method which, by providing agents of known qualities and strength, reduces the measure of skill required to a minimum; and secures, with a very small degree of care and moderate expenditure of time, uniformly excellent bread.

APPENDIX.

The details of the common method of making bread practised in Paris, the method of Mège-Mouriès, and the new method, are subjoined, to enable the reader to judge of their comparative simplicity.

Common Method practised in Paris.

At eight o'clock in the evening a mass of paste (leaven or sour dough) is taken, composed of eight kilogrammes of flour and four kilogrammes of water. This is left until six o'clock in the morning, and constitutes the *main leaven.*

Eight kilogrammes more of flour and four kilogrammes of water are then added: this forms *the first quality of leaven.*

At two o'clock in the afternoon sixteen kilogrammes of flour and eight of water are added: this is *the second quality of leaven.*

At five o'clock *the complete leaven* is prepared by adding a hundred pounds of flour and fifty-two kilogrammes of water, mixed with from two hundred to three hundred grammes of yeast.

At seven o'clock a hundred and thirty-two kilogrammes of flour and sixty-eight kilogrammes of water, holding in solution two kilogrammes of salt, and mixed with from three hundred to six hundred grammes of yeast, are added to the leaven, and made into well-kneaded dough.

With this quantity of paste five or six batches of bread are made in the following manner: —

1*st Batch.* — This is composed of half the dough prepared as above, which is moulded and left to rise, and then set into the oven.

The bread of this first baking is sour, rather brown, and not particularly light.

2d Batch. — The dough remaining of the first batch is mixed with a hundred and thirty-two kilogrammes more of flour and sixty-eight kilogrammes of water, mixed with the same proportion of salt and yeast as the preceding batch. Half of this dough forms the second baking, the bread of which is whiter and better than the first.

3d Batch. — The same quantity of flour, water, and salt, with three hundred grammes of yeast, are again added to the dough, of which half is baked as usual.

4th Batch. — Same proceeding as for the third.

5th Batch. — This is prepared like the foregoing, and produces what is called fancy bread, the finest quality of any.

Method of Mège-Mouriès.

It is assumed that one hundred kilogrammes of wheaten meal have given,

72	kil.	750	grammes	finest white flour.
15	"	750	"	dark groats.
11	"	500	"	bran.

1. At six o'clock in the afternoon take 40 litres[1] (kilogrammes) of water at 18° R. (72½° Fahr.), add 70 gram. of pure yeast, or 700 gram. common grocer's yeast, and 100 gram. starch-sugar. (Instead of the yeast and sugar, take, if necessary, 26 gram. of tartaric acid.) The place where the mixture is set aside must be maintained nearly at the temperature of 18° R.

2. The next morning, at six o'clock, the fluid will be saturated with carbonic acid. Stir in the 15 kil. 750 gram. of groats. Fermentation will commence immediately.

3. At two o'clock in the afternoon add 30 litres of water, and pass the whole through a very fine silk or silver-wire sieve, to separate the fine bran.

4. The 70 litres with which the groats have been treated, after passing through the sieve, will be reduced to about 55 litres,

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[1] A litre of water weighs 1,000 grammes = 1 kilogramme = 2.2 lbs. avoirdupois.

with which the 72 kil. 750 gram. of white flour and 700 gram. of salt are to be kneaded into a dough.

(The bran is again extracted with 30 litres of water and the extract employed in the next batch.)

5. The dough is then placed in baking-pans to ferment.

6. When raised, it is placed in the oven.

The New Method.

I. Self-raising flour is prepared, in which the phosphoric acid, bicarbonate of soda, and common salt are present in the required proportions. With this flour, it is only necessary thoroughly to knead in sufficient water to make a slightly sticky dough, and bake in covered tins, in a quick oven. The time required for a single person to prepare four loaves of a pound each, does not exceed five minutes, and the baking takes from thirty to forty-five more.

II. The acid is prepared by itself, and may be mixed with the flour and bicarbonate of soda at the same time; the equivalent quantities having been put up in separate parcels, and with them the measure for each.

III. Lastly, the dry acid and dry bicarbonate of soda, mixed in equivalent quantities, may be added to the flour directly. This is the most convenient form for household use. The method applied to making a quart of flour into one loaf of bread for family use, is as follows: —

1. Provide a quick oven. [This requires a temperature of from 350° to 450° Fahr.]

2. Stir a measure[1] each of acid and soda into a quart of sifted dry flour, to which a teaspoonful of salt has been added. Mix intimately with the hands. Then add from time to time *cold* water from a pint cup, stirring and kneading meanwhile, until just a pint of water has been most thoroughly incorporated with the flour.

3. Shape the mass of dough into a loaf, place it in a deep tin bake-pan, with a cover so high as to be out of the reach of the risen dough, and set it immediately in the oven.

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[1] The acid measure should contain 140 grains (9 grammes), and the soda measure 62 grains (4 grammes), for one pound of flour.