SIEBEL'S MANUAL and RECORD BOOK for BAKERS AND MILLERS

SIEBEL'S

MANUAL AND RECORD BOOK

FOR

BAKERS AND MILLERS

COMPRISING A CONCISE YET COMPREHENSIVE TREATISE ON MODERN BAKING, AS ALSO SCIENTIFIC INFORMATION IMPORTANT TO THE BAKER AND MILLER, TOGETHER WITH A COLLECTION IN CONVENIENT FORM OF BREAD AND CAKE FORMULAE AND FORMS FOR MAINTAINING BAKESHOP RECORDS.

FIRST EDITION

CHICAGO
1917

EDITED AND PUBLISHED
BY THE
SIEBEL INSTITUTE OF TECHNOLOGY

Foreword.

Considering that neither efforts nor expense have been spared in time, study, and original investigation so as to make this Manual a credit to the industries which it represents, as indeed also to the Institute itself, we may be permitted to transgress from the usual practice and enlarge somewhat more upon its scope.

In the compilation of the data presented in the following pages, the fact was not overlooked that this manual as the name correctly indicates, was to serve as a ready and immediate reference book and at the same time we have constantly borne in mind the dire necessity of presenting in a brief, yet concise form the more pertinent elementary principles of the sciences involved.

More space has been devoted to some subjects than to others, but this is only true in such instances where brevity might entail an incorrect understanding, which we aim to avoid more particularly so where relating to the application of science to practice.

Referring again to the compilation of the data it must be added that it has been found more expedient to re-arrange the same on a somewhat different plan than what had originally been anticipated, as was indicated by the sample copy of the table of contents which was issued before the matter had all gone to press.

We are convinced that a perusal of the Manual will make this readily evident, as also the further fact that only by this change were we able to add other chapters, and at the same time present the matter in a systematic manner.

While the first chapter treats on milling exclusively, it must not be overlooked that the same is also important to the baker in the same measure, as the contents of the following chapters are equally pertinent to the miller.

This fact will become readily apparent when referring to the subject of Flour under Baking Materials, Chapter II, Flour Analysis, Chapter V, and more particularly so in the chapters relating to Chemistry, Physics, Microscopy, and Mensuration, containing, as they do, what might be termed the meat of these subjects in a concrete and what is especially important definite manner.

Chapter II of this Manual brings a condensed yet comprehensive discussion of baking materials, primarily flour and flour blending, but also of the various other materials and their composition including yeast foods and bread improvers, and is followed in Chapter III by a more extensive and complete discussion of the technology of baking, including sponge and straight dough processes and fermentation as also the proofing, panning and baking of bread, a few special points of practical importance being discussed in Chapter IV.

The Manual suggests a systematic and accurate control of all the conditions that enter into consideration, at the same time giving a treatise on methods such as are mentioned in no other volume.

"Time is Money" is one of the maxims of modern industrial life. This Manual will be found a time-saver, owing to its condensed arrangement of subjects. It relieves the man in charge of the necessity of consulting three or four other books, in order to be posted, while giving him at the same time, a complete knowledge and control of all the details of operation. The fundamental principle of modern successful business methods is to reduce the cost of manufacture to a minimum, without impairing the quality of the product or to produce a better article without increased cost in manufacture. With that in mind we have also added a book of records such that if properly adhered to forms an accurate and concise outline of the details of the entire operation of the Bake-shop, and from a careful perusal and analysis of such a completed report, the Baker is able to determine the optimum conditions for manufacture. From the reports, he may readily see the influence of different ingredients that enter into his formula, of the effect of temperature, humidity and pressure and time, etc., on fermentation and that upon the quality of the loaf. From these observations he is enabled to have a complete and accurate control and knowledge of his product both as to proper conditions for manufacture and as to the cost of the product.

We wish to point out and emphasize the convenient form in which the formulas for different cakes and bread are introduced and contained. The charts are so arranged that the Baker has ready access to the many formulas, each of which has proven to be an excellent one. Some of the formulas are standard ones, but many are new and are included inasmuch as after a thorough trial they have given excellent products.

As already stated the writing and compilation of the material for such a book as this has necessitated arduous effort on our part in an endeavor to reduce the errata to a minimum. In spite of our diligence, however, errors may have crept in, and the Industry will confer a favor upon the Institute by bringing them to our attention. Furthermore, any suggestions as to the arrangement or otherwise, will be welcomed so that we may make the necessary changes in subsequent editions.

We are indebted to the individual members of the Faculty whose arduous devotion has made this Book possible, and we feel that the result of their efforts merits the commendation of the members of the Baking and Milling Industry to whose judgment this Book is confidently submitted.

Very respectfully,

SIEBEL INSTITUTE OF TECHNOLOGY.

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DISCOURSE ON MODERN MILLING AND BAKING TECHNOLOGY AND BAKING MATERIALS.

Introduction.

The progress that has been manifested in the Milling and Baking Industry in the last few years is indicative of the scientific study of the conditions that enter into and effect these industries, and only since science has entered into these fields has any real progress been made.

Of the two, that of Milling has certainly been the most alert to the advantages to be derived by the application of Science to Practice, as is so well evidenced by the completely equipped laboratories under the guidance of thoroughly competent chemists which form an important unit of the great flour mills of this country. Yet, in spite of this, the number of mills that apply technical control to their operation is exceedingly small as compared to the total number of fairly large sized mills in operation.

This is probably explained in that the average mill owner or operator, did either not have the opportunity of becoming acquainted, that is understandingly so, with the principles of the sciences upon which his practices are based, or else that he had gathered the impression that the chemistry, physics, etc., required in milling, differed from that required in other industries.

It is for these reasons that we solicit both the mill owner and operator, that in addition to such study as they may give to Chapter I, which is confined to Milling, they also give equal, if indeed not greater, attention to the thorough treament of flour in Chapter II under baking materials, and again Chapter V under analysis of flours and more especially to such chapters which relate in a concise and instructive manner to the subjects of chemistry, physics and microscopy.

Bread making is a craft dating back to earliest history—and our records show that in the year 150 B. C. the city of Rome had municipal inspection of the bakeries which were then producing bread using a "sponge" system and sour dough (Sauerteig). This system had been little changed until within comparative recent years through the advent of compressed yeast which was the result of years of careful scientific research.

Simultaneously came chemistry and physics into the Industry and have shown the Baker that temperature and pressure have their effect on the dough, that humidity influences the fermentation, that there is an optimum temperature at which dough should be maintained, etc. It has gone farther than demonstrating the existence of these varying factors—it has explained them and has given the Baker methods by which he may control them. The extent to which the various suggestions of science have been followed indicates closely and accurately the success of the Baker. The Baker with a technical education immediately recognizes that flour may be purchased to advantage through a chemical analysis, that scientific blending of flours produces flour of desired quality, and that different procedures in mixing of doughs produce characteristic results in the baked loaf, and so on.

In the following chapters, these several varying factors and phases of baking will be developed completely, showing the effect of using different kinds of flour, different methods of mixing doughs and results to be looked for in using the several bread improvers and yeast foods.

CHAPTER I.

Milling Technology.*

CHARACTERISTICS AND PROPERTIES OF WHEAT.

Wheat for the Milling of Flour.

Among the countless varieties of cereals a rather large number are more or less adaptable for the milling of flour; however, the cereal wheat stands out foremost among these for milling purposes, not alone in that it yields a large percentage of flour, but also that the flour milled therefrom produces at the same time a palatable and highly nutritious loaf of bread which is good in color and fine in texture.

Flour is also milled from rye and other cereals such as corn and even potato flour can be and indeed is employed in the making of bread and other baked food; nevertheless neither one of these flours can replace wheat flour fully, so that in this sense they can at the most be considered only as adjuncts to wheat which for centuries has been the most universally used flour yielding cereal of the world.

Differences in Wheat.

Wheat like many other plants is cultivated in a great number of recognized varieties which differ morphologically as well as chemically, at least insofar as they contain varying percentages of the different substances making up the wheat berry, although the same are in general common to all cereals.

A further difference between these different kinds of wheat is particularly to be found in their cultivation which is largely dependent on the respective climatic conditions, since certain varieties cannot withstand the severe cold prevailing during the winter season in some parts of the country, and therefore must be planted in spring, whereas others are sown in fall.

These conditions again having an effect upon the constituents of the wheat berry, it becomes at once evident that the different kinds of wheat must produce flours possessing entirely different properties, which is enlarged upon in Chapter II.

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* See also flour, Chapter II and flour analysis, Chapter V.

Structure and Composition of Wheat Berry.

If a section of a wheat berry is placed under a magnifying glass, it will be observed that the same does not present a homogeneous appearance, but rather shows to consist of layers of different materials. (See Plates II and III.)

The first or outer layer is the cuticle or **epidermis,** followed by two other strata, consisting of long and round cells and termed **epicarp** and **endocarp** respectively.

Next follows a thin layer, the **testa,** containing the coloring matter of the skin of the grain, and it is these four layers together which form the entire coating or skin enveloping the endosperm or mealy part of the grain, and which are generally designated as **bran.**

The inner and greatest part of the berry is the **endosperm,** of which the layer immediately beneath the skin or bran consists of large and practically cubical cells, called **aleurone** cells containing chiefly protein (not gluten), a little fat and mineral salts, while the longer and larger cells filling up the central part of the endosperm contain **starch** granules enclosed in a thin cellular wall and surrounded by **gluten.**

At the lower end of the grain the **germ** or **embryo** is located, from which the new plant will grow if the berry commences to germinate after being planted or sown in the ground.

From this it is to be observed that not alone the percentage of the various substances making up the whole wheat berry will be very uneven, but that this is also true of their distribution in the grain. In general it can be said that the bran consists almost entirely of cellulose, coloring matter and mineral salts, the endosperm contains chiefly starch and gluten, as also other protein in the aleurone cells, but very little cellulose, while the germ is filled with fat, some protein and mineral matter, but is practically free of starch. Starch and protein possess nutritive value and this is to a certain measure also true of the mineral salts; cellulose, however, being indigestible for the human system, is of no value as a food.

Therefore to grind the wheat into flour of the highest quality a two-fold object must be attained; aside of reducing the contents of the wheat berry into an impalpable powder, the particles of germ, bran and endosperm must be separated at the same time as much as possible, and it is chiefly for this second reason that the modern process of milling has necessarily become a rather elaborate one, making it more and more desirable, if indeed not imperative, for the miller to support his practical experience with a thorough scientific training.

As already indicated, the composition of wheat varies considerably with the different varieties, at least as far as the percentage of the various constituents is concerned, the following table must therefore be understood to give only the typical composition of an average sample of wheat.

Average Composition of Wheat.

Water	13.5 %
Starch	67.9 "
Protein	12.5 "
Cellulose (fibre)	2.6 "
Fat	1.7 "
Mineral salts (ash)	1.8 "

Varieties of Wheat.

Although more than 200 different types and varieties of wheat are known and have been named, yet for all practical purposes a classification into four or five general, large groups or classes will suffice to insure an understanding of the essential characteristic differences of these types as are grown in this country, as well as of the flours milled therefrom.

1. In the northern states, Minnesota, the Dakotas, Northern Wisconsin, Iowa and Nebraska, where the climate is rather cold in winter, **hard Spring wheat** is grown. It is of red color and contains in the average the highest percentage of gluten, 11 to 16%, making a strong flour.

2. In the middle states between the Mississippi River and the Rocky Mountains, south of Minnesota and the Dakotas, **hard Winter wheat** varieties are prevalent. They are like the Spring wheats of red color, but somewhat lower in gluten, 9 to 11%, and yield fairly strong flours.

3. In the central and Atlantic states, varieties known as **soft Winter wheat** are chiefly grown. They are generally much lighter in color, from amber to only a light red, and character-

ized by the much lower percentage of gluten, which amounts in the average to 6 to 9%, in consequence of which these wheats will yield weak flours, but of good color.

4. Very light colored wheat, so called **white wheat** which is also soft and rich in starch is grown on the Pacific coast and on the western slope of the Rocky Mountains. Since these wheats contain the lowest percentage of gluten of all varieties, from 4 to 7%, the flour made from these types is like that from the soft Winter wheats, weak but rich in starch.

5. A special variety of hard and glassy wheat of yellow color, known as **Durum wheat** is grown in some southern states, as also in Montana. The same is very high in gluten, 14 to 17%; however, the gluten is very hard and by reason of its highly creamy color, flour made from this wheat is litttle used for bread making; it is, however, largely employed for the manufacture of maccaronis and noodles.

TREATMENT OF WHEAT PRECEDING MILLING.

Blending of Wheat.

Differences similar to those with reference to gluten are to be observed in the different varieties of wheat also with reference to other properties of the flour made therefrom, most notably in the color, however, they do not necessarily run parallel.

In consequence thereof the best grades of flour are not obtained by milling only one definite variety or kind of wheat, which is generally also excluded for practical reasons, but rather by employing a mixture of different varieties, blended in such a way, that, for example, the excess of gluten in the one makes up the deficiency of this substance in the other, while possibly the better color of the second wheat will improve the somewhat poorer color of the first.

Hence, the blending of wheat is a necessity and it is only by a judicious application of this procedure that a product of uniformly high quality can be obtained not alone during one season but for years, if this blending is done rationally, and proper consideration is given to the characteristics of the varieties to be used for this purpose.

Cleaning, Scouring and Tempering of Wheat.

Wheat as it arrives at the mill contains considerable foreign matter, seeds, dirt, etc., which must be fully removed by a thorough cleaning and grading process and the more thoroughly this is done the greater will be its influence upon the quality of the final product, a fact which should not be underestimated.

It is true not all mills do require nor do they use the same machinery or appliances for this purpose; nevertheless certain machines must be employed in every mill.

After the preliminary cleaning of the wheat in the warehouse by passing through a separator which is sometimes connected with a scouring machine, it undergoes its first treatment in the mill by passing through the **mill separator** of which in some mills two or even three are employed for this purpose.

This serves to remove such foreign substances as strings, stones, corn cobs, pieces of wood, paper, short straw, but also shrunken and broken wheat grains, barley, oats, beans, larger seeds, dust, chaff and etc.

From the separator the wheat passes to the **scourer**, in which by mechanical agitation impurities still clinging to the wheat kernel are loosened, the fine hairs at the end of the berries are broken off as is also a portion of the outer skin and any chaff which had not been removed in the separator.

The wheat should next undergo a special treatment designated as **tempering** or **conditioning**, which is performed in what is known as the tempering bin.

At this stage the wheat receives an addition of water varying from 1 to 4%, depending upon the dryness and hardness of the wheat; the water which is mixed very thoroughly has the effect not only to loosen any dirt which had been clinging to the kernels so persistently as to resist previous scouring, but also toughens the bran, so that in grinding it will come off in large flakes, instead of in fine powdery form as would otherwise be true by reason of its natural brittleness.

The proper tempering of wheat is attained by allowing it to remain in the bin for quite some time, generally from 4 to 7 hours, depending as stated upon the condition of the wheat.

The wheat is then subjected to a **second scouring** which removes whatever has been loosened in the conditioning stage and which, as it were, puts the final touches on the wheat before it is ready for the milling process proper.

MILLING OF WHEAT.

The wheat having been thoroughly cleaned by the separating, cleaning and scouring process then passes to the mills.

Here it is reduced to flour, but at the same time all those parts of the berry which are undesirable in the flour, bran and germ, are removed. Since this, however, can never be accomplished by grinding the wheat directly into flour but only by a rather gradual reduction, so a series of **mills** and **scalpers** and **graders** or **sifters** must be employed for this purpose, the number of which depends on both the capacity of the mill as also the different grades of flour that are to be made.

The rolls used for this purpose in sets of two, are of two different types: the one corrugated, called **break rolls,** the others smooth and called **reduction rolls.**

Even small mills should have at least three sets of break rolls and five sets of reduction rolls, while large mills and any mill making a number of different grades of flour must have more, say five or six breaks and from nine to thirteen sets of reduction rolls and a corresponding number of sifters and purifiers.

A high grade flour and a good yield at the same time can only be obtained if the bran and germ is separated as fully as possibly from the mealy part of the endosperm; hence, the principle to be strictly observed in milling, is to break up the wheat berry by the first break only into very large particles, making at this stage as little flour as possible, but producing rather a large percentage of coarse and mealy **middlings.**

It is then the gradual reduction by means of the reduction rolls of these middlings, after they had been scalped and graded by properly selected sifters which will result in flours of the highest quality, generally designated as "**patent flours.**"

In this grade of flour are to be combined only those mill streams which are obtained from the best middlings, while the balance of the streams are included in the "**clear**" grades.

For "**straight**" flours no such selections of the different mill streams is required, but they are all combined, understanding, of course, that the bran and the very last flour that can be obtained from the same, the "**low grade,**" are always separated.

PRODUCTS OBTAINED.

Different Grades of Flour.*

From the foregoing, it appears that the different grades of flour must show notable differences in their composition, as particularly manifested in their respective percentage of gluten and ash, as also in their color.

The "**patent**" flours, chiefly made from the more central parts of the endosperm are low in gluten and ash, but they will possess the best color.

The "**clear**" flours on the other side are highest in gluten and ash, and since they contain also more particles of bran their color will be darkest, if we do not include in here the "low grade" flours, which indeed do not come into consideration for bread making.

The "**straight**" flours stand, as it were, between the "patents" and the "clears," that is, they are higher in gluten and ash than the patents, but lower than the clears, and the same is true of their color.

This is shown more in detail in the comparative analysis of these flours, given in Chapter II, under the heading of flour.

But even between different flours representing the same grade, for example between a number of "patent" flours, again characteristic differences are to be observed, although these flours might have been milled from the same wheat, insofar the percentage of endosperm particles or middlings, included in the respective flour as compared with the total

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* See also grades of flour, Chapter II.

amount of flour obtainable, will influence percentage of gluten and ash as well as color.

In the case of patent flours the lower the percentage of the flour, the lower will be the gluten and ash and the lighter will be the color, as evidenced by the so-called "**short**" or "**first**" patents, while the "**long**" or "**second**" patents consisting of a higher percentage of the endosperm, will be correspondingly higher in gluten and ash and somewhat poorer in color. This is also true of 'straight" flours, while in the case of clear flour, the conditions are just opposite. In "clears" gluten and ash will be lowest and the color lighter with a higher percentage of flour and reversedly.

Bleaching of Flour.

One of the most apparent and therefore most desirable properties of flour is its white color, which, if representing the natural color of the starchy contents of the endosperm, is indeed an indication of high quality.

However, for lower grades of flour a better color is also desirable, therefore to obtain this result from that part of the endosperm containing more branny material, bleaching of the flour is frequently resorted to, the more readily so because it has been observed, that particularly new flour is improved thereby also in other directions.

A more detailed discussion of the processes used for this purpose will be found in Chapter II on flour, to which reference is made herewith.

Use of Offals.

The various by-products and offals obtained in the making of flour, bran and shorts, screenings, shrunken wheat, buck wheat, oats and barley, are generally used for making up various feeding mixtures for cattle, horses, hogs and chickens.

In mixing these feeds and particularly if the same should serve any special purpose the composition of the various ingredients entering into the feed, especially with reference to their relative percentages of starch or other carbohydrates, protein, fat and crude fiber must be taken into due consideration as is demonstrated in the following analysis and opinion on same.

Analysis of Commercial Feeds.

	No. 1	No. 2	No. 3	No. 4
Water	7.03%	10.55%	11.00%	6.44%
Ash	8.69 "	2.65 "	3.14 "	6.51 "
Protein (N. x 6.25)	20.31 "	9.98 "	14.13 "	12.50 "
Crude Fibre	8.69 "	3.10 "	3.43 "	21.09 "
Ether Extract	8.29 "	6.11 "	3.04 "	1.21 "
Nitrogen Free Extract	46.99 "	67.61 "	65.26 "	52.25 "

Sample labeled "No. 1" represents an Oil Cake Feed, and is not a pure linseed meal, as is indicated by its high ash and nitrogen free extract, as also by its low protein content.

Sample labeled "No. 2" Red Dog Flour, does not come up to the requirements in that its protein content is below one-half that required by standard, while its fat is somewhat higher, as also by reason of the fact that the same in reality represents a hominy feed.

Sample labeled "No. 3" (Rye Middlings) comes up fully to the required standard, with the possible exception that the fat content is about 0.87% below.

Sample labeled "No. 4" represents Malt Sprouts, and does not come up to the standard in protein content by some 12%, while its fibre content exceeds by 7% the required amount. These conditions, that is low protein and high fibre content, are attributable to an excessive amount of barley hulls contained in this feed.

Not infrequently, the addition of special other materials, such as oil cake or cotton seed meal, brewers dried grains, molasses and even mineral matter in form of ground bones, is desirable in some instances.

CHAPTER II

Baking Materials.

FLOUR.

Different Kinds of Flour.

There are four different and distinct kinds of flour on the market, namely, hard Spring wheat flour, hard Winter wheat flour, soft Winter wheat flour and Durum wheat flour. Each kind possesses widely different qualities and qualifications in regard to bread making, and cake and pastry baking.

Hard Spring Wheat Flour.

The principal kind to be considered is hard Spring wheat flour, which is milled from hard Spring wheat grown in Minnesota and North Dakota and the area immediately adjacent. This flour has a rich creamy color and possesses a high content of gluten which is of the best quality. The flour is "sharp" or granular to the "feel," and because of its gluten quality and content, produces a well risen loaf of bread. A vigorous fermentation is required for the proper development of the gluten, which becomes elastic, tenacious and pliable.

Hard Winter Wheat Flour.

Hard Winter wheat flour, as indicated, is milled from hard Winter wheat and has as a synonym the name **Kansas Flour** because Kansas produces most of the hard Winter wheat flour. Nebraska also produces a large amount of hard Winter wheat flour. It is of good color, well defined flavor and rather strong gluten, although not so strong as the Spring wheat flours. In the bread-making industry only the Spring wheat flour and the hard Winter wheat flour are to be considered, inasmuch as soft Winter wheat flour is seldom used. Generally a blend of the first two mentioned is used—and are so blended as to combine the desirable features of the strong gluten in Spring wheat flour with the superior flavor and color of Kansas flour.*

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*See Blending of Flour.

Soft Winter Wheat Flour.

The third kind of flour is the soft wheat flour or soft Winter wheat flour, grown throughout the Central States and on the Western Coast. It has a low gluten content, the gluten is poor in quality, and produces a loaf of bread very poor in quality as compared to Spring wheat flour. The flour itself is very white, has a soft and "fluffy" texture and possesses an excellent flavor, but on account of the low gluten content and its poor quality, it is seldom used in bread making. The soft Winter wheat flour is used to advantage as a pastry flour, on account of its color and of the fact that less shortening is required, and further because there is no demand made upon the gluten of the flour such as is necessary in producing a loaf of bread.

Durum Wheat Flour.

Durum wheat flour is a yellowish, creamy product, milled from Durum wheat which is an extremely hard wheat grown in Western North Dakota and Montana. The flour is very granular, has a high content of gluten which is very strong and hard, and consequently develops somewhat slowly in fermentation.

Because of its high creamy color which is retained to quite some extent in the baked product, it is seldom used alone for bread-making; a mixture however of soft Winter wheat flour with Durum wheat flour produces a blend very suitable for bread. It is chiefly employed in the manufacture of maccaroni, noodles, etc.

Composition of Flour.

The composition of the several kinds of flour varies with climatic conditions, so that a Spring wheat flour in one part of Minnesota may not be exactly the same as one grown in another part of Minnesota, and the same may be said of Kansas flours. The soft wheats grown in Ohio and Michigan for instance produce a flour of higher gluten content than the flour milled from the wheats grown in Illinois, while the flour produced from the wheats grown in the mountains of Tennessee produces a gluten content still higher than the average soft wheat flours.

The seasonal changes have a decided effect upon wheat and upon the flour milled from it. For instance a dry hot season fosters the development of a higher gluten content, while a wet and cold season produces a wheat lower in gluten and higher in carbohydrates. Thus, the flour produced by any one mill will vary from season to season, and, unless the miller exercises a scientific and rigid control over the plant, it is impossible to find the same brand of flour of uniform quality, year after year.

Composition of the Patent Grade of Hard Spring, Hard Winter, and Soft Winter Wheat Flour.

	Spring Standard	Hard Winter	Soft Winter
Moisture	11.40 %	12.52 %	12.36 %
Color	100.00	101.00	103.00
Ash	0.420 %	0.406 %	0.372 %
Absorption	61.00 "	57.50 "	54.00 "
Gluten	10.95 "	9.86 "	8.32 "
Protein (N x 6.25)	11.16 "	10.06 "	8.52 "
Loaves per barrel	100.00	97.60	94.20
Volume of loaf	100.00	98.60	96.30
Quality of loaf	100.00	97.00	97.00

From the foregoing analysis it is very evident that the differences in the three flours, hard Spring wheat flour, hard Winter wheat flour and soft Winter wheat flour, are manifested in many ways. The ash content is high in the Spring wheat flour and low in the soft Winter wheat flour, while the absorption, gluten, loaves per barrel and quality of the loaf, decrease in the same order.

Grades of Flour.

In milling it is found convenient to divide the product into several grades, such as **first patent, second patent, straight, clear, low grade,** and the quality of the flour under each grade varies according to the individual miller. For instance a patent flour from one mill may comprise 65-70% of the total available flour, while another so-called patent comprises 85 to 90% of the total flour, and although they are both "patents" the quality of one is much better than that of the other. With the idea of standardization of flour the U. S.

Dept. of Agriculture has suggested—but has not as yet adopted—the following definitions of standards.

Straight Flour, made from hard Spring, soft Spring, hard Winter, Durum or soft Winter wheats, is the fine, clean, sound, unbleached product made from such wheat meals by bolting or by a process accomplishing the same result, from which none of the purified middlings flour shall have been removed, and which does not exceed 97% of the total flour produced, and contains not less than a specified percentage of nitrogen (1.50 for hard Spring and hard Winter, 1.75 for Durum, 1.15 for soft Winter), not more than 0.50% of fibre, and not more than a specified percentage of ash, (0.52 for hard Spring, 0.50 for hard Winter, 0.65 for Durum, 0.44 for soft Winter), when these determinations are calculated to a moisture content of 11%.

Patent Flour, made from hard Spring, soft Spring, hard Winter, soft Winter or Durum wheats, is the fine, clean, sound, unbleached product made from such wheat meals by bolting or by a process accomplishing the same results, produced by the reduction of the best of the purified middlings, and containing not more than a specified percentage of ash (0.42 for hard Spring, 0.40 for hard Winter, 0.37 for soft Winter, 0.55 for Durum), when calculated to a moisture content of 11%.

First Clear Flour, made from hard Spring, soft Spring, hard Winter, soft Winter or Durum wheats, is a straight flour made from such wheats from which the patent flour or a portion of the purified middlings has been removed, and which shall not contain more than a specified percentage of ash (0.80 for hard Spring, 0.70 for hard Winter, 0.60 for soft Winter, 1.0 for Durum), when calculated to a moisture content of 11%.

Whole Wheat Meal (Flour) is the fine, clean, sound product made by grinding wheat without the removal of more than 1% of the wheat in the form of bran.

Bolted Wheat Meal (Fine Wheat Meal) is the fine, clean, sound product made by grinding wheat without the removal of more than 10% of the wheat in the form of bran.

Graham Flour (Graham Meal) is the unbolted wheat meal made from clean, sound wheat.

Rye Flour is the fine, clean, sound product made by bolting rye meal, and contains not less than 1.36% of nitrogen, and not more than 1.25% of ash, when these determinations are calculated to a moisture content of 11%.

First patent includes generally about 70% of the best portion of the flour and second patent comprises about 85% of the total flour, while "straight" is the total flour from which has been excluded only 3-5% of "low grade." Clear flour is that portion amounting to 15-30% that remains after drawing off the patent flour.

Average Analysis of Different Grades of Flour, Milled from Hard Spring Wheat.

	1st Pat.	2d Pat.	Straight	First Clear	Low Grade
Moisture	12.86 %	13.08 %	13.24 %	13.76 %	14.36 %
Color	100.00 "	95.50 "	91.00 "	70.00 "	49.00 "
Ash	0.421 "	0.448 "	0.486 "	0.680 "	0.890 "
Absorption	62.00 "	63.00 "	64.00 "	65.00 "	68.00 "
Gluten (dry)	10.84 "	10.98 "	11.46 "	12.36 "	13.54 "
Loaves per barrel	100.00	101.60	103.20	104.80	109.70
Volume of loaf	100.00	98.60	95.90	93.70	91.30
Quality of loaf	100.00	97.50	96.80	95.00	84.00
AVEVRAGE VALUE	100.00	98.30	96.73	90.88	83.50
Fermenting period	100.00	105.40	109.30	116.00	120.40
Quality of gluten	100.00	96.00	93.20	87.50	80.90

It is evident from this table of analysis that the quality of the first patent is much better than second patent, while the latter is better than the subsequent grades indicated. The gradations from first patent to low grade are more or less constant, increasing or decreasing as shown. For example: the color of the flour decreases as we pass from patent to low grade, while the ash content increases. The volume of the loaf and the quality of loaf as well as the quality of the gluten, which may be considered as indices of the quality of the bread produced therefrom, decrease most constantly, until it is evident from the analysis that the quality of a loaf of bread produced from the first clear or low grade flour, is so much below that produced from patent, that it is never used alone in the baking industry. The poor quality, loaf volume, and the color of the baked loaf of the low grade flour is so low that it is never to any advantage to use it. The flour generally in use for bread making is a long patent—85 to 90%—or straight grade.

The detection of poorer grades of flour by analysis is both simple and desirable, especially since a lower grade may be treated—for instance, bleached—so it may pass as far as external appearances are concerned as a higher grade flour. However, in such instances a chemical analysis, as previously indicated, becomes the only method whereby the fraud may be definitely detected.*

Storage of Flours.

The question of storing of flour is quite as important as the buying, although usually it gets much less consideration. Flour should not contain more than 13% of moisture, because above that amount, there is danger of its spoiling—becoming musty or rancid. A high moisture content promotes the activity of the enzymes present in the flour, causing the small amount of fat contained in it to rancidify, producing a sharp taste and an unpleasant odor.

Flour should be stored in a cool, dry, light place—never in a cold, dark basement nor upon the floor. All extremes of temperature and moisture are to be avoided. The **optimum temperature** for the store room is about 65-75°F. with a relative humidity near 70%. Flour very readily absorbs odors and should be carefully protected against them. Ventilation and proper circulation of air are necessary and flours in "jute" should be piled with a "two-by-four" between each tier. When flour is stored in bags, it should be changed more or less frequently to allow the particles to come in contact with air, and to prevent it from packing.

Storing of flour has a decidedly beneficial effect upon its quality. New flours generally become sticky upon being fermented in the dough, but proper aging is conducive to normal fermentation. The effect is due to the decrease in quantity of gliadin, which is converted upon storing into glutenin.

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* See Chapter V.

The large percentage of gliadin which gives to the gluten the sticky adhesive qualities is decreased until the gliadin ratio, that is the relative amount of gliadin in the gluten, is reduced to the optimum amount.

Aging has a bleaching effect upon flour, and also tends to increase its power of absorption. Newly milled flour when properly stored, may lose 2 to 3% of moisture, but the ability to absorb water when made into the dough, increases at the same time often as much as 6 to 7%, so that the flour requires a larger amount of water to make the dough of the proper consistency.

Flour Blending.

Experience among bakers who have given consideration to the many variables that enter into a loaf of bread has shown that different flours exhibit quite different characteristics and qualities; that wheats grown and best adapted to the several localities of the world, having as they do different climatic and soil conditions, produce flours that have inherent qualities and properties peculiarly distinct and individual.

It is quite generally known that from the hard Spring wheats of Minnesota and Manitoba there is milled a flour of a rich creamy color, and whose gluten is very strong and elastic, its water absorbing power high, etc. It is also of record that the flour produced from the wheats in the southwest United States has a good color and flavor. Each different kind of flour, as a Northwest hard Spring and a Kansas Southwest, shows a character decidedly of its own. Unfortunately no one wheat produces a flour that combines all the good qualities that the industry desires. Wheat seems to develop certain qualities at the expense and neglect of others. This perhaps is the first and best reason that initiated blending of flours.

The blending process may seem from this to be quite simple. All that may seem necessary to do is to dump a sack of Kansas flour in a bin with another sack of Minnesota; thereby obtaining a blend combining all the qualities that had been hoped for. However this is not true, because we realize that flour may be blended to accord with other conditions. At this point it should be said that a haphazard method in blending different flours may not only be of no advantage whatever, but may serve to impair the value of the flour. Blending must be controlled by a method of procedure which is regulated by careful analysis and scientific reasoning if the optimum results are to be obtained.

Reason for Blending.

The **principal reason for blending** is due to characteristic differences in quality exhibited by the different kinds of flour. A hard Spring wheat flour with high content of strong gluten and high absorptive power could well be blended with a Kansas hard Winter wheat flour, because the latter improves the color and flavor of the loaf baked from the blend and at the same time does not decrease the gluten content nor impair its quality to any great extent. The blend generally yields to fermentation so that the gluten is properly and more readily developed.

Flours should never be blended necessarily to reduce cost because in doing so it has the effect of adulterating a good grade of flour with a poorer one. This does not mean however that one should never blend a high or short patent with a straight grade, because quite often it is advantageous to buy for blending purposes the strongest and best flour, so that in the end a cheaper blend may be produced. Some flours during the fermentation **tighten up**. This type of flour could well be blended with another that has a tendency to become soft and sticky. Other flours produce **gluten bound** dough and should be blended with a softer flour. Flours are blended differently according as the bread is made by hand or by machinery.

To blend successfully, one should have an accurate and intimate knowledge of each flour, its character and properties, and understand the effect that each individual flour may have on each of the others and on the blend. If he blends to improve the quality of gluten, he should know that that flour must have a stronger gluten. If for color and flavor, the added flour should be one that will give the better color and flavor in a loaf made from the blend. It would be folly to blend a hard Spring wheat flour and a soft Winter wheat flour for a sponge, and then more of the same blend to make the dough. In the mechanical manipulation, it should be seen that the flours are perfectly mixed so that the blend is uniform in composition, and the apparatus should be tested by analysis to show whether or not the blend is an intimate mixture of the several flours.

Flour Bleaching.

The process of bleaching flour has developed into one of enormous proportions, largely because of the constant demand of the baker and of the housewife for whiter bread. The ambition of the miller has been to produce a flour whiter than his competitor and to assemble the various streams from his mill which would give the whitest product. The bleaching industry is due to the observation that certain flours of same quality and character exhibited a darker or lighter color. The white flour, however, commands a higher price. It was recognized that the storing of flour had the effect of bleaching it and it was supposed that a bleaching agent could be applied to flour which would effect the same condition. This occasioned much experimentation before the process became mechanically perfected.

The color of flour is that of the endosperm of the wheat, from which it is produced, and is a natural one. Color is peculiarly characteristic of the different kinds of wheat and is inherent to each particular kind of wheat flour. Crease dirt and bran particles find their way into flour and affect to no small degree the color of the flour. Color of this kind may be considered due to foreign matter.

Methods for Bleaching.

The first general method for bleaching flour was in an atmosphere of oxides of nitrogen, into which flour was conducted and agitated. A spark between two electric terminals effects a chemical union of the nitrogen and oxygen of the air, forming **nitrogen peroxide** gas, which, when mixed with flour, has a bleaching action. In the method of operation, the flour is passed through a chamber or agitator into which is conducted the nitrogen peroxide gas from the generator. Meanwhile a process in which **chlorine** gas is used as the bleaching agent has been developed. The effect by both processes is the same. The mechanical detail has been so perfected that the operation is almost automatically continuous. The claims made at first by the bleaching advocates have been tempered by facts supported by numerous experiments, so that now we admit that the process with its limitations has quite some merit.

Bleaching has the least effect upon the gluten of soft flours, while in hard and especially harsh flours which have been bleached, the dough works more easily and makes a bold, well risen loaf. Bleaching does not destroy the enzymes, although the fat in the flour does not seem to rancidify as easily as in an unbleached flour—that is, the keeping qualities of a bleached flour, as far as rancidity is concerned, is enhanced. Bleaching has the effect of a **quick aging process** without a long storing. New flours are prone in fermentation to become sticky and soft, while the same flour, properly aged, works up better and has a higher absorption value. A bleaching apparatus has been used in many bakeries to treat new flour, which of itself can with difficulty produce a good loaf of bread.

Objections to Bleaching.

The most serious objection to bleaching of flour is that a low grade flour, which is evidenced by its color, may be bleached and made to compare favorably with a higher grade flour. This may be considered a **serious objection** inasmuch as the baker or the consumer, who ordinarily buys his flour from the appearance, can readily be misled by a bleached low grade flour.

Furthermore, flour which serves as the basis of food products, should not be treated by chemical processes unknown to the public. Flour is a natural product and as such can be used without chemical treatment. Bleaching is not an improved milling process, because bleaching does not remove any impurities. In bleached flour there remains a small quantity of a chemical agent which is physiologically active, although the quantity may not be sufficient as to be deleterious to health. Nevertheless, when large quantities of flour or bread are consumed, there may be a sufficient amount of active constituents to deter digestion.

The exact nature of the bleaching process is not fully agreed upon as yet and while we know that bleaching produces certain effects upon flour, giving from one standpoint a better product and from another a poorer one, the chemical effect upon the flour is as yet unknown. Chemical analysis however may readily detect bleaching, and the extent to which flour has been bleached. Bleached flour is not necessarily an inferior product and if offered for sale, strictly upon its own merits, it would meet competition of unbleached flour very favorably.

WATER.

Importance of Water.

The great importance of the **character, general composition** and **bacteriological purity** of the water employed in baking, has only been recognized within the last few years. Natural water, while its biological purity may be satisfactory, is never found to be chemically pure, owing to the fact that it is a ready solvent for many substances, mineral or organic, with which it comes in contact during its course. The dissolved substances have been found to influence the fermentation that bread has to undergo in its dough stages and this affects certain essential properties of the finished product such as flavor, color, loaf, volume, texture and stability.

It has been frequently said that water fit for drinking purposes is also fit for bread making; but while this is true in general, it is not so under all conditions. In fact a certain type of water, the so-called alkaline waters, may be very desirable drinking water yet it is very undesirable, if indeed not unfit for baking. In other cases the composition of the water may at least necessitate certain modifications in the formulas employed in the manufacture of bread as well as of various cakes.

Turbid Water.

Turbidity, which is caused by suspended particles of insoluble substances, such as **fine clay, hydrate of iron, organic**

matter, etc., does not necessarily exclude such water from being used for baking. If the turbidity can be fully removed by **filtration**, resulting in a clear water of good quality otherwise, the water may well be used. In cases wherein the turbidity is caused by organic refuse, it is difficult through filtration alone to render water fit for baking purposes. On the other hand, even a clear and sparkling water may be **contaminated** by organic matter and **infected** with bacteria to such an extent as to affect fermentation by the development of foreign organisms.

Hard and Soft Water; Alkaline Water.

If a water contains in solution appreciable quantities of calcium and magnesium salts in form of bicarbonates or sulphates, it is termed **hard** water, otherwise it is **soft**. Since the bicarbonates of calcium and magnesium which are found practically in all natural waters can be precipitated by boiling, and the hardness thereby removed, this hardness is termed **temporary** hardness. Hardness due to the dissolved sulphates of the same two elements and which cannot be removed by boiling, is called **permanent**. Waters containing sodium carbonate (soda) in solution, are termed **alkaline**, and have an alkaline reaction when being boiled. Other substances occurring in natural water are sodium chloride (common salt) silicates, occasionally iron salts, and organic matter of various composition.

Effect of Different Waters in Baking.

Important in the baking industry inasmuch as they have a decided effect upon the dough and its fermentation or upon the finished product, are the substances or salts causing hardness, particularly calcium sulphate, sodium carbonate and sodium chloride.

It has been demonstrated by extended experiments in the laboratories of the Institute and by practical observations, that waters possessing a fair degree of permanent hardness (calcium sulphate) **strengthen** or **toughen** the gluten, so that in doughs made with such waters the carbondioxide is retained and enmeshed better, producing a finely grained texture. Excessive hardness, however, **retards the fermentation** so that higher temperatures or an increased quantity of yeast will be necessary to properly develop the dough.

Soft water, particularly if used in connection with a weaker flour, permits **softening of the dough** during fermentation, which makes the dough sticky and the resulting bread "soggy." Alkaline waters by virtue of the soda causing their alkalinity, will not only **reduce the acidity** developed during fermentation, and thereby decrease the activity of the enzymes present in the flour as well as in the yeast used in the dough, but have directly a **solvent effect upon the gluten**, weakening it and reducing its gas retaining capacity. Hence, neither very soft nor alkaline waters should be used without being improved by proper treatment.

Analysis of Typical Waters.

(Parts per million.)

	Soft	Hard	Alkaline	Lake Michigan
Calcium carbonate	30 parts	353 parts	64 parts	75 parts
Magnesium carbonate	19 "	56 "	36 "	15 "
Calcium sulphate	7 "	275 "	none	9 "
Magnesium sulphate	none	130 "	23 parts	12 "
Sodium carbonate	none	none	105 "	none
Sodium chloride	54 parts	63 parts	29 "	11 "
Ammonia	trace	none	trace	none
Silicates	3 parts	10 parts	15 parts	5 "
Organic matter	31 "	12 "	14 "	10 "

The waters designated as "soft" and "Lake Michigan" are quite similar and in general of the same type, the slight differences in the quantities of the various salts contained in these two waters being of no significance.

The "hard" water shows a high amount of both carbonates as also the sulphates of calcium and magnesium; yet these quantities do not exceed the maximum permissible for a water used for baking, and hence this water must be considered as well adaptable for this purpose.

The sample of "alkaline" water is of moderate hardness, but contains a fairly high amount of sodium carbonate sufficient to have a detrimental effect upon the dough; hence, its use is not to be recommended.

SUGARS.

Sugars as Sweetening and Improving Agents.

Sugars play an important part in the baking industry as **sweetening** agents and **improving** agents. There are a great variety of sugars of different quality and composition and according to their most characteristic properties, one or the other should be used for specific purposes. In order to obtain a pronounced sweetness, sucrose is the most advisable, since the same has a greater sweetness than any other commercial sugar. The sugars belong to the class of bodies which are known as carbo-hydrates. Chemically, they consist of the elements of oxygen, hydrogen, and carbon. A characteristic of the majority of sugars is their sweet taste and solubility in water. Other carbohydrates, such as cellulose and starch, do not possess these properties or only to a very slight degree. By reason of their great solubility, sugars may be regarded as having a higher nutritive value than other carbohydrates, since insoluble carbohydrates must be converted into sugars before being fermented. Sugars are of vegetable as well as of animal origin.

Sugar is the substance from which during fermentation, the **carbondioxide** gas and **alcohol** is formed as indicated by the chemical formula $C_{12}H_{22}O_{11} + H_2O = 4CO_2 + 4C_2H_6O$.

The carbondioxide gas generated is held enmeshed in the small gluten cells and causes the dough to rise. Sugar is a factor in the moisture retaining quality of a loaf and gives the loaf in baking a nut brown color. In the growth of the yeast cells, no sugar is absorbed or assimilated by the yeast. The inversion as well as the fermentation of the sugar is effected not by the yeast cell itself, but by the enzymes that are generated by the healthy and vigorously growing yeast cells.

Sucrose, Cane or Beet Sugar.

Sucrose is derived from the sugar cane, sugar beet, maple tree and the sorghum plant. The two first named are commercially of greater importance and the granulated sugar of commerce is obtained from these sources. From a chemical standpoint, cane and beet sugar in the refined state, due to their great purity, are therefore identical and there is also no marked difference in the physical properties, such as sweetness, solubility, fermentability, etc. It is an erroneous opinion that cane sugar is sweeter than beet sugar or vice versa, because the sweetness depends solely on the degree of refinement. The fineness of crystal does not indicate the source of the sugar since each one of these sugars may be obtained coarse, fine, or powdered. On the other hand, there is a marked difference in the chemical and physical character of these sugars in the raw or partly refined state, on account of the variation of the amount of invert sugar, ash and nitrogenous bodies which they contain.

Cane sugar is **unfermentable** with yeast, but by the enzymatic action of the invertase contained in the yeast, it is slowly converted into the **fermentable invert** sugar, which is a mixture of glucose and fructose. For this reason cane sugar must be regarded as being very slowly acted upon and when time is to be gained in fermentation, other sugars which may be directly fermented with yeast are preferable. For cake making, cane sugar (sucrose) cannot, at least not entirely, be substituted for by other sugars, on account of its great sweetening power. Cane sugar forms invert sugar not only through the action of certain enzymes as mentioned above, but also by heating with dilute acids and, though very slowly, by continuous boiling of an aqueous solution.

The **granulated sugar** of commerce is a very pure food product. The United States standard for white sugar is 99.5% sucrose, the sucrose content of granulated sugar as a rule varies between 99.5% and 99.8%. Aside of a little moisture and invert sugar it usually contains minute amounts of ultramarine blue, which is added to the sugar to counteract the natural yellow tint. Granulated sugar is hardly ever adulterated, while powdered sugar sometimes contains starch and other adulterations which may be easily detected.

Brown Sugar is a lesser refined sugar containing often a large percentage of impurities. Its sucrose content varies between 83 and 92%. It contains 3 to 6% invert sugar, 3 to 6% moisture and 1 to 3% mineral matter. As a sweetening agent brown sugar is inferior to granulated sugar, but it promotes a more rapid fermentation.

Maple Sugar is never as pure and sweet as refined cane or beet sugar, but possesses a good flavor, for which it is highly estimated. It is often subjected to adulteration with brown sugar. It contains between 72 to 88% sucrose and 1 to 8% invert sugar.

Syrups are liquids separated from the granulated sugars by centrifuging. There is a great variation in the composition of syrups and therefore a wide range in price of the various grades. Aside of the sucrose, they contain a large amount of invert and other reducing sugars, water and mineral matters. Syrup for table use contains about 40% sucrose, 20% water, 10% organic matter and 5% mineral matter. Maple syrup is quite frequently adulterated with the latter. The molasses represents the best mother-liquid from which sugar is crystallized and from which no more sugar can be obtained profitably. Molasses contains between 25 and 43% sucrose, 15 to 40% invert sugar, 10 to 20% organic non-sugars, 20 to 30% water and 4 to 8% ash.

Dextrose or Corn Sugar.

Corn sugar is known as **starch** or **grape sugar, dextrose, glucose or anhydrous** sugar, etc., and occurs together with levulose in honey and with levulose and cane sugar in fruits. It is manufactured in this country exclusively from corn starch by the action of dilute acids. In this process a number of intermediate products are formed of which the dextrines are of the greatest importance. The more thorough the conversion of the starch, the smaller will be the percentage of dextrine and the larger glucose. Time, temperature and concentration of acid are mostly responsible for the difference in composition. Since corn sugar is used by the baker mostly on account of the easy fermentation, it will be of the greatest advantage for his purposes to use the starch sugar in as pure a condition as possible, since the dextrine is not fermentable and remains as an indifferent admixture.

Corn sugar shows great variations in its appearance, and it is well to call attention to the fact that from the appearance no conclusion can be drawn as to the purity of the product. Corn sugar may be either a syrup or solid, in form of **powder, lumps,** or **granulated.** The color varies from white to dark brown, the brown color being caused by a little caramelized sugar.

Corn sugar is only two-thirds as sweet as cane sugar and therefore as a sweetening agent is of less importance than the latter. It is readily soluble in water and is **directly fermentable** by the action of the yeast without any further conversion. For this reason corn sugar in its various forms may be applied with great advantage in bread making; however, it must be used in larger quantities than cane sugar, due to its water content. Aside of shortening the fermenting period, corn sugar means a considerable saving for the baker on account of its lower price.

Commercial glucose varies in composition according to methods of manufacture. A high dextrine content is to be avoided because dextrine is not fermentable.

Composition of Corn Sugars.

Moisture	1 to 18%
Dextrose	80 " 97 "
Maltose	trace " 2 "
Dextrine	1 " 10 "
Mineral Matter	trace " 0.8 "

Levulose or **Fructose**, together with dextrose, is formed in the inversion of cane sugar. It is sweeter than dextrose, but not quite as sweet as cane sugar. Pure levulose is now manufactured commercially.

Maltose or **Malt Sugar** is obtained from gelatinized starch by the action of the enzyme diastase, which occurs in malt. Malt itself contains a certain percentage of maltose, but the greatest part is formed in treating starch with malt. Maltose is slighly sweeter than corn sugar, but not as sweet as cane sugar. Like the latter it is not directly fermentable, but must be transformed into dextrose. This is accomplished by the action of the maltase, an enzyme contained in yeast. Malt extract contains beside the soluble proteid matter and diastase, a large percentage of maltose. Maltose, like corn sugar, though to a lesser degree, hastens fermentation but it must be used carefully and with restrictions. An excess will have the tendency to over-ripen the gluten.

Milk Sugar, also known as **Lactose**, is the principal carbohydrate in milk in which it is normally present in amounts varying from 3 to 5%. This sugar has only a very slight sweetening power and its use as a baking material is still somewhat questionable. The same is prepared from skim milk, and is frequently adulterated with grape and corn sugars in consequence of which its purity should always be established by chemical analysis. Like cane sugar it is readily inverted with dilute acids into fermentable sugar, dextrose and galactose, but unlike cane sugar by its very nature it favors lactic acid fermentation when used in the dough. The principal use of this sugar is for the preparation of infant foods; its cost makes its employment in baking rather prohibitive except in special instances where certain effects are desired.

SALT.

Purity of Salt.

Salt is produced from three different sources and may be named according to their source; bag or sea salt, rock or mine salt, natural or pit salt. It is not found in nature sufficently pure for bread making, its chief impurities are calcium and magnesium salts. There are obtainable on the market several brands of refined salt for use in baking, which are almost chemically pure sodium chloride. It is preferable to use the best grade of salt because of its purity which gives a pure salt flavor unmixed with a "biting" or burning taste imparted by impure salt.

Effect of Salt.

Salt is used for two purposes each of which is very important in bread making. It imparts a pleasant flavor to bread and without it bread would be insipid. A small quantity of salt has a sensitizing action upon the palate which accentuates the more delicate and less pronounced flavors of other substances. For example, the sense of taste can detect a small amount of sugar in the presence of salt, when without salt, it would not be tasted.

Upon fermentation salt has the greatest influence. It is used as a "**governor**" to control the fermentation of the dough, and has a powerful action upon lactic acid and other foreign ferments in that it checks their activity and growth and yet is conducive to the proper yeast fermentation. Salt is used to the extent of 1.75% based on the flour ($3\frac{1}{2}$ pounds to the barrel) although somewhat less effects a retarding action upon alcoholic fermentation. The **retarding action** due to salt is often taken advantage of on hot sultry summer days when the dough "comes fast" by adding an extra supply of salt. However, decreasing the quantities of yeast and sugar are to be recommended instead, inasmuch as too much salt makes the bread bitter and impairs its quality in general. Salt checks the diastasis and controls the hydrolysis of the starch particles and can well be used in larger amounts with new flour on account of its content of very active enzymes. In average amounts, salt produces a **bleaching action** upon the bread although the nature of this action is not agreed upon.

Analysis of Three Different Samples of Salt.

	No. 1	No. 2	No. 3
Moisture	0.027 %	0.390 %	3.60 %
Matter insoluble in water	0.010 "	0.045 "	0.084 "
Calcium sulphate	0.040 "	1.894 "	2.100 "
Calcium chloride	none	none	none
Magnesium sulphate	0.012 "	0.340 "	0.542 "
Magnesium chloride	0.007 "	0.080 "	0.106 "
Pure salt (sodium chloride)	99.534 "	97.251 "	93.568 "

According to the foregoing analysis, sample "No. 1" represents a good grade of salt, having as it does a low moisture content, low content of calcium and magnesium salts. Sample "No. 2" and "No. 3" are both lower in grade on account of the total impurities and moisture content.

YEAST.

Introduction of Pure Yeast.

One of the greatest evolutions in the baking industry has probably been effected by no other one material to any greater extent than the introduction of compressed pure culture yeast. In fact this has been of such great importance that without compressed yeast, it would be impossible to manufacture bread by the straight dough process. Yeast itself, is a microscopic form of plant life belonging to the Fungus group, as is more fully described in Chapter VIII, to which reference should be made in this connection.*

Functions of the Yeast.

Healthy and vigorously growing yeast excretes a series of soluble bodies or substances which are of the utmost importance to the fermentation of dough and baking of bread. These active principles are known as **enzymes** and are produced by living organisms. The most remarkable characteristic of enzymes is that a very small amount is able to change or convert an enormously large quantity of substance and at the same time remain unaffected. Chiefly of interest among enzymes are **zymase, invertase, maltase, diastase** and **protease.** Zymase is the enzyme which is directly responsible for breaking up of sugars into alcohol and carbon-dioxide gas. It acts only upon the simpler sugars of the dextrose type. The rising of the dough is due then to the activity of the zymase. Invertase "inverts" or converts cane sugar, which cannot be fermented directly, into dextrose and levulose which are readily fermentable. Maltase converts maltose or malt sugar into dextrose so that consequently maltose may be used in bread making, but is converted into simpler sugars before being in a condition that they are of use in fermentation. Diastase is an enzyme that effects a transformation of starch into maltose. Yeast excretes diastase but malt extract furnishes a large supply of diastase and is used quite extensively (see Malt Extract). Protease is a proteolytic enzyme that acts upon proteins. It has a solvent action and renders the nitrogenous material soluble so that it may be readily used and assimilated by the growing yeast. Protease also has a softening effect upon the gluten in the dough and aids in its proper development.

Growth of Yeast.

For the proper growth and development of yeast, certain soluble substances are necessary, including mineral salts and soluble proteid material. The mineral salts are furnished in part by the flour which contains, among other substances,

* See also Plate VI.

potassium, calcium, and magnesium phosphates. Potassium phosphate is absolutely indispensable to the growth and development of yeast while magnesium salts are of great value if not necessary. Sodium and calcium phosphates cannot effectively replace the potassium salt. Oxygen is another constituent that is necessary for yeast growth. It promotes activity and a rapid and vigorous growth of yeast cells. In fermentation of dough, the oxygen incorporated in the dough is used up by the yeast before the fermentation of the sugar is begun. Peculiar also is the action of yeast upon the dextrose and levulose, the former is fermented first and not until all the dextrose has disappeared is the levulose attacked. For a good, strong healthy and vigorous fermentation, a supply of food that may be readily assimilated is necessary and may be supplied through the use of malt extract, special sugars, and other yeast foods and improvers.

Various Kinds of Yeast.

While the various kinds of yeast employed heretofore for baking purposes are of no more than passing interest to the baker at this time, still for the purpose of completeness a short reference should be made thereto. Among these probably the principal one is the Barm-Yeast or Ferment, sometimes called **Stock Yeast,** prepared in different ways. The next step was the Dry Yeast and then the Compressed Yeast. The Barm or Stock Yeast is obtained from spontaneous fermentation, a variety of formulae having been pursued with greater or lesser success. These consisted chiefly of boiling some dried hops in water and after being brought down to a moderate temperature of about 114° F., flour, sugar and ground malt were added and the same kept at this temperature for a few hours and allowed to settle, when the liquid was separated from the insoluble matter which had settled, and cooled to ordinary temperature. It was subjected to ordinary air and spontaneous fermentation which was completed after about 24 to 48 hours.

Dry yeast was a subsequent product which in many instances was prepared from the stock obtained from spontaneous fermentation in the manner indicated. In order to press and dry it, and overcome the difficulties of bacterial infections, the same was mixed with corn meal and corn starch.

In this way, of course, the yeast was frequently in a highly weakened condition and would produce results only after somewhat more extended time. The dry yeast is still being used quite extensively by the housewife, but very little by the practical baker. These yeasts are not to be recommended nor are they adaptable since by reason of the way in which they are obtained, spontaneous fermentation, it is evident that foreign infection is difficult to avoid, while it is absolutely certain that there can be no question of uniformity either with regards to appearance and flavor of the product, through their use.

Pure Culture Yeast is derived by isolating one single cell of a certain yeast, the characteristics of which have been definitely ascertained and which is then propagated under the most sterile conditions, until larger quantities have been obtained, which are then used to innoculate Pure Yeast Apparatus, in which the amount is increased by further propagation.*

Compressed Yeast.

In the manufacture of compressed yeast a quantity of corn ground to a meal is cooked under pressure to effect gelatinization of the starch. This is known as the corn mash. It is then run into the malt mash, which is prepared in a tub provided with a false bottom and in which the cleaned and ground or crushed malt is mixed with water at a temperature of about 40 to 45° C. The temperature is then raised to 50° C., whereupon the raw grain or gelatinized corn mash is led in and digestion continued between 50 and 60° C. until all the starch is converted into sugar. By means of the false bottoms the liquid is then separated from the grains and contains beside the sugar that has formed, also soluble mineral matter as well as soluble nitrogenus substances. This liquid or wort is then mixed or "pitched" with the yeast and fermentation allowed to proceed until all of the sugar has been converted into carbonic acid and alcohol. During this time, the yeast, as already indicated, multiplies very rapidly. The yeast is then removed from the completely fermented liquid by centrifuging. It is conveyed through cooling apparatus to receiv-

* See Chapter VIII.

ing tanks, and then passes through a series of filters, where the superfluous liquid is pressed out. The compressed yeast remaining in the filter presses is mixed and by means of packing machinery is put up in convenient and suitable sized portions which are then kept in cold storage until they are brought to the market for use.

Pure compressed yeast should contain about 73.5% of moisture; it should be free from starch and somewhat crumbly but not slimy. It should be of pale yellowish brown color. The composition of yeast varies considerably.

Varying Chemical Composition of Compressed Yeast.

Moisture	from 60 to 75 %
Protein	from 10 to 25 "
Ash	from 2.5 to 10.5 "
Fat	from 1 to 5 "
Starch	from 0 to 35 "
Fermenting power (CO_2)	from 85 to 100 "
Dead cells	from 0 to 10 "
Bacteria	from 0 to 15 "

The chief adulterant in compressed yeast is starch which is easily detected. The use of starch may be considered objectionable when the purpose is to give added weight, but at the same time an added 5 to 10% may greatly facilitate its keeping qualities. Starch absorbs and retains moisture and keeps the yeast cells in a drier condition. Starch was formerly added because the bacterial content of the yeast produced a slimy product which could only with difficulty be filtered. Adding the starch overcame this difficulty. Inasmuch as through the improved methods of manufacture, yeast is practically free from bacteria and since pure yeast has keeping qualities that adequately meet the demands of commercial conditions, the addition of starch is not favored.

Analysis of Three Different Compressed Yeast Samples.

	No. 1.	No. 2.	No. 3.
Weight of cake	10.00 oz.	15.95 oz.	16.27 oz.
Moisture	74.92%	68.86 %	63.69 %
Starch	none	3.2 "	14.1 "
Gas producing strength	92.9%	83.5 "	64.3 "
Dead cells	occasional	1—2 "	6—7 "
Bacteria	none	1—2 "	2—3 "

Sample No. 1 represents a high grade yeast. This is indicated by its purity, high gas producing strength and perfect soundness. While No. 2 is not as good as the previous one, it is decidedly better than sample No. 3, which is the poorest kind of yeast that a baker could buy, by reason of its high starch content, dead cells, bacteria, as well as low gas producing strength.

SHORTENING MATERIAL.

Animal and Vegetable Fats and Oils.

Lard, oil, etc., are substances that are chemically known as fats and are found and obtained from animal sources (lard, oleo oil) and vegetable sources (cottonseed oil, corn oil, soy bean oil, cocoanut oil). They have a certain definite function to perform in bread making and the baking industry, certain of which afford advantages of merit and convenience over the others.

Pure lard is made from the fat of the hog, and is white, granular in texture and possesses an agreeable and characteristic odor and flavor. It is made by rendering in a steam kettle either open or closed the entire fat of the hog. This is known as **kettle-rendered** lard. **Leaf lard** is expressed from the fat which surrounds the kidneys and is the choicest and highest grade portion of the lard. Lard is graded in quality according to its source, and next to leaf-lard in the following order is lard from the fat from the hog's back, the region of the breast, and that portion cut from small intestines. **Neutral** lard is produced by treating "leaf lard" by chilling and pressing and subsequent washing with very dilute acid. This represents the very best hog fat and is used almost exclusively in the manufacture of oleomargarine. **Oleomargarine** is made by churning refined oleo oil—the oil remaining after chilling the stearin from fat—with neutral lard, milk and some pure butter. Cottonseed oil is extensively used in oleomargarine. There is no objection to the use of oleomargarine; it is, as now manufactured, a pure and wholesome product. The flavor, however, is hardly so good as that of butter, but as a shortening agent, or as a food in general, no objection can be made to oleomargarine.

Butter is the fat obtained from cow's milk and is used in cake baking because of its flavor. Butter is not pure fat but contains water, casein (curd) salt and a small quantity of milk sugar, etc. Its flavor is due to its content of volatile fatty acids which give it the peculiar "buttery" flavor.

Chemical Composition of Normal Butter.

Moisture	11.05 %
Fat	87.00 "
Casein	0.50 "
Ash	0.10 "
Lactic Acid	0.75 "

The United States Department of Agriculture maintains the following standard for butter:

Moisture	14.50 %
Fat	82.50 "
Casein	1.25 "
Milk sugar	0.30 "
Ash	0.40 "
Lactic Acid	0.75 "

All butter that enters interstate shipment that falls below this standard is considered inferior and adulterated. Water is the most common adulterant, although salt and other fats are often used.

Renovated butter is made by washing and steaming butter that has become rancid, and subsequent churning with fresh milk. The flavor of the finished product is peculiar and is due to substances that cannot be removed by the process of manufacture. It is used but little in the baking industry.

Fats or compounds are used to produce a "richness" in the product. Butter is employed mostly in cakes, although oleomargarine, lard and lard compounds replace butter in part. In bread making, lard, cottonseed oil and compounds are used to "shorten" the product.

All of the foregoing mentioned fats have various melting points and broadly speaking those which are solid at ordinary temperatures are called "fats" while those which under this condition are liquid receive the name of "oils." Many fats and oils possess a distinct odor and flavor, agreeable or otherwise, and indicative of their origin, such characteristics are due, however, to minute traces of associated substances, rather than to the pure fat or oil itself.

Fats and oils are practically insoluble in water but are soluble in alcohol. If protected from air and sunlight, they remain unchanged for a considerable time, but on exposure are liable to develop **rancidity.** This is hastened by the presence of bacterial infection. Once rancid it is useless to try to improve them as no restorative or preservative will help to bring the oil or fat back to natural soundness and when used in bread or cake the pungent odor will remain even after baking.

In the manufacture of cakes, pure butter should always be given preference for its flavor cannot be replaced no matter what the compound is. Butter should always be used sparingly not alone on account of its high price, but for the reason that butter is rich, and unless employed in the right proportions it will not only cause the cake to fall in the stage of baking but will also produce a heavy cake that is not easily digestible.

Method for Mixing the Shortening.

Fats in bread making serve different purposes. Either lard or a good cottonseed oil can be employed. The shortening should be accurately weighed and melted down and special attention given to distribute it evenly in the dough. The object is to combine the shortening partly with the gluten to make it more elastic. It will not only tend to give the dough what is termed "spring" in the oven, but will also soften and shorten both crust and crumb, and help the loaf to retain the moisture longer. Shortening should be incorporated in the mix after all the other materials have been mixed for a short time. Lard, etc., has a stimulating effect upon the gluten and the softer the flour the more shortening should be used.

YEAST FOODS AND BREAD IMPROVERS.

What is Yeast Food?

"Yeast Food" is a term that has been incorrectly applied to designate a material or substance that has a stimulating effect upon fermentation. For instance, sugar has been called an yeast food; malt extract is known as an yeast food. A substance to be a food must be **capable of assimilation** by the organism fed. Some substances are essential and necessary to the growth of yeast and may or may not be yeast foods. Potassium phosphate is necessary for yeast growth, but it is not a food. Ammonium salts are converted into proteid material and hence are foods. Sugar is not yeast food because it is not assimilated by the yeast. True, the kind and amount of sugar influences fermentation, but sugar is acted upon by zymase secreted by the yeast, and furnishes the energy by which the yeast cells are enabled to perform their functions. Malt extract is partly a yeast food because it supplies a quantity of soluble proteid matter readily assimilated by the yeast, but the content of maltose and diastase does not necessarily characterize it as a yeast food.

What Is a Bread Improver?

Bread Improver is the term applied to a material added in bread making to improve the quality of the product or to supplant part of the materials and hence reduce the cost of production. Such substances as milk, milk powder, malt flour, special sugars as maltose, corn sugar, also special mineral or chemical salts act as improvers.

Malt or Malt Extract.

Malt extract is manufactured through concentration of an aqueous extract of germinated barley. In the process of preparing the malt, the barley after being thoroughly cleaned is **steeped** in water, and transferred to the malting floor where it is allowed to **sprout** under careful control. Sufficient moisture, proper temperature and suitable ventilation or aeration of the germinating barley is provided. The proper conditions insure a uniform growth and development of the enzymes that are desired. After the germination has proceeded to the proper point, it is carefully **kiln-dried**. The kilning operation arrests the growth of the germ, but does not destroy the action of the enzymes which have developed during germination. The dried germinated barley grain, now known as malt, is ground, macerated and digested with water and the aqueous extract containing the soluble constituents in the malted barley is concentrated by evaporation in vacuum apparatus. The concentrated extract is more convenient to handle.

In the germination of the barley, three distinct enzymes are active, namely: **cytase, diastase** and **peptase.** Cytase dissolves the walls of the starch cell so that the diastase may react upon the starch contained within. At the same time the proteid material is attacked by the proteolytic enzyme peptase and is rendered soluble and available for food for the growing germ. In the extract these three enzymes, along with soluble nitrogenous bodies, and maltose, which is obtained through the action of the diastase upon the starch, are the active substances. However, malt extract by its nature favors adulteration and in few other products are the opportunities for buying a product so devoid of the constituents desired as in the case of malt extract. To guard against any possible deception and to detect any inferiority, a chemical analysis becomes necessary.

Parallel Analyses of Two Samples of Malt Extract.

Water	27.69 %	19.47 %
Extract	72.31 "	80.53 "
Consisting of		
Maltose	62.27 "	64.39 "
Dextrine	5.24 "	8.99 "
Albuminoids	3.33 "	5.53 "
Acid (as lactic acid)	0.26 "	0.22 "
Ash	1.21 "	1.40 "
Diastatic power (degrees Lintner)	21°	87°

While these two samples show a great variation in their respective diastatic power, these variations may oftimes be considerably greater, so that in some instances the extract contains practically no diastatic power, while in others this may be as high as 100 to even 120°. Therefore, the necessity of a correct analysis with regards to diastatic power becomes apparent.

While from the foregoing results, sample No. 1 indicates a lower percentage of unfermentable sugar (dextrin) as also ash, nevertheless sample labeled No. 2 must be considered as being superior by virtue of the fact that the moisture contained therein is lower, the extract as well as albuminoids, and maltose is correspondingly greater and particularly that the diastatic value in the latter is considerably higher.

Aside from the mineral salts (ash) and the maltose found in the malt extract (and which have been discussed in preceding chapters) the two enzymes diastase and protease or peptase are the desirable substances, and of the two, there is some question as to their relative advantages and merits.

Action of Diastase.

In bread making, the diastase acts upon the starch in the flour converting it into maltose and this through maltase and zymase, enzymes secreted by yeast, is readily fermented. However, this diastatic action is very slow at the temperature of fermentation, but in the proof box and for the first ten or fifteen minutes in the oven, the action is very vigorous and at 150° F. diastase converts 2,000 times its own weight of starch in ten minutes. The maltose produced is little fermented, on account of the elevated temperature, but its presence in the baked loaf improves the quality and increases its moisture retaining power.

Action of Peptase.

Protease or peptase has a solvent action upon the proteid material or gluten in the dough. Part of the gluten is digested and rendered soluble and as such is readily absorbed by the yeast. This soluble proteid material is an excellent yeast food and promotes a **vigorous fermentation.** The gluten throughout the dough is softened and rendered more pliable and elastic. Protease then favors the development of the gluten in the dough and especially so with the "harsh" or strong flours. The peptic power and the diastatic power of malt extract generally run in parallel so that an extract of high degree of diastatic power in most cases has a high degree of peptic power.

How to Use Malt Extract.

Therefore malt extract should be used cautiously in bread making the amount depending upon the strength and stability of the flour. In spring wheat flour one to one and a quarter pounds is used with every hundred pounds of flour, while more than this generally darkens the color of the loaf and favors over-fermentation. With weaker flours, smaller quantities and extracts of lower diastatic power should be used. Malt flour or malt extract if used in excess will promote the tendency of the dough to become "sticky" and soften too much. Malt extract offers several advantages, however, in that it imparts a palatable flavor to the loaf. It furnishes a supply of readily assimilable food for the yeast and this food supply, together with the maltose, is conducive to vigorous fermentation. The quantity of sugar and of yeast, principally the former, must be reduced correspondingly. Malt extract imparts a rich brown color to the crust of the loaf and increases the quality in general. It also keeps the bread moist longer, that is with its use the water retaining power is increased. Malt, through the action of its diastase on the starch in the dough, produces a large quantity of sugar, reducing at the same time the large preponderance of starch. This improves the bread as a food product inasmuch as the sugars are very easily absorbed by the human system. **Malt flour,** which is milled from the germinated barley grain has the same property as the extract, and both the malt extract and the flour are the best yeast foods and bread improvers from all standpoints.

Milk.

Another improver added to bread formulas to improve both the flavor and general appearance of the loaf is milk. Oftentimes whole milk or skimmed milk is added direct to the mix, but the practice for the most part now is to add milk powder or condensed milk. From the variety of milk products on the market, one is able to select that kind which adapts itself most conveniently to his purpose.

Analysis of Fresh, Unskimmed Milk.

	Specific Gravity	Water	Fat	Casein	Albumen	Total proteids	Milk Sugar	Ash
Maximum	..1.0370	90.32 %	6.47 %	6.29 %	1.44 %	6.40 %	6.10 %	1.21 %
Minimum	..1.0264	80.32 "	1.67 "	1.79 "	.25 "	2.07 "	2.11 "	.35 "
Average	...1.0315	87.27 "	3.64 "	3.02 "	.53 "	3.55 "	4.88 "	.71 "

The **specific gravity** is of great importance for determining whether or not the milk has been adulterated with water. When the specific gravity falls below the minimum in above table, it is almost certain that water has been added. A specific gravity which is below the average may indicate that water or skimmed milk has been added, though a very high fat content will also tend to lower the specific gravity. In this case the fat determination will decide whether the low specific gravity is due to adulteration or high fat content. The **milk fat** is undoubtedly the most valuable part of the milk. It gives richness to the loaf and cake. The **proteins** confer moistness and mellowness. The **casein** though insoluble in water can not be separated from fresh milk by filtering. It can be separated only by acidifying the milk, which may be done either by addition of acids or by the formation of lactic acid, due to the development of bacteria which convert the milk sugar into free lactic acid. As soon as the acidity reaches a certain percentage, the casein coagulates and may easily be separated from the milk. Rennin precipitates casein from milk. Milk freed from casein is practically transparent. For the evaluation of milk two points come into consideration, namely, the fat content and the amount of total solids, which remain after evaporation of the water in the milk. The total solids consist of fat, casein, albumen, milk sugar, and mineral matter. The higher the water and the lower the fat content, the more inferior will be the quality of the milk. It is for this reason that creameries purchase their milk on the fat content basis. In order to protect the small purchaser, every state in the Union has fixed the milk standards by law. Standard milk should contain not less than 3.25% of milk fat, and not less than 8.50% of milk solids not fat.

Skimmed Milk is milk from which a part or practically all milk fat has been removed. Centrifugally skimmed milk runs, as a rule, lower in fat than milk skimmed in the usual manner. The specific gravity of milk after skimming is higher than before skimming, and the total solids, not fat, are higher in skimmed milk. The standard for skimmed milk is not less than 9.25% of milk solids.

Analysis of Fresh Milk.

	Whole-Milk	Skimmed Milk
Water	87.00 %	89.50 %
Fat	3.78 "	0.65 "
Protein (N x 6.38)	4.26 "	4.40 "
Milk-Sugar	4.28 "	4.71 "
Ash	0.68 "	0.74 "

Condensed Milk is obtained by evaporating a part of the water of milk in vacuum apparatus, and is either unsweetened or sweetened by addition of cane sugar. As much as 50% sugar is sometimes added to condensed milk. The condensed milk may be derived either from unskimmed or skimmed and according to its source as well as to the amount of water which has been evaporated, the composition will show great variations. The United States Department of Agriculture has adopted the following standards for condensed milk:

Sweetened condensed or evaporated or concentrated milk, is the product resulting from the evaporation of a considerable portion of the water from the whole, fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving to which sugar (sucrose) has been added. It contains, all tolerances being allowed for, not less than twenty-eight per cent (28.0%) of total milk solids, and not less than eight per cent (8.0%) of milk fat.

Condensed, or evaporated, or concentrated skimmed milk, is the product resulting from the evaporation of a considerable portion of the water from skimmed milk, and contains, all tolerances being allowed for, not less than twenty per cent (20.0%) of milk solids.

Sweetened condensed, or evaporated, or concentrated skimmed milk, is the product resulting from the evaporation of a considerable portion of the water from skimmed milk to which sugar (sucrose) has been added. It contains, all tolerances being allowed for, not less than twenty-eight per cent (28.0%) of milk solids.

No admixture of butter fat, butter oil, or any other fat than milk-fat is permitted. The fat contents of condensed milk derived from unskimmed milk varies from mere traces to 10%. Just as in ordinanry milk so in condensed milk the value depends on the fat content and total solids.

Analysis of Condensed Milk.

	Sweetened Condensed Milk		Unsweetened Condensed Milk	
	No. 1	No. 2	No. 3	No. 4
Water	20.83 %	30.69 %	64.60 %	71.86 %
Milk solids	31.32 "	29.10 "	25.17 "	28.14 "
Cane sugar	47.85 "	40.15 "	10.23 "	none
Starch	none	none	plain traces	none
Milk sugar	9.57 "	11.89 "	8.65 "	9.84 "
Total protein (N x 6.38)	8.05 "	12.26 "	6.10 "	8.75 "
Fat	12.00 "	3.07 "	9.13 "	8.11 "
Ash	1.80 "	2.05 "	1.37 "	1.53 "

Milk Powders of various kinds are at present on the market, derived by nearly complete evaporation of the water from whole, half skimmed and skimmed milk. According to the quality of the original milk from which these powders are manufactured, the price and the quality of the latter will vary. There are on the market whole milk or full cream powders containing on an average 30% fat, half-skim milk or half cream powders with an average of 15% of fat and skim milk or separated milk powder with from 1 to 5% of fat. The United States Department of Agriculture has formulated the following standards for milk powder:

Analysis of Milk Powders.

	Whole-Milk	Skimmed Milk
Moisture	3.62 %	8.16 %
Fat	26.75 "	1.78 "
Protein (N x 6.38)	32.65 "	34.55 %
Milk sugar	31.90 "	49.35 "
Ash	5.67 "	6.87 "

Dried milk is the product resulting from the removal of water from milk, and contains, all tolerances being allowed for, not less than twenty-six per cent (26.0%) of milk fat, and not more than five per cent (5.0%) of moisture.

Dried skimmed milk is the product resulting from the removal of water from skimmed milk and contains, all tolerances being allowed for, not more than five per cent (5.0%) of moisture.

Adulteration of Milk.

The most common form of adulteration is the **watering** of the milk and skimming to such an extent, that the fat content sinks below the standard. Ingredients which are sometimes added to milk are chalk, starch, glycerin, cane sugar, coloring matter, preservatives, etc. The **coloring** matters which are mostly used are annatto, caramel and certain aniline colors. The **preservatives** most commonly used, are formaldehyde, boric acid, borax, sodium bicarbonate, salicylic and benzoic acids.

Ascertaining the nutritive value, the following determinations will ordinarily suffice: fat, protein, ash, milk-sugar, water, total solids. Occasionally it is desirable to make a distinction in the case of protein between its casein and the total albumens present.

Chemical Analysis of Various Milks.

	Fresh	Sweetened Condensed	Evaporated	Dry
Moisture	87.30%	22.07%	69.57%	3.63%
Total solids	12.70 "	77.93 "	30.34 "	96.38 "
Ash	.67 "	1.47 "	1.49 "	5.67 "
Milk sugar	4.53 "	11.97 "	10.18 "	31.90 "
Protein	3.50 "	9.20 "	8.86 "	32.00 "
Milk-fat	4.00 "	5.50 "	3.50 "	12.00 "
Cane sugar	none	42.63 "	none	none
Undetermined matter	none	none	2.76 "	14.81 "

From the foregoing analysis the actual value of these products, pound for pound, may be readily ascertained. To this end we can take into consideration only the actual amount of milk fat, milk-sugar and protein present. The moisture, that is, the water, in fresh milk should not exceed 89%. In condensed milk as well as in evaporated milks, this amount will vary from 25 to 75%, depending on the amount of total solids. Therefore, the more total solids found, the lower must be its moisture content, and vice versa. The total solids represent the fat, protein, ash, milk sugar and sometimes also, as an adulterant, cane sugar.

Milk fat in fresh milk should not fall below 3.25%, while the fats in other varieties of milk will vary from 1 to 15%, depending upon their concentration. Starch is not found in fresh milk, but frequently is found as an adulterant in condensed milks and particularly in the dry milk powders. This amount may vary from 1 to 15%. Cane sugar while serving the purpose of a sweetener, is often added to milk powder, its chief function being to increase weight and bulk.

Milk fat is a valuable adjunct in bread and cake making. Each 100 pounds of milk when used in the bread dough will contain from 3.5 to 4 pounds of milk fat, a quantity sufficient to produce the finest quality of bread.

When milk is used principally to improve the quality of bread, at least 1.5% of malt sugar should be added so that an adequate amount of gas for leavening the dough will be readily produced. It is true that a very small amount of fermentable sugar is contained in the flour itself, but not sufficient to effect the desired or necessary fermentation to produce a good loaf of bread. For this same reason a certain amount of cane sugar should be added to the dough so that the bread after baking, has the desired keeping qualities and likewise the desired effects upon the flavor. As a whole, the use of milk and its products have a beneficial influence upon color, both interior and exterior, and further they improve the texture and flavor, and produce a thin and crisp crust.

CHAPTER III.

Baking Technology.

THE MAKING OF THE DOUGH.

Different Methods.

Modern baking involves, in addition to a thorough understanding of the art of producing a good and uniform loaf of bread, a study of the commercial reasons for the adoption of certain methods and conditions. It involves also what is most important and that is the ability to devise and develop methods of manufacture, manipulation, and treatment that afford products of the best quality and highest purity.

Perhaps the very first decision is as to the method of making the doughs, and of the accepted systems, there are but the **sponge** and **straight dough methods** to choose between. But the selection or choice of a method embodies some difficulty because the advantages that are to be had in one instance may be more than counter-balanced by the disadvantages which that system entails. Therefore in the selection of a method of dough making, a full knowledge of the results to be obtained through the use of each is necessary in order to determine which combines the points of favor that are most desirable in the light of conditions peculiar to different localities.

Sponge Doughs.

The sponge dough dates back to the period when Rome was in the height of its glory, and at that time inspectors were in charge of the public bakeries, wherein sponge or leaven bread was manufactured. This system, somewhat antiquated, has survived, although it has been changed considerably, largely because conditions have been changed by the modern methods of compressed yeast manufacture, flour milling, etc.

The sponge method consists in mixing a portion of the flour to be used with water, sugar, and yeast. This mixture is called a **sponge**. It is allowed to ferment a certain length of time according to the kind of sponge, after which more water, flour, and sometimes yeast and malt, are added and a dough made. A so-called **short sponge** is allowed to ferment from three to six hours, while a **long sponge** may ferment as long as six to ten hours, in each case, however, the quantity of yeast and water will be varied. If to a sponge all the water that is necessary for making up the dough is added at one time, it is called a **batter-sponge.**

In setting a sponge experience has shown that a strong flour should be used on account of its content of strong gluten, which, through the vigorous fermentation, is readily developed. However, when doughing up, a weaker or softer flour should be used, because the dough is allowed to ferment generally about two hours, during which time the gluten in a strong flour would not develop properly.

The flour used in a sponge method is apt to be overfermented in part while the flour used in doughing up would be under-fermented, thus producing somewhat of a coloration in the baking process.

A custom among bakers for a long time was to make a long sponge and use the same sponge for making up several varieties of bread, thus saving time, but this practice in the light of commercial competition, has not proven satisfactory because it necessitated a sponge standing a long time before being worked up. That is, the first bread made therefrom will be made from underfermented sponge, while the last portion would be much over ripe. A short sponge should break not more than once, while a long sponge, which should be set stiffer because it slackens considerably during fermentation, can be allowed to break twice.

A sponge requires less sugar, yeast, and shortening, and the bread keeps moist longer than bread made from a straight dough. The increased acidity of a sponge dough imparts a flavor to the bread which is distinctly peculiar although not unpleasant. Sponge produces a larger loaf on account of good strong fermentation and the added fresh supply of yeast food in doughing up. Sponge can be held longer when ripe, while a straight dough has to be worked up when ready. In doughing up in the sponge method, lower grade of different flours may be used, which lends itself to a selection of a variety of flours both as to quality and kind. Sponge doughs should go through the brake or rolls as this produces a loaf of better texture and color.

Straight Doughs.

A dough in which all of the ingredients necessary for the entire batch are added to the mixture and mixed in one operation, is called a **straight dough.** This system is based upon the theory that a strong fermentation may be obtained by an added supply of yeast, sugar, and yeast foods, such as malt extract, which promote a vigorous fermentation and rapidly develop the gluten. Straight doughs are more economical in one way, because the mixing is done in one operation, thus saving time.

With the straight dough process, the fermentation may be very accurately controlled, although it is necessary to work up the doughs immediately upon their becoming ready. An interval of a half hour in the fermentation of a straight dough produces a much more manifest change in the quality of the resulting bread than would the same interval in a sponge dough.

The straight dough requires more mixing, which is conducive to a rapid development of the gluten, while a sponge dough should not be mixed too strenuously because the gluten is properly developed by the vigorous fermentation of the sponge. The conditions of fermentation in a short straight dough may be regulated more conveniently because atmospherical conditions of temperature, pressure, and humidity are not prone to change as much in a few hours as they might in a longer period such as is given to a sponge.

The flavor due to a sponge dough is a natural one; in the straight dough, however, since yeast foods and improvers are added, the flavor is influenced by the nature of these added improvers and, although it may be considered somewhat artificial, the result is a more palatable loaf. By the straight dough method a much sweeter flavored and richer product may be obtained, and since quality and flavor are the predominating factors which promote sales, it is considered advisable, if the proper facilities in a bakery are to be had, to adhere to a straight dough system.

"Sauerteig."

The "sour dough" or "sauerteig" system hardly merits consideration, since it is so little used in this country at the present time. The method consists in making a **soft sponge,** using a pound of dough from the previous day's batch, mixed with 2 or 3 quarts of water, without the addition of salt, sugar, etc. This soft sponge is allowed to ferment two and a half to three hours at 85° to 90°F.—and often as long as six or seven hours—and used as the sponge in the mix. After doughing up the dough is allowed to rise only about one hour. It is then scaled, moulded, and proofed, and baked on the oven bottom. It is seldom panned.

This system gives a coarse dark product, with a distinct and pronounced flavor that cannot be called mild and sweet. The only advantage that this method affords is that no materials other than flour, water and salt are used. The baker who uses sour dough generally maintains that his bread is made without yeast, whereas under the microscope the "sauer teig" is shown to be teeming with bacteria, cultured and wild yeasts. The inferiority of the product is largely due to the foreign infection that is carried in the innumerable wild yeasts and bacteria that are present in the sour dough and over which the baker can exercise so little control. As a system, it is to be condemned because of the inferiority of the product and the antiquated method of procedure.

FERMENTATION.

Fermentation of dough is a question that demands more consideration than has been given it. In fact, its importance has not been realized and largely because there has been no effective means of determining the proper degree of fermentation, the result has been a difficulty to maintain a uniformity of product. Fermentation may be defined in a general way as being the chemical changes associated with and effected by the development of micro-organisms.

Alcoholic Fermentation.

Of the kinds or types of fermentation that are met in the fermentation of bread dough, only one is to be desired, and that is called **alcoholic fermentation,** and which produces alcohol and carbon dioxide from the sugar. The production of carbon dioxide has already been discussed under the subjects of Sugars and Enzymes and little will be said of the mechanical action in fermentation. Fermentation produced by pure yeast is desirable, but other kinds of organisms may develop products that are not only undesirable but may be ruinous.

Lactic Acid Fermentation.

Lactic acid fermentation is often a source of annoyance to the baker in that it produces a high acidity in the bread. It is quite generally found in doughs that have been fermented at too high a temperature or in old doughs. Yeast fermentation is best carried on at a temperature of 78 to 82° F., and any temperature above this promotes the activity of **lactic acid bacteria.** Lactic acid in small amounts aids in developing the gluten by partially dissolving it and softening it. Glucose, cane sugar, and maltose all are readily decomposed into lactic acid under favorable conditions. Milk sugar or lactose is very susceptible to lactic acid fermentation. Lactose is converted by the enzyme lactase occurring in yeast into d-galactose and d-glucose (dextrose), the former being readily fermented by lactic acid bacteria with the formation of lactic acid. Lactic acid fermentation occurs simultaneously with alcoholic fermentation, but proceeds slowly at the relatively low temperature (78-82° F.) where the activity of the yeast is at its maximum. A small quantity of lactic acid beside favoring the development of the gluten in the dough, imparts a "nutty" flavor to the bread which, if not too pronounced, is very desirable. Larger quantities of lactic acid developed through fermentation decrease the palatableness of the loaf, impair its quality and indicate improper fermentation of the dough.

Butyric and Acetic Fermentation.

The formation of butyric acid through development of **butyric acid organisms** is favored by the same conditions that promote lactic acid fermentation, although the butyric fermentation generally follows the lactic acid fermentation. Butyric acid imparts a disagreeable flavor and odor to bread and its presence is extremely objectionable. **Acetic** fermentation is always subsequent to alcoholic fermentation and effects the conversion of alcohol into acetic acid after prolonged fermentation or after the supply of yeast food is so diminished that the yeast is no longer in a vigorous and healthy condition. Abnormal fermentation may be avoided through the use of strong and vigorous yeast, proper control of fermenting conditions and a good supply of available yeast food.

Viscous Fermentation.

The most objectionable and most to be feared infection that may enter into a bake shop is known as **viscous** fermentation and which produces **ropy** bread. Hot weather during the summer is particularly favorable for rope development and once an infection is found, it is difficult to eradicate it. Rope manifests itself in from twenty-four to forty-eight hours after baking and is due to a spore-forming organism that is very resistant to high temperatures. The spore withstands the temperature of the loaf in baking and develops and grows after the bread is cooled. The bread develops a peculiar odor, the interior becomes brownish in spots and becomes moist and sticky. The gummy interior may be drawn out into long silky threads which gives the name of "rope" to this condition. Rope organisms are generally introduced through the flour, and there is more danger in the use of low grade flour than with the better grades. Quite frequently the spores are found in cracks and crevices and in the troughs only awaiting favorable conditions for development.

When ropiness is found to be present in the bakery, steps should be taken immediately to ascertain the source of infection, but while this is being investigated a series of "first-aid" measures should be adopted to grant temporary relief from its development. All doughs should be acidulated with acetic or lactic acid, and acetic acid is to be recommended only because it is cheaper. Steps should be taken to procure flour known to be sound. The content of salt should be increased as also the yeast and yeast foods, the object being not only to shorten but to insure a more vigorous fermentation. The bread should be baked longer and drier as a moist and sodden interior is conducive to development of rope. After baking, the bread should be cooled quickly and if stored for any length of time should be kept cool. Wrapping is to be avoided if possible as the retention of excess moisture favors after-fermentation. The execution of the above recommendations will control and inhibit the growth of rope, but a complete disinfection of the shop is absolutely essential. The services of an expert, acquainted with "rope" are to be preferred so that the source of infection may be definitely located and proper measures inaugurated to stamp out the disease.

Humidity.

Principally among the many varying factors which enter into bread making, each of which has its influence upon the quality of the loaf, are **temperature** and **humidity.** The need and advantages of temperature control have been exploited sufficiently so that every baker now appreciates that there is an optimum temperature for fermentation of his dough. Just as important and advantageous to the baker is the accurate control of the humidity or moisture content of the air in his bake shop, and experiments have conclusively shown that without proper humidity, the baker is only "trusting to luck" that his product will be uniform from day to day.

The term **relative humidity** is used to express the percentage amount of moisture or water vapor that air at any definite temperature contains. For instance, air containing no moisture has 0% humidity while if saturated the humidity is 100%. Furthermore, air at any temperature is able to contain in actual amounts more moisture than air at any lower temperature. Air saturated at 80° F. with water vapor when cooled to a lower temperature would immediately precipitate out moisture in the form of rain or dew. No air is absolutely free from moisture. Even the air of the deserts has a relative humidity of about 20%. But if air on a cold winter day is led into a bake shop wherein the temperature is 80° F., the humidity falls below that of the air of the driest desert. The apparatus for determining the relative humidity is very simple and consists quite generally of a "dry" and a "wet" bulb thermometer, and from the difference in their temperature readings, the per cent humidity is easily calculated.* There are also direct reading hygrometers found on the market.

Experiments have shown that the proper relative humidity to maintain in a bakery is not less than 70% nor more than 80%. A difference of ten per cent affects the period of fermentation on a five-hour dough about 8 minutes, so that on a day in which the humidity is as low as 30%, the time of fermentation has to be lengthened by approximately 40 minutes. If the humidity runs high the period of fermentation should be shortened correspondingly. This same effect has been observed upon hot sultry summer afternoons preceeding a storm when the doughs **come fast.**

Perhaps the greatest source of annoyance to the baker has been due to the **encrusting of the dough** while fermenting in the troughs and this upon consideration is more serious than the baker suspects. The hardened crust is due to the evaporation of water from the surface of the dough and the lower the humidity of the fermenting room, the more rapid the evaporation and the heavier the crust formed. The crust cannot be eradicated once formed and appears as hard lumps in the baked loaf which are especially objectionable and obnoxious to the consumer. Proper control of the humidity prevents evaporation from the surface of the dough and eliminates any possibility of encrusting. Furthermore, the evaporation is a source of actual loss to the baker. Often in a one-barrel batch of dough the evaporation of the water from its surface amounts to as much as 6 pounds during the period of fermentation so that the baker is losing that amount that might be made into bread. The heavy crust formed retards fermentation because the dough is prevented from rising to the fullest extent. The gluten is not properly stretched and developed, and hence the volume of the loaf is sure to be lower. To counteract the hindrance due to the crust, more power

* See Appendix, table of humidity.

has to be furnished in the form of increased supply of yeast foods so that another source of loss results.

The consuming public have a right to demand bread of good quality, and uniformity of good quality is the best asset that any baker can possibly have. There is no longer any question of the effect of humidity upon bread making nor of the advantages which proper regulation afford, and the progressive baker will readily see the merits of humidity control.

Mechanical Factors Affecting Fermentation.

Other than influences of atmospherical conditions of temperature, pressure, humidity, etc., there are numerous other mechanical factors that affect fermentation. Certain manipulations favor while other conditions of operation are adverse to fermentation. For instance, a **slack dough** ferments more rapidly than a **stiff dough** largely because there is a larger supply of yeast food, sugar, etc., in solution and this furnishes readily available material for the yeast. Again, doughs that are coming up too fast are given more space in the trough while crowding the dough hastens the fermentation.

Another instance wherein the method of handling the doughs effects fermentation is in **the time of punching** or "cutting over." The dough is worked—"punched" or "cut-over"—when it becomes light in order that the subsequent rising may properly stretch and develop the gluten. Working down effects an equal distribution of the gas cells beside giving an impetus to fermentation. In "cutting over," the dough is so distributed that all portions are fermented evenly. The temperature of the dough is evened up and the fermentation proceeds more uniformly throughout. The "cut" is made by pulling the dough over the sides of the trough, first from one side and then the other and has the effect of folding the dough over upon itself.

Sometimes, in order to be sure that the dough is fermented evenly, portions are cut from it and spread out in another trough, successive portions being spread out on the preceding ones until all the dough has been transferred. This perhaps is the better method but takes more time and is not so convenient.

The **first punch** should be carefully timed and used as an index of the total period for fermentation. The interval of time between setting the dough and the first cut should constitute three-fifths of the total fermenting period so that on a five-hour dough, the first cut should be made three hours after setting. On a four-hour dough, the first cut should come two hours and twenty-five minutes after mixing. The custom has been generally to allow only half the fermenting period before the first cut, but it is better to have the dough slightly over-ripe because it puts more "life" into it. "A "young" dough or one punched too soon, never "catches up with itself" and behaves unseemly during its course in the bakeshop.

New flour not adequately aged has a tendency to slacken and to work young. This is due to the activity of the enzymes present in the flour. If it becomes absolutely necessary to use freshly milled flour, best results are to be obtained through the use of more salt, more shortening and giving the dough less fermentation but punching the dough more often. The increased salt reduces the activity of the enzymes in the flour while the shortening acts as a stimulant to the gluten. Less fermentation should be given the dough because of the danger of over-developing the gluten which in new flour is not matured. In punching the dough more often, it is not allowed to rise to its maximum which would over-develop the gluten, while the numerous punches improve the grain and texture.

PANNING AND PROOFING.

Importance of Proofing.

Improper proofing is the most common error made whereby all the effort spent in properly mixing and fermenting the dough may go for nothing. The best materials prepared under the most exacting control cannot be made into a loaf of good bread unless attention is given to the proofing of the dough in the pans. Proofing is just as important as fermenting, and the quality of bread in many bakeries is impaired because due regard is not given the dough in the proof box.

Method of Panning.

The accepted procedure in panning consists in **dividing** the dough into portions of such size desired to make one loaf,

rounding up that portion so that there is formed on the exterior a thin **skin.** This ball of dough is given a first proof of ten to twenty minutes at the temperature of the room and then moulded, placed in pans, and put into the proof-box or steam-closet for final proofing. When sufficiently proofed or light, it is baked.

In many bakeries, the manipulation of the dough is done in part if not entirely by machinery. A **mechanical divider** automatically cuts off portions of the desired weight and once adjusted accurately divides the mass of dough into pieces that later become loaves. Quite generally, the dough, before going to the divider, is run through a **brake** and worked several times. This is necessary for all sponge dough and is of advantage when straight dough method is used. This brake effects an even distribution of gas cells, produces uniform texture and improves the color of the loaf.

Moulding of Loaf.

The dividing process produces two "raw" ends so that in order to stop the **bleeding** it is necessary to **round up** the portion of dough and to put a skin over the exterior so that the carbondioxide gas does not break through but is retained by this enveloping skin. The first proofing permits of the dough recovering from the shock of the divider and allows for the formation of a small quantity of gas so that it may be easily moulded. The "rounding up" or "balling up" is generally done by hand although larger outputs necessitate machines. The balls of dough are put into a chest of drawers or in trays so that they are kept covered, during the first proofing of ten to twenty minutes. Quite generally in the larger bakeries, the preliminary proof is given by conveying the balls of dough direct from the rounder and carried in individual canvas pockets back and forth through an over-head case or long cabinet until sufficiently proofed. After the doughs recover sufficiently and possess some "life," they are moulded, and put in pans. The gas in the dough permits of tight or loose moulding depending upon the kind of bread being made. Moulding is quite generally done by machine.

Proofing.

After moulding, the loaves are placed in a closet heated with live steam at a temperature of 95 to 105° F. for the final proofing, which requires from thirty minutes to an hour according to conditions and kind of bread.

Quite often, however, the dough must stand in the proof box for longer time than would be necessary to obtain proper proof, and the baker at the same time is distressed because his bread comes from the oven poor in quality. One of two conditions is generally at fault. In colder seasons of the year when the temperature of the shop is comparatively low, the baker makes a practice of setting his doughs somewhat warmer in order to correct in a way for the low temperature of the shop. A large mass of dough is to some extent heated by the activity of the yeast during fermentation that by the time the mix goes to the bench, the dough is not so much cooled as to show any effect of the low temperature of the room. However, when the dough is divided, each small piece is exposed to the chill of the room and of the machines, and the "shock" is so great that the yeast does not recover very easily.

Yeast and doughs should never be subjected to sudden changes in temperature, either high or low, because the activity is so retarded that even though it is again brought to the optimum temperature, the action is very slow. Sudden changes in temperature effect in a measure a paralysis of the yeast and heroic treatment can little help the situation. The result of the sudden cooling is that the bread does not proof properly, even when left for a long time in the proof box, and the quality of the loaf is thus affected. The slow proofing is conducive to foreign fermentation inasmuch as the activity of the yeast is depressed, and as the high temperature in the proof-box favors the development of lactic and butyric acid bacteria, the dough is apt to become sour. Thus, the importance of proper attention to the proofing is very evident.

Improper proof may be had in a dough in which the supply of readily available yeast food has been so depleted that the yeast is no longer vigorous, and foreign fermentation crowds out the alcoholic fermentation. This has the same effect as shown above and produces a loaf of poor quality and flavor.

Relation of Proofing to Baking.

In proofing of bread, proper regard for oven temperature must be had. Over-proofed dough should be baked in a **quick** oven, or if the oven is not quite ready by not being hot enough, the loaves should have less proof. In other words, **slow** ovens for underproofed dough and short proof for "slow" ovens. This is readily apparent when we stop to consider that an over-proofed dough has risen near its maximum and is in danger of **falling**. A "quick" or hot oven forms a crust over the surface of the dough which allows for the "spring" and at the same time lends support to the loaf. In a "slow" oven the reverse is true. The formation of the crust is delayed until the proper expansion of the loaf. Over-proofed loaves have a coarser texture but a larger volume while under-proofing produces a denser texture and lower volume.

In the manufacture of the split loaf, only half-proofed or two-thirds proof is given it. This with plenty of steam effects a good "break." The split effect may be imparted by placing two thin loaves side by side in the pan or by pressing down the middle of the loaf from end to end with a scraper or similar instrument. The most effective method is to slash quickly and deeply the loaf from end to end with a sharp knife held not perpendicularly, but slightly inclined. Proper proof, experience in cutting, and plenty of steam are necessary in the production of a good split loaf.

BAKING.

Proper Temperature for Bread-Baking.

The temperature necessary to bake bread is dependent upon the kind of bread, the formula used in making the dough, the size of the loaf and the personal preference and prejudice of the bakery foreman or superintendent. The greatest source of difference of opinion is due to the inaccuracy of the ordinary oven pyrometer in that a correct reading of the exact baking temperature cannot be obtained.

Pyrometer.

The ordinary **pyrometer** is not a thermometer but only an indicator. Quite generally the pyrometer is inexpensively constructed and is so placed that the actual average temperature of the oven cannot be obtained. As an indicator, however, it is indispensable because when once the proper baking heat is reached, that same oven heat is attained when again the pyrometer indicates the same point. Again, one oven may be quite right when the pyrometer registers 450° F., whereas another oven bakes properly when the pyrometer registers 525° F. and yet both may be at the same heat. It is not necessary to know the exact temperature but to know that the oven is or is not ready when a certain temperature is indicated.

Time for Baking.

Experience has shown that the actual temperature necessary to bake one-pound loaves in tin is 450° F. for 30 minutes. This pre-supposes an oven loaded to capacity and if the oven is not full, slightly lower temperature should be used. A single loaf or only a few loaves would burn badly if placed in a large oven at 450° F. Larger loaves should be baked correspondingly longer and at lower temperature. Three-pound tinned bread should be baked at 325 to 350° for about an hour and a quarter to an hour and a half. For hearth bread, slightly higher temperature is required than for panned bread.

Loss of Weight in Baking.

Pan bread, in baking, loses about one-eighth of its weight due to the water evaporated. A loaf scaled at 16 ounces should weigh very close to 14 ounces when baked, two ounces of water having been baked out. Bread baked quickly at a higher temperature loses less water than when baked at a longer period at a lower temperature. This must be taken into consideration when the tolerance in the net weight of bread allowed by regulations is very low. The loss in baking of hearth bread is much greater, while the loss is much less when twin loaves are made in one pan. If bread is to be used on the day that it is baked, it should be baked more thoroughly than when for use the following day.

Use of Steam in Oven.

The practice of using steam in the oven has been adopted almost universally. Steam produces a thin crust, permits of full **spring** of the loaf in the oven, prevents cracking and improves the appearance of the loaf in general. In baking the split-loaf, steam is quite as essential as the heat of the oven, while with hearth bread, steam is quite necessary.

Steam under a gauge pressure of 15 to 20 pounds should be used. The action of the steam depends upon the condensation of a small amount of moisture upon the surface of the loaves. From **high pressure steam,** which has a correspondingly high temperature, the condensation is not sufficient to precipitate the necessary quantity of moisture, and as a result no effect of the steam is to be had. In fact, steam at 50 pounds gauge pressure, and which has a temperature of 298° F., is of little better service than no steam.

The film of moisture formed upon the surface of the loaves delays the formation of the crust so that the loaf attains its full volume. It also keeps the surface crust from drying out and produces an elegant bloom. In the split-loaf type of bread, a large quantity of low pressure steam is necessary in order to produce effectively the crack or break in the top crust.

Too much steam, however, softens the top of the loaf, causing it to flatten out and producing a dense ring next to the crust. Often too much steam accounts for the large blisters that appear in the crust of the bread. In baking hearth bread, steam should be admitted to the oven before loading, during, and for about five minutes after. The steam should be turned off and the damper opened, and allowed to be open for five minutes, after which it is closed during the remaining period of baking. Too much steam causes the loaves to run together or crack along the sides in attempting to "kiss."

CHAPTER IV.

General Discussion.

SCORING OF BREAD.

Method of Scoring.

The method that has been used in scoring bread depends largely upon personal ideas and the standpoint from which the bread is to be judged. By some bakers, quality may be given the most weight while other bakers strive to produce a loaf of large volume and naturally their bread score card would differ. Again, commercially made bread cannot be scored as the housewife's bread because we don't expect the latter to be in a position to control conditions as in the bake shop, no matter how small. Bread offered for sale to the public is carefully scrutinized and all the points whereby the choice of the public is affected must be taken into consideration in preparing a score card according to which "baker's bread" may be scored.

Score Card.

Following is a score card in which quality bread rather than quantity bread is given a decided preference. It corresponds very closely with the average of a series of score cards submitted by many bakers, and for that reason may be called representative of commercial conditions inasmuch as the baker has used the same card in scoring his own and his competitors as well. On a 100 points or 100 per cent basis the factors are given the following values or scores:

General appearance	15
Color of Crumb	10
Texture	15
Grain	10
Flavor (taste 20, odor 15)	35
Loaf Volume	15
	100

The **general appearance** includes the general shape, symmetry of form, crown, color and bloom of crust; and it is these factors that should be given first consideration in a contest concerning a large series of loaves.

Color of crumb of the cut loaf is very important inasmuch as the grade of the flour and the general conditions of fermentation influence the color, but the color of a loaf without a standard for comparison would not be duly appreciated. The color also is affected by the grain, a close and even grain causing the color to appear whiter.

Texture is often taken to include "grain" or to be even "grain" itself. **Grain** indicates the distribution of gas cavities, their size and number, and might be called porosity. **Texture** includes the elasticity and is determined by pressing the cut edges of a loaf together or by pressing with the tips of the fingers, and noting the spring in resuming its original shape. Under texture is grouped the "**lightness**" although the "grain" also indicates to some degree the lightness of the loaf. The "**feel**" as the back of the index finger—that part between the last joint and the nail—is rubbed over the cut surface, as well as the "sheen" when observed from an obtuse angle, may suggest velvet to the operator and a soft "velvety" surface indicates good quality. The crust, whether brittle, crisp, tough or leathery, should be scored as texture.

The **flavor**, after a definite standard has once been formed, is of prime importance and induces the consumer to favor one product as against another. Under flavor, the odor of the bread is scored. The personal element is stronger here than with any other factor in scoring because often a decided flavor is liked as compared to a mild and mellow flavor such as is obtained from a short straight dough method.

Loaf volume, except in communities wherein the size of the loaf, and not quality necessarily, appeals to the purchaser, has little importance except that it indicates proper development of the gluten in the fermentation and proofing, as well as proper moulding.

HOLES IN BREAD.

There are many factors that are associated with the manufacture of bread that cannot be sufficiently standardized by definite laws and rules so that one is enabled to assure himself of uniform results in bread quality. Of constant annoyance to the baker is the prevalence of **holes in bread.** The causes of these are several and are due to the improper fermentation or to the actual physical handling of the dough itself. Holes may be produced in bread through over fermentation and to this is due the greatest majority of cases. If the gluten in the dough has been fermented too long or too strenuously it becomes weakened, loses its elasticity and tenacity, and the thin walls of the gluten "cells" or pockets, being fragile, become disrupted so that several gas cells unite to form a hole. The condition usually manifests itself in the proof box and often results in a complete breaking down of the gluten with the formation of holes two to three inches in diameter.

Sometimes cases are found in which under-fermented dough contains holes. This is little different as far as the cause is concerned from a case of over-fermented dough. In this case the gluten has not been sufficiently fermented so as to develop its elasticity and tenacity, and therefore cannot enmesh and retain the carbon dioxide gas. This can best be demonstrated by taking a series of portions from one large dough at regular half hour intervals, moulding, proofing and baking. The first loaves will show very poor texture and contain many larger or smaller holes.

Holes in bread may be caused by the inadequate breaking down of the sponge when doughing up and especially is this true when using a weaker flour in doughing. The imperfect mixing leaves portions of the sponge intact in the dough, and the gluten in these portions becomes over-developed, losing its elasticity which permits of the formation of holes in the loaf.

Often the method of moulding, combined with the proofing process, produces poor texture. Too much pressure or uneven distribution of pressure by the fingers have a retarding action upon the proofing and the uneven proof gives rise to holes. The amount of pressure and working of the dough in moulding should be regulated according to the dough, the amount of fermentation it has had, and the strength and elasticity of the gluten in the dough. Often in pounding the gas from the dough in moulding, the loaves are blistered so that the holes occur slightly beneath the crust.

The causes that produce holes are generally due to carelessness, inexperience or improper moulding, combined with over-fermentation, and all flours, and all bread formulas are subject to their development. Using proper manipulation, any sound flour, however weak or strong, can be made to produce a loaf of even grain and free from holes.

DEGREE OF FINENESS OF FLOUR AND ITS EFFECTS UPON ITS COMPOSITION AND BAKING QUALITY.

Bakers and millers as well as chemists have for a long time held that the granular **feel** of flour served as a good index of its quality and character. The flours that were granular or **gritty** or **sharp** when rubbed between the fingers were supposed to be good quality and declared to be so, whereas flours of softer texture were declared to be inferior.

Uniform Granulation.

In the analysis of flour, use had been made of a nest of eight flour sieves numbering consecutively from 9 to 16, through which a weighed quantity of flour was bolted. If on three adjacent sieves 75% of the sample remained, the flour was considered uniformly granulated and the inference was that uniform granulation permitted of an even fermentation of the flour when made into dough.

At one time this test may have been sufficient to characterize a flour, but with modern milling methods, which permit of the most elastic system as far as the method of manipulation is concerned, the infallibility of the test has been so frequently refuted by facts that it is gradually being relegated to the position it merits.

Recent Experiments.

Recent experiments have shown, however, that the quality and grade of flour does not depend upon the degree of fineness necessarily, but that a fraction of the same degree in fineness differs in quality and composition as compared to another fraction of finer or coarser particles even when both are derived from the same wheat or separated from the same flour.

In the experiments, a series of commercial brands of flour as well as several flours of known history, having been milled from known varieties of wheat in an experimental mill, were bolted through a nest of four sieves numbered respectively

15, 18, 20 and 21 standard silk. This produced from the original flour five fractions of flour, since part remained on each sieve and a portion passed through No. 21.

The several fractions, together with the original flour used as a standard, were carefully analyzed, baking tests made, and the results compared.

Results.

The average results of all the experiments indicated that one-third of the sample bolted through the No. 21 sieve, while 85% passed through the No. 16 sieve which is much more finely meshed than the finest flour silk ordinarily used in any mill, viz: No. 10 to No. 12, and that on the three intermediate sieves, No. 18, No. 20 and No. 21, there remained approximately 7, 12 and 30 per cent respectively. The four coarser separates show quite similar qualities and characteristics while the finest fraction stands apart strikingly. The four coarse separates produce bread of better quality than the original flour. The volume, texture, grain and color of the loaves are better than the original, while the protein, absorptive capacity, and expansion are higher and the ash content and acidity much lower than the original flour. The protein of flour passing the No. 21 shows peculiar properties in that the quality of the loaf is much inferior to that of the original. The loaf volume, color, texture, grain are woefully low while the gluten is more than 2 per cent lower than the original flour and the expansion and absorption much lower, and the ash content and acidity much higher.

The results of these experiments indicate that the flour is much finer than might be inferred through the use of No. 10 to No. 12 bolting cloth by the miller. The granulation test as formerly used is not applicable to modern milled flour. The extent and character of the finest fraction indicates that the finest flour is not always the best in quality as is generally held. Furthermore, the miller has been given a method whereby he may measure the extent of attrition flour and be able to find out when he has reduced this to a minimum. The experiments have suggested that proper manipulation may result in the separation of a lower grade of flour from a patent grade thereby obtaining an excellent patent portion.

FLOUR SUBSTITUTES.

On account of the high price of wheat as compared to other cereals, and also in an effort to find a commercial source for the disposal of a series of products, there have been tried numerous experiments to find suitable substitutes for wheat flour.

Since no other cereal, except rye and that only to a slight extent, possesses gluten, which is the constituent that renders wheat flour valuable as a bread-making material, it can be said that any other materials, however closely resembling wheat flour superficially and which might be classed as a substitute, should really be considered as an **adulterant.** The present existing "Mixed Flour Law" has proven ample protection against the frauds which without it might easily be perpetrated against the consuming public.

Numerous products have been made into flour and substituted in part for wheat flour, among which are potato-flour, potato-starch, corn-starch, corn-flour, rice-flour, cotton-seed meal, peanut meal, soybean meal, etc. Of these, only the products made from **corn, potato** or **rice**, as far as color is concerned may well be used. **Peanut meal** with wheat flour makes a very palatable loaf, as does **cottonseed meal,** but the color mitigates against them so that neither can hardly become popular. **Rice flour** has been found of use in pastry and cake baking, and although it reduces the nutritive value of the product, nevertheless, it improves its appearance quality.

Corn starch and **potato starch** have no place in a loaf of bread. Addition of either to wheat flour is a plain and evident case of adulteration of wheat flour with a substance (starch itself) of which the flour has already a large excess. In increasing the quantity of starch, the content of the other valuable constituents such as gluten, mineral substances, is correspondingly reduced and hence the nutritive value lowered. If corn starch or potato starch were any other color than white, their use as a substitute would hardly have been suggested. Under certain conditions wheat flour has been mixed with other materials without seriously impairing the quality, but no substance when used in as small amount as 10 per cent fails to have a deleterious effect upon the quality of the finished product.

The Use of Corn Flakes with Malt Extract in Bread-Making.

Corn flakes are manufactured by passing corn, after the removal of the hull and the germ, between hot rolls. The corn before going to the rolls is cooked so that the starch is gelatinized. The pressure of the rolls is sufficient to flatten out the corn in the shape of flakes and the heat of the rolls drys them. **Flakes** are used in bread making for two distinct purposes: to increase the absorptive capacity of the flour as well as the moisture retaining power of the bread.

Corn flakes have the power to absorb and retain often as much as 200 per cent of water, so that 3 pounds added to a barrel of flour (not more than 3 pounds per barrel is the most advisable quantity to use) may increase the amount of water necessary for making the dough by 6 pounds, whereas the absorption of 3 pounds of flour is only about 2 pounds. The best results are obtained by adding the required amount of corn flakes in the proportion of 3 pounds per barrel directly to the mixer with the flour with no other change in the formula except the increased amount of water.

Corn flakes are used also with **malt extract** to effect a vigorous fermentation and to cut down the quantities of sugar and yeast necessary.

The theory in this method is that at 150° F. the conversion of the gelatinized starch of the corn flakes is effected by the diastase contained in the malt extract, producing maltose, principally. When the yeast is added at 90 to 95° there is begun a vigorous fermentation and it will be noted that when added to the mixer it shows of being vigorous. By this method, the yeast is strengthened and upon making up the dough, the added ferment causes fermentation to proceed very rapidly.

In using this method, the quantity of sugar may be reduced 3 pounds per barrel while the yeast should be reduced to 2 or 2¼ pounds per barrel, making a great saving in both. The loaf produced has an excellent bloom, and has a very thin and crisp crust. Not more than 3 pounds of corn flakes per barrel should be used and the diastatic power of the malt extract should be sufficiently high so as to insure complete conversion of the corn flakes.

CHAPTER V.

The Analysis of Flour.*

VALUE OF CHEMICAL ANALYSIS.

The value of chemical analysis of flour and baking and milling materials should be apparent to all enterprising and energetic millers and bakers. To the miller it affords an opportunity whereby he may know the quality of each grade of wheat; he may know the relative merits of each stream in his mill and with this knowledge may blend the streams in a manner to conform to the needs or specifications of his customers; he may find that he has been cutting off his reduction streams permitting a large quantity of flour to go to the "clear" when perhaps it should go to the "patent" flour bin, or he may find that a low grade middlings flour may be the cause of his patent being low in quality. On analysis of the several streams a slight discrepancy will show that the bolter may be working improperly or that the silks need changing. In having an accurate knowledge of his own flour, the miller can readily compare his competitor's products and determine their relative qualities, as is best established by following analysis and opinion thereon.

Technical Analysis of Flour.

	No. 1	No. 2	No. 3	No. 4
Color	98.0	100.00	102.00	99.50
Ash	0.592	0.558	0.440	0.501
Absorption	61.0	61.0	63.0	61.0
Gluten	11.45	10.95	10.74	10.62
Protein (N x 6.25)	11.53	11.15	10.98	10.83
Loaves per Barrel	100.0	100.0	103.4	100.0
Volume of Loaf	97.6	100.0	99.0	103.2
Quality of Loaf	98.0	100.0	102.0	101.0
AVERAGE VALUE	98.4	100.0	101.6	100.7
Fermenting Period	107.3	100.0	98.9	94.9
Quality of Gluten	91.4	100.0	100.4	107.8
Moisture	10.84	11.58	11.05	11.37

Sample No. 1 is a straight grade flour of poor quality. This opinion is based on the following facts: the color is rather dark

* See also flour, Chapter II.

and the ash contents very high, and while the gluten is high, it is very poor in quality and dark of color.

From these conditions it is evident that the volume and quality of the loaf is poor, as indicated in the above. Odor and flavor of the flour however was normal.

Sample No. 2 is a very good straight grade flour, having good gluten content of a creamy color. This flour produces a loaf of good volume and quality, and since it is furthermore of normal flavor and odor, it possesses all the qualities which would commend it as a "standard" for straight grade flours.

Sample No. 3 is a good patent flour, having a very good color and low ash content. The gluten is of average amount and good quality and has a light creamy color.

The yield as indicated by the absorption is very high and since the flour was also normal in odor and flavor it must be designated as of very good grade.

Sample No. 4 represents a long patent grade, as indicated by the ash content. It is slightly dark in color, possesses normal absorption and gluten, which is however, of very good quality.

This flour produces a loaf of very good volume and quality and we particularly call your attention to the fermentation period which is rather short.

In view of all these facts this sample must be considered as representing a good article of its kind.

To the baker, an analysis is almost indispensable because of the wide variance in the quality of flour. If the moisture content of a flour is very high, he is not only buying too much water but also a flour that is in danger of spoiling upon storage. The absorptive power should be known because it is an index into the yield, the more water is absorbed by the flour the larger will be the quantity of dough made. The ash content indicates the grade of the flour, and since so-called patents vary from 75 to 100% of the total available flour and since a "patent" from one mill need not correspond to but may be much superior or inferior to a "patent" from another mill, it is evident that analysis is of great importance. The acidity, the gluten, the expansion and stability, etc., are all indicative of the quality of flour and the more that is known concerning any sample of flour, the more likely will the baker be able to control uniformity of his product.

METHODS OF ANALYSIS.

Moisture.

For the determination of moisture, 5 grams of flour are weighed off in a small aluminum dish or cup and dried at 100° C. (the boiling point of water) until it ceases to lose weight which requires three to five hours. From the loss in weight, the percent of moisture is easily calculated. A moisture content higher than 13 per cent is conducive to spoilage and also indicates to the baker that he is buying too much water and to the miller that he is improperly tempering his wheat.

A very rapid and accurate method of determining moisture in flour and especially in grains and food stuffs, etc., consists in heating a weighed quantity of the material to be tested (100 grams) in a flask with oil. The water distills over into a graduated cylinder and the volume is read. The apparatus is known as the **Brown-Duvel moisture tester.** It is simple in construction and very easy of operation and has been adopted as official in establishing corn grades.

Ash.

The ash is determined by igniting over a flame or in an electric muffle furnace a weighed portion (5 or 10 grams) of material contained in a weighed crucible until a white or greyish residue of ash remains. From the weight of the ash the percentage is then calculated. The ash content indicates the grades of the flour and gives a valuable index as to its quality.

Color.

The color of flour is determined by comparing the sample with a standard. The sample and the standard are "slicked up" alongside each other on a glass slide or narrow board in the shape of a wedge. The line joining the two is made sharp and distinct so that the color difference is readily seen. The slide with the flour is dipped into water for 10 to 15 seconds, and the surface dried by placing in an oven. The wetting and subsequent drying accentuate the difference in color. The color of the patent standard is 100 per cent while that of the clear standard is 70 per cent, so that using mixtures of the two with known varying percentages the color of the sample under examination may be accurately determined.

Absorption and Loaves Per Barrel.

Absorption is the percentage amount of water that flour absorbs in making a dough of standard consistency. It is determined by adding sufficient water from a burette to 50 grams of flour contained in a cup, and working with a spatula or knife until the mass has the consistency of the standard which is run in parallel. Absorption value is an index of the quantity of water that may be used in doughing up. Some flours "tighten up" while others ferment soft and sticky, so that the absorption test is not an infallible one. Loaves per barrel is the ratio of the absorption value of the sample to the standard and is quite generally expressed in percents.

Dry Gluten.

Dry gluten is determined by weighing the dry mass obtained after separating the starch by washing in water. Twenty-five grams of flour are doughed up with water, allowed to stand under water for at least an hour and washed through three changes of water or in a fine stream of water until the wash water is perfectly clear and free from starch. The mass of gluten is washed over a fine wire gauze or bolting cloth to collect the small fragments of gluten which break away from the main portion. The mass is baked, dried, and weighed, and the percentage calculated. The mass of wet gluten gives to the experienced operator a knowledge of quality and character of the gluten which is quite generally of more importance than the actual amount contained in the flour.

Protein.

The total protein is determined chemically by digesting 1 gram of flour in 20 c.c. of concentrated sulphuric acid in a Kjeldahl flask, subsequently liberating the ammonia formed from the protein by means of concentrated caustic soda solution and distilling the same into a measured quantity of standard acid solution.

Titrating the excess of standard acid with standard alkali gives the amount of nitrogen which when multiplied by 6.25 will give the amount of protein present in the original 1 gram of flour.

While this chemical method gives accurately the actual amount of protein, it does not enable the operator to form any idea as to the quality and character of the gluten contained in the flour.

Acidity.

Acidity of flour is determined by titrating an aqueous extract with standard alkali. Eighteen grams of flour are digested at 40° C. with 200 cubic centimeters of water for 10 minutes, and allowed to stand at room temperature for an hour with occasional shaking. The extract is filtered and 100 cubic centimeters of the clear filtrate titrated with tenth normal (N/10) alkali using phenolphthalein as an indicator.

1.0 cc. of tenth normal alkali corresponds to an acidity of 0.10 per cent, calculated as lactic acid. A high acidity value indicates usually improper storage and unsoundness, although ash content has to be taken into consideration. Acidity and ash content of sound flours run in parallel, high acidity associated with high ash content.

Gliadin and Gliadin Number.

Gliadin is one of the two important proteid bodies that constitute gluten and is that adhesive part of gluten which serves to bind the mass of flour into dough. The ratio of gliadin to the total protein of the flour when expressed in percentage is called **Gliadin number.** Gliadin is soluble in 70% alcohol and is determined analytically by digesting 2 to 8 grams of flour with 200 cubic centimeters of 70 per cent alcohol, filtering, taking an aliquot sample with subsequent treatment as under the method for determining protein.

Expansion or Fermentation Value.

Fermentation value is determined by fermenting 100 grams of flour made into a dough with 3 grams of sugar and 5 grams of yeast, and under standard conditions. The dough is placed in a graduated glass cylinder and its volume read at 15 minute intervals until its maximum expansion or volume is reached. The ratio of this volume to that of the standard fermented under the same conditions is called the expansion or fermentation value. The maximum expansion is the volume of the dough as read on the cylinder when an interval of 15 minutes shows no increase in volume.

Fermentation Period.

The time required for the dough to rise to its maximum volume under the expansion determination is called the "fermentation period." It is generally expressed in per cent of the standard.

Quality of Gluten.

The quality of gluten is the ratio of the expansion per gram or per cent of gluten in the sample to that of the standard and expressed in per cent. The expansion per gram or per cent is obtained by dividing the maximum expansion by the percentage of gluten.

Stability.

The stability of flour may be defined as the ability to withstand fermentation when made into dough. The stronger the flour the more fermentation is required and the more the flour will withstand. Weak flours break down under strong fermentation so the stability test is a measure of the strength of the flour.

The stability test is the average of three successive risings using the expansion method. After the dough has come to the maximum volume in the expansion test, punch down well with a spatula or knife and allow to come to maximum. Punch a second time and allow to rise. The average ratio of the maximum expansion for the three rises as compared to the standard is termed the stability.

BAKING TEST.

The baking test is the one test which of itself has real merit. The chemical analysis gives a valuable index as to quality, when more than one determination is considered. For instance, the ash determination indicates the grade of a flour, but like any other single determination it does not sharply differentiate between good and poor flours. But the ash test, along with the acidity, color, expansion and gluten, etc., sufficiently characterize it. The baking test combines in a measure a series of tests. The color, absorption, quality of the gluten, expansion, etc., have their influence upon the loaf so that a baking test quite generally substantiates the results of chemical analysis. In fact an analysis of a sample of flour should include not only the purely chemical determinations, but also a baking test.

Of the several accepted methods of making comparative baking tests, the one outlined below is considered to be best because it approaches more closely the methods employed in the bake shop. The dough is made up and manipulated according to the "straight dough" methods, whereas the other methods provide for a ferment of yeast and sugar to stand for 30 minutes to an hour before using to make up the dough. Again, the doughs are "punched" according to a time schedule, and in a manner which is similar to the bake-shop methods.

The size of the loaf is generally a matter of convenience. A larger loaf baked in a standard pan is to be preferred. The formula is varied somewhat in quantity of flour used—340 grams for hard Spring and hard Winter wheat flour, and 380 for soft Winter wheat flour, but the quantities of other ingredients is constant, i. e., sugar 10 grams, yeast 10 grams, salt 5 grams, shortening 8 grams and water in sufficient quantity to make a dough of standard consistency and determined from the absorption value.

The flour, sugar and salt are weighed out into a shallow stone jar, or crock, and placed into a warming cabinet at 80 to 85° F. until same reaches this temperature. The yeast is smoothed in a portion of the water and the dough made up using the remaining portion of water, the total amount corresponding to the absorption of the flour, and adding the yeast liquid last. The shortening is added after the batch has been mixed for some time, and thoroughly incorporated in the mix. The proper temperature of the water to be used in this test is determined by subtracting the sum of the temperature of the flour and room from 246°. The mixing is best done with a large spatula or palette knife that has been cut off or a dulled ordinary "butcher's" knife or a putty knife.

After 10 minutes the crock, containing the dough, is removed from the closet and the dough worked again with a spatula or knife and replaced in the closet. The first, second, third and fourth "cuts" are made at intervals of 90 minutes, 45 minutes, 23 minutes and 12 minutes, respectively, following mixing and is done by removing the dough from the crock, working on the bench to remove the gas and in a manner similar to "rounding up." The dough in a neat round ball is replaced in the crock, put back in the closet to be "cut" at intervals as indicated. Ten minutes after the fourth working, the dough is moulded and panned. The interval of time between mixing and panning is three hours so that a test loaf is a three-hour straight dough loaf. The loaf is placed in a steam closet heated to 100 to 105°F. with live steam and when proofed to three times its original volume is baked at 425° to 475°F. A one-pound loaf should be baked 30 to 35 minutes and other sizes accordingly.

LABORATORY OUTFIT.

1 Balance, Baker's scale.
1 Analyt. Balance, cap. 100 grs.
1 Set of weights, analyt. 100 grs.
2 Retor stands with 3 rings.
1 Tripod, 6 inch.
1 Drying oven, for gas or electric.
1 Waterbath, 6 inch.
1 Test tube support
3 Sets of beakers, No. 00 to 3.
4 Erlmeyer flasks, 250 and 500 cc.
2 Flasks, fl. b. 250 cc.
1 Washing bottle, 500 cc.
3 Kjeldahl flasks, 500 cc.
2 Funnels, 4 inch.
2 Funnels, 2½ inch.
4 Crucibles, porc. No. 1.
1 Evaporating dish, porc. 3½ in.
3 Moisture cups, alum. 2 inch.
2 Doz. test tubes, 6 x ⅝ inch.
1 Cylinder, graduated 50 cc.
1 Cylinder, graduated 250 cc.
1 Pipette, vol. 5 cc.
1 Pipette, vol. 10 cc.
1 Pipette, vol. 25 cc.
1 Pipette, vol. 50 cc.
1 Burette, Mohrs, 50 cc. 1/10.
1 Burette clamp holder.
1 Burette pinch cock.
6 Glass slides, 2 x 5 inch.
4 Glass rods, 4 to 8 inches long.
3 Watch glasses, 5 inch.
1 Thermometer, 220° F.
1 Thermometer, 400° F.
3 Triangles, pipe cov. st. 2 inch.
6 Wire gauze, iron, 5 x 5 inch.
1 Wire gauze, brass or copper, 40 mesh, 12 x 12 inch.
6 Porcelain cups.
1 Porcelain gluten bowl, pint size
3 Jars, stoneware, ½ gal.
2 Jars, Chidlow expansion, cap. 1,000 cc.
1 Spatula, 4 inch.
1 Table knife, 6 inch.
1 Table spoon.
1 Teaspoon.
1 Flour slick.
1 Triangular file.
1 Forceps, brass.
1 Tong, brass double bent.
1 Test tube brush.
1 Camel hair brush.

1 Dessicator, Scheibler's, with plate 8 inch.
1 Extraction apparatus, Soxhlet's compl.
2 Condensors, Liebigs.
2 Condensor bulbs, Kjeldahl's.
2 Clamps, Universal condensor.
2 Clamp holders.
2 Doz. reagent bottles, glass stopper, 8 oz.
200 Filters, white, 5 inch.
100 Filters, white, 10 inch.
Glass tubing, assorted sizes, 1 lb.
Red and blue litmus paper, 2 books each.
Rubber hose of different size.

Additional Apparatus for the Baker.

1 Microscope, double nose piece, magn. power 550.
12 Slides, microscopic, 1 x 3 inch.
1 Box cover glasses, ⅝ inch rd.
1 Dropping bottle.
1 Babcock milk and cream tester compl.

Additional Apparatus for the Miller.

1 Microscope, double nose piece, magn. power 300.
12 Slides, microscopic, 1x 3 inch.
1 Box cover glasses, ⅝ inch rd.
1 Bushel weight grain tester.
1 Moisture tester; Brown-Duvel complete.
2 Gooch crucibles.
1 Filter pump.
1 Erlmeyer filter flask, side neck.

Reagents, Solutions.

Hydrochloric acid, dil.
Sulphuric acid, dil. and n/10 sol.
Nitric acid, dil.
Acetic acid, conc.
Ammonium hydroxide, dil.
Ammonium chloride.
Ammonium carbonate.
Barium chloride.
Caustic soda, conc. and n/10 sol.
Sodium carbonate.
Potassium ferrocyanide.
Silver nitrate, n/10 sol.
Methyl orange.
Phenolphthalein.
Alcohol, ethyl 95%.
Sulphanilic acid.
Alpha Naphtylamine.
Ether, sulphuric.
Iodine sol.
Mercury.

Reagent, Solids.

Asbestos, washed for Gooch crucible.
Calcium chloride for Dessicator.
Permanganate of Pot. cryst.
Sodium hydroxide, sticks.
Sodium hydroxide, Greenbanks.
Zinc, granular.

BREAD AND CAKE FORMULAS.

Introduction.

In the formula charts for different kinds of bread, it will be noticed that all are based upon a **half barrel unit,** using straight dough method. It is perhaps needless to say that in mixing the dough it is best to add the salt and milk with most of the water to the mixer, at the proper temperature, and effecting solution by a few turns of the mixer arms. The yeast and sugar are added to the remaining water at 80 to 85° F. containing the malt extract and smoothed down and allowed to stand while the other ingredients are being weighed out and dissolved. Milk powder and malt sugar should be stirred in with the flour before mixing. Approximately four-fifths of the flour is added to the mixer and mixed several minutes before adding the remainder of the flour and the yeast-malt solution. After the mixing is practically complete, add the shortening and complete the mixing. In making a larger or smaller dough, the ratio of yeast will of necessity be changed slightly as a larger dough requires correspondingly less yeast and a smaller one somewhat more.

In using the **cake formulas,** it must be remembered that they are not intended for household or amateur use. It is presumed that the baker understands the proper order in the addition of the several ingredients as also the proper manipulation of the mix.

As an illustration of the use of the cake formulas, let us take Sponge No. 2 under Chart IV. In that case the procedure would probably be to first weigh off all the materials, sifting the one-half ounce of baking powder with the flour. Weigh out the sugar, add the whole eggs and whip until light. Add the butter which should be rather soft and free from salt and excess water and beat until light, adding the vanilla before finishing, and finally the flour. When a machine is used, mix the flour on low speed. In adding the vanilla with the butter, the flavor of the product is not baked out as is the case when added during the last stage of the mixing. The flavor is due to substances that are quite soluble in the shortening, and consequently is retained more completely in the case by this method. The results to be obtained do not necessarily coincide with the amount of effort expended in whipping a mix, especially so when made by hand, inasmuch as it requires experience and a "knack" to incorporate the maximum amount of air.

Taking another example, for instance, wine cake mixes, as indicated in Chart III, the method of procedure should probably consist of creaming the lard and butter together with the sugar, adding the quantity of eggs slowly and in about six portions. Cream thoroughly after the addition of each portion. The vanilla is beat in, and the flour, with which has been sifted the baking powder, and all the milk, are added at one time, and mixed on low speed. Oftentimes, especially in rich mixes, the flour is mixed in by hand as this produces a lighter mix.

In this connection it might not be amiss to add that a process is adopted which appears quite practical and consists in working a small quantity of the flour containing no baking powder into the shortening at low speed, finishing after a few minutes on high speed. The remainder of the flour into which the baking powder has been sifted, together with the milk in which the flavoring and the sugar has been dissolved, are added and mixed at high speed for a few minutes, finishing on low speed until the batter is smooth. This method insures a close and even texture to the cakes and permits of incorporating a larger quantity of sugar and milk or water.

In the foregoing, we have selected as the most practical, to indicate first the quantity of the flour,—which may be a soft Winter wheat variety or a blend of rice or tapioca flour with the soft Winter wheat flour—as giving an index to the size of the mix, and not the butter and sugar which in ordinary practice would be weighed off first. The formulas are supposed to suggest to the foreman and superintendent new cake mixes copies of which might appear individually as were chosen to be introduced in the bake shop.

CHART I.

BREAD FORMULAS
(STRAIGHT DOUGH)

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KIND OF BREAD	Flours: Patent	Flours: Light Rye	Flours: Dark Rye	Flours: Coarse Rye Meal	Flours: Whole Wheat	Flours: Bran	Flours: Spring Clear	Flours: Graham	Water*	Sugars: Brown	Sugars: Granulated	Malt Extract	Milk Powder	Lard	Salt	Raisins	Potato Flour	Molasses	Yeast	Temp. of Dough	Total Time Ready to Bench
Quantity	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	qts.	lbs.	lbs.	lbs.	lbs.	lbs	lbs.	lbs.	lbs.	lbs	lbs.	°F	hours
Vienna	98											1	1½		1¾				1¼	80	4½
Milk	98										1¾	1	2	1½	1¾				1¼	80	4¼
French	98										1¼	¾			1¾				1½	80	4½
Twist	98										2	1	2	1¼	1¾				1¼	80	4½
Potato	88										1¾		1	1¼	1½		10		1½	80	4½
Cottage	98										1½	¾	2½	1½	1¾				1¼	80	4½
Rye (Light)	32	33					33								1¾				1¼	72	4½
Rye (Dark)	32		33				33								1¾				1¼	74	4½
Pumpernickel	55			43											1¾				2	74	5
Bran	78					20				1					1¾			6	1¾	74	4½
Whole Wheat	60				38					1				1½	1¾			2	1½	74	4½
Concord	98										2	1	1	1¾	1¾				1¼	80	4½
Raisin	98										2	¾	2	2½	1¾	45			1¾	80	4½
Sweet Raisin	98										4	1	3½	2½	1½	30			1¾	80	5
Graham	72							26		1½				1½	1¾			4	1½	80	4½
Home-made	98										2½	1	2	2	1¾				1½	80	4½

*NOTE.—Water is added in sufficient quantity to make dough of proper consistency.

CHART II.

WATER AND MILK ROLLS

(STRAIGHT DOUGH)

KIND OF ROLLS	Flours				Sugars		Shortening		Milk Powder	Malt Extract	Molasses	Water*	Yeast	Salt	Temp. of Dough	Time Ready to Bench
	Patent	Rye	Graham	Bran	Granulated	Brown	Lard	Butter†								
Quantity	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	lbs.	qts.	ozs.	ozs.	°F.	hrs.
Graham	24		11			10	10				3		10	12	82	4
Bran	27			7		8					2		8	12	78	4
Milk	30				16		8	8		4			8	10	78	4
Parker House	34				36		24	12		4			10	10	80	4
Rye	28	10								8			9	12	74	4
Sandwich	30				24		24			2			9	10	80	4
Vienna I	36				16		16		18	4			9	12	80	4½
Vienna II	36				12		12		12	4			9	12	80	4½
Vienna III	36								12	4			9	12	80	4½
Pocket Book	31				24		24						8	10	80	4½
Kipfel	36				12		12		24	4			8	12	80	4½
Twist	33				10		10		8	4			8	12	80	4½
French	35				8		12		16	4			8	12	80	4½

*Note.—Water is added in sufficient quantity to make dough of proper consistency.

†Butter to be worked in when ready for bench.

CHART III.

COUNTER MIXED CAKES

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KIND OF CAKE	Cake Flour	Milk	Molasses	Almond Paste	Sugars		Shortening		Cream of Tartar	Soda	Baking Powder	Eggs			Flavors		Chocolate	Raisins	Mixed Spices	Almonds	Walnuts	Citron	Anise	Cherries	Preserved Ginger
					Brown	Granulated	Lard	Butter				Whole	Whites	Yolks	Lemon	Vanilla									
Quantity	lbs.	qts.	qts.	lbs.	lbs.	lbs.	lbs.	l bs.	ozs.	ozs.	ozs.	qts.	qts.	qts.	ozs.	ozs.	ozs.	lbs.	ozs.	lbs.	lbs.	lbs.	ozs.	lbs.	ozs.
Devil Food I	3	1¼				3	¾	¾		½	2	1					8								
Devil Food II	1¾	½			¾	1		¾			1¼	½					2								
Ginger	6		¾		1	3½	1½	3		¾		2¼							3						5
Loaf	7	1½				4½	1	2½			4½		1½		½	¼					3	2			
Gold	4½	1				3		2			3			1		¼									
Wine	5	1½				3		2			4	1				¼									
Centennial	4¾	¾				4½		2¼			1½		1½		½	¼									
Anise	8	½				6					2	4				¼							3		
Chocolate	3½					3½	2	4		1		¾					12								
Yellow Florence	5	1½				4½		2½			4½	½		½		¼									
Royal	5	1½				4½		2½					1	1		¼		1½				1½			
Genoa	4¼			¾		3		3				1½				¼		2				½		½	
Golden Rod	2¼	½				2¼		1¼			1			1		¼									
White Mountain	5	1½				3¾		2¼			4		¾		½										
Dundee	4			½		3¼		3¼					2			¼		5		¾		¼			
Dorothy	6	2				4		3	2	1		¾		¾		¼								4	
White—Florence	5	1½				4½		2½			4		1½		½	¼									

CHART IV.

SPONGE GOODS AND OTHER CAKES

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Kind of Cake	Cake Flour	Sugar	Eggs: Whole	Eggs: Whites	Eggs: Yolks	Butter	Chocolate	Vanilla Flavor	Baking Powder	Ammonia	Cream of Tartar	Walnuts	Corn Starch	Milk	Water	Rum
Quantity	lbs.	lbs.	qts.	qts.	qts.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	lbs.	ozs.	qts.	qts.	ozs.
Sponge I	2	2	1					1/4								
Sponge II	3	3	1 1/2			1/2		1/4	1/2							
Sponge III	5	4			1 1/2	2		1/4								
Walnut	1	2		2	3/4			1/4				3	16			
Angel Food	1 3/4	4		2				1/4			1		4			
Sponge Drops	5	3	1					1/8		2				1		
Swiss Roll	3	3 3/4	3					1/8								
Savoy Fingers	4 1/2	4	2		1			1/8								
Jelly Roll I	4	3			1/2			1/4	4							
Jelly Roll II	4	3			1	1/2		1/4	4					1		
Chocolate Roll	3 1/2	4	2				8	1/8								
Cocoanut Square	5	5	1			2		1/8	1/4							
Vienna Mix I	2	2	2		1			1/8							1/2	
Vienna Mix II	2 1/4	2 1/2	1 1/2		1	1 1/2		1/8					8			
Vienna Mix III	2	4	1 3/4			3/4		1/4					32			2
Vienna Mix IV	4	4	3 1/4		1 1/2	3		1/4								

CHART V.

LAYER CAKES

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KIND OF CAKE	Cake Flour	Milk	Water	Molasses	Rum	Maple Syrup	Corn Starch	Sugars: Granulated	Sugars: Powdered	Shortening: Lard	Shortening: Butter	Eggs: Whole	Eggs: Whites	Eggs: Yolks	Flavors: Lemon	Flavors: Vanilla	Soda	Cream of Tartar	Baking Powder	Mace	Chocolate	Citron	Walnuts	Almond Paste	Assorted Fruits	Mixed Spices	Cake Crumbs
Quantity	lbs.	qts.	qts.	qts.	ozs.	qts.	ozs.	lbs.	lbs.	lbs.	lbs.	qts.	qts.	qts.	ozs.	ozs.	ozs.	ozs.	ozs.	ozs.	lbs.	ozs.	ozs.	lbs.	lbs.	ozs.	ozs.
White	4	1							3	1	1		1		½	½	¾	1½		¼							
Yellow	4	1							3	1	1			¾		½			3								
Plain	4½	1¼						3		1	½	1				½	1	2		¼							
Chocolate	4	1							3	1	½	¾					1		2		½						
Devil Food	3	1¼						3		¼	½	1					½		2		½						
Special	4	1							3		2	½		½		½	¾	1									
Metropole	3				3				½				¼	1		¼				¼	2	2	4				4
Almond	2								3		½		2	2										1			
Fruit	2¼	½		¼	4			2			2	1										2			10		
Sponge	3	¼						3				1		¾		½			½								
Walnut	4	1						3		½	1		1			½			3				2				
Spice	5½			2	2			½		1½	½			½			3									1	
Wine	3½	1						2¼		½	1½			½		¼			2								
Savoy	3½	1½						3	¾	1			1¼			¼	⅓	1									
Delmonico	3						4		3		3		¾	¾		½											
Vienna	4	¾						3			2	1				½			2								
Maple	5	1				½			3	1	1	1				½			3								

CHART VI.

POUND AND FRUIT CAKES

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KIND OF CAKE	Cake Flour	Milk	Rum	Brandy	Molasses	Sugar	Corn Starch	Shortening		Soda	Cream of Tartar	Baking Powder	Eggs			Vanilla	Mixed Spices	Mixed Fruit	Almond Paste	Ground Ginger	Preserved Ginger	Cherries	Raisins	Walnuts	Citron
								Lard	Butter				Whole	Whites	Yolks										
Quantity	lbs.	qts.	ozs.	pint	qts.	lbs.	ozs.	lbs.	lbs.	ozs.	ozs.	ozs.	qts.	qts.	qts.	ozs.	ozs.	lbs.	lbs.	ozs.	lbs.	lbs.	lbs.	lbs.	lbs.
Plain	4					4			4			½	2			¼									
White	4					3¾			3			⅜		2		¼									
Yellow	4	½				4		½	1½			1			2	½									
Citron	3½					3		1	2			½	1½			½									4
Cherry	4½					3			3				1½						¾			4			
Walnut	3½	1				3	8		2	½	1		½		½									3	
Raisin	4½					4		2	2			½	2			¼							8		
Ginger	6				1½	3½		2½	2	1			2¼				1½			1½	5				
Fruit	3¾					3		1½	1½				1½				1½	2				2	3		5
Black Fruit	3½			½	¼	3			2½	¼			1½				3	9							
Molasses Fruit	4½			½	½	4		2	1	¼		¾	1½				4	8							
Philadelphia	4	1				2¾	4		1¾			3	1				1								
Light Fruit	4½					4¼		1½	2½				2					6					6		3

CHART VII.

SNAPS

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KIND OF CAKE	Cake Flour	Milk	Molasses	Sugars		Shortening		Soda	Ammonia	Baking Powder	Flavors		Whole Eggs	Mixed Spices	Ground Ginger	Cake Crumbs	Peanuts	Chocolate	Cocoanut	Raisins	Figs	Almond Paste	Coffee Essence	Water	Honey
				Brown	Granulated	Lard	Butter				Lemon	Vanilla													
Quantity	lbs.	qts.	qts.	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	qts.	ozs.	ozs.	lbs.	lbs.	ozs.	lbs.	lbs.	lbs.	lbs.	ozs.	qts.	qts.
Honey	5			1		½				2½				2										½	¾
Lemon	5				5	2			½		2		¾												
Ginger	8	1	2			1½		4							1½										
Scotch	8	½	1	4		1½		2						½										¾	
Vanilla	4¼				3¾		3¾					1	1												
Chocolate	5	¾			4		1			4			¾					12							
Cocoanut	6	2			4	1	1	1		1		½							3						
Vanilla	3¼	1			2¼		½			1		½	¼												

BARS

KIND OF CAKE	Cake Flour	Milk	Molasses	Brown	Granulated	Lard	Butter	Soda	Ammonia	Baking Powder	Lemon	Vanilla	Whole Eggs	Mixed Spices	Ground Ginger	Cake Crumbs	Peanuts	Chocolate	Cocoanut	Raisins	Figs	Almond Paste	Coffee Essence	Water	Honey
Peanut	4¾		¾	4½		2½		½	½			¼	½	2		3	2½								
Cocoanut	6	1			4	2				4		¼	½						8						
Fruit	4		½		4	2				2			½	2		3				4					
Fig	7	¾			6	1½		1		2			½								3				
Raisin	6	½	½	3		1½		2					1½	2						5					
Coffee	6	½			4	1½	2			1½			1¼										2		
Chocolate	8	½			4	2	1	½	1			¾	1					8							
Almond	3				3				½				½									¾			
Cinnamon	3	½	½	1¼		½		½					¼	2											

CHART VIII.

SMALL FANCY MIXED CAKES

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KIND OF CAKE	Cake Flour	Water	Chocolate	Almond Paste	Sugars: Powdered	Sugars: Granulated	Butter	Ammonia	Baking Powder	Eggs: Whole	Eggs: Whites	Eggs: Yolks	Vanilla	Corn Starch	Cake Crumbs	Cocoanut	Mixed Spices	Anise Seed
Quantity	lbs.	qts.	ozs.	lbs.	lbs.	lbs.	lbs.	ozs.	ozs.	qts.	qts.	qts.	ozs.	ozs.	lbs.	lbs.	ozs.	ozs.
Plain Macaroons				5	2½	2½					1			2				
Macaroons, Fancy				5	3½						½							
Macaroons, Horns				3		3					¾					1		
Meringue, Plain					6						1							
Meringue, Chocolate			8		6						1							
Vanilla Waffles	3					2½	2½			¾			2					
Anise Drops	2	½			2					¾								1
Cocoanut Macaroons	⅛					4½					1					2½		
Fancy Kisses					7						1							
Cocoanut Bowls					1½	1½					½					3		
Petit Fours	2				2		1½				¾	¾						
Springerle	3½				3			½		¾								2
Othellons	2				2					1								
Lady Fingers	2				2					1			¼					
Chocolate Rings	4		8			1				1½					1		1	
Chocolate Drops			8		4½						½							

SUGAR CAKES

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KIND OF CAKE	Cake Flour	Milk	Water	Molasses	Honey	Sugars: Brown	Sugars: Granulated	Eggs: Whole	Eggs: Yolks	Shortening: Lard	Shortening: Butter	Soda	Cream of Tartar	Baking Powder	Flavors: Lemon	Flavors: Vanilla	Oatmeal	Cake Crumbs	Mixed Spices	Raisins	Currants
Quantity	lbs.	qts.	qts.	qts.	qts.	lbs.	lbs.	qts.	qts.	lbs.	lbs.	ozs.	ozs.	ozs.	ozs.	ozs.	lbs.	lbs.	ozs.	lbs.	lbs.
Plain I	6	½	¾				3			2				2		¼					
Plain II	6	1¼					3	¼			2			2½		¼					
Langhties	3½						1½	½			2			2		¼					
Lemon	4½	½					3	½			1½			2	2						
Diamond	5	½					3	½			1½					¼					
Rough and Ready	6	1¼					3	½			1½			3		¼					
Perkins	7			3			2½				2	2				¼	3½				
Scotch Short	5	2					1	¼			¾	1¼	2½			¼					
Cocoanut	4	1					2		¼	1						¼					
Crumb	4½	¾				2½				1¼		2½						2½	1		
New York Tea	3½			¼			2	½		1						¼					
San Antony	4½	¾					2½	¼		¾	¾	½	1			¼					
Rock	4½	¾					2½	¼			1¼	½	1			¼				1	1
Pecan	4	½					3	½			1½			3		¼					
Short Paste	6						2	1			4					¼					
Honey	6½				1½	2		¼				1½									
Molasses	8		1	1		2	1			1½		2							2		
Maryland	6						2	¼			4	1	1			¼					
Fruit	6	½					4	½			2			1						3	

RECORDS FOR THE BAKESHOP.

Introduction.

The maintenance of an accurate record of operations, formulas, etc., in a bakery should be a source of profit to the management, as well as convenience to the superintendent. A completed record abounds in ready and valuable information, showing the exact output, and records of the different kinds of bread, together with the quantities baked of each. Changes in the formulas can be referred to in a moment's notice and their influence upon the quality of the product noted. Daily record is on file of the course of the dough through the sponge room, the doughing and fermenting room, whereby the cause of any differences in the quality of the loaf can be traced Record of all temperatures concerned, as well as the time for the several operations and combined with records of humidity and atmospheric pressure should be maintained as data on the variable factors that affect bread making. Through an examination of a series of such records, one is enabled to see the differences that are effected by each factor. For instance, it may be noted that the doughs get "sloppy" when the pressure is low and the humidity very high. The logical and proper procedure would be to regard the indication of the barometer and hygrometer before setting a sponge or dough, and to vary the yeast, sugar, malt, etc., accordingly. It may be that the doughs are not being properly timed and punched or are being set too warm or that the yield is too low. A little calculation would indicate whether the divider is accurately sealing to the fraction of an ounce, while a study of the dough sheet might indicate that the flour being used has not a profitable absorption and so on.

The more opportunity one has of becoming acquainted with the variable factors in bread-making, the better chance there is of controlling the same.

The Store Room Records are self explanatory. Entries are made of amounts of materials received as well as delivered to bake shop under respective date. The total of materials used, deducted from the sum of the monthly receipts plus material on hand on the first of the month, gives material on hand on the closing of the last day of the month, which figure is forwarded to sheet for next month as material on hand on the first of the month. As the kind of materials used in the bake shop vary considerable, except flour, sugar, shortening, etc., it was deemed advisable to leave open headings to be filled in with the respective name of ingredients as employed in the respective bake shop.

RECORD I

SPONGING ROOM RECORD

Date	No.	Shift	Kind of Sponge	Flours		Yeast Food	Water	Milk	Yeast	Temp. of Water added	Sponge		Temp. of Sponge when set	Room Temp.	Humidity	Barometer Reading	REMARKS
				Blend	Rye						Time Set	Time Taken					
				lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	°F			°F.	°F.	%	Inches	

RECORD II

DOUGHING ROOM RECORD

Date	No.	Shift	Kind of Bread	Flours						Salt	Sugars		Yeast	Lard	Molasses	Water	Milk	Condensed Milk	Milk Powder	Malt-Extract	Yeast Food	Room Temp.	Temp. of Water	Temp. of Dough	Dough-Mixing		Humidity	Barometer Reading		REMARKS
				Spring	Rye	Graham	Whole Wheat	Hard Winter (Kansas)	Soft Winter		Brown	Granld.													Time Mixed	Out of Mixer				
				lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	° F.	° F.	° F.			%	Inches		

FERMENTING ROOM RECORD

Date	No.	Shift	Kind of Dough	Temp. of Dough	First Cut	Secoud Cut	Third Cut	Fourth Cut	Fifth Cut	To Bench	Room Temp.	Humidity	Barometer Reading	REMARKS
				°F.							°F.	%	Inches	

RECORD IV

BENCH RECORD

Date	No.	Shift	Kind of Dough	Temperature of Shop	Temperature of Dough	Total weight of Dough	Dough on Bench Time	Humidity	Barometer Reading	Weight of Loaves Scaled		Number of Loaves Obtained		Total Yield	REMARKS
										Large	Small	Large	Small		
				°F.	°F.	lbs.		%	Inches	ozs.	ozs.			%	

RECORD V

STORE ROOM RECORD
FOR
FLOUR—MILK—SUGAR

MONTH:__________ 1st to 17th

YEAR: 19___

DATE	FLOUR																								MILK				SUGAR							
	Spring Patent		Spring Straight		Spring Clear		Hard Winter Patent		Hard Winter Straight		Hard Winter Clear		Soft Winter		Graham		Whole Wheat		Corn		Light Rye		Dark Rye		Powder		Condensed		Brown		Granulated		Corn		Powdered	
	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used
	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	bbls.	lbs.	lbs.	bbls.	bbls.	bbls.	bbls.	lbs.	lbs	lbs.	lbs	lbs	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
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RECORD VI

STORE ROOM RECORD
FOR
SHORTENING—EGGS—MISCELLANEOUS

MONTH:____________ 1st to 17th

YEAR: 19____

DATE	SALT		Malt Products		SHORTENING								SEED						EGGS				MISCELLANEOUS													
	Salt				Butter		Lard												Powdered		Whole															
	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used
	lbs	lbs.	lbs.	lbs	lbs.	lbs.	lbs.	lbs.	lbs	lbs	lbs.	lbs.	lbs.	lbs	lbs.	lbs.	lbs	lbs.	lbs.	lbs	doz.	doz.	lbs.	lbs	lbs.	lbs.	lbs	lbs	lbs	lbs	lbs.	lbs	lbs.	lbs	lbs.	lbs.
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RECORD VII

YEARLY STORE ROOM RECORD
FOR
FLOUR — MILK — SUGAR

YEAR: 19——

(Copyrighted: Siebel Institute of Technology.)

	FLOUR																							MILK				SUGAR							
	Spring Patent		Spring Straight		Spring Clear		Hard Winter Patent		Hard Winter Straight		Hard Winter Clear		Soft Winter		Graham		Whole Wheat		Corn		Light Rye		Dark Rye		Powder		Condensed		Brown		Granulated		Corn		Powdered	
	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used
	bbls.	bbls	bbls.	bbls	bbls	bbls	bbls.	bbls	bbls.	bbls	bbls.	bbls	bbls.	bbls.	bbls	bbls	bbls	bbls.	lbs	lbs	bbls.	bbls.	bbls.	bbls.	lbs.	lbs.	lbs	lbs	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
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RECORD VIII

YEARLY STORE ROOM RECORD
FOR
SHORTENING—EGGS—MISCELLANEOUS

YEAR: 19___

(Copyrighted: Siebel Institute of Technology)

	SALT		Malt Products		SHORTENING								SEED						EGGS				MISCELLANEOUS													
	Salt				Butter		Lard												Powdered		Whole															
	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used	Rec'd	Used
	lbs.	lbs.	lbs	lbs	lbs	lbs.	lbs.	lbs	lbs.	lbs	lbs	lbs	lbs	lbs.	lbs.	lbs	lbs	lbs.	lbs.	lbs.	doz.	doz.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs	lbs.	lbs.	lbs.	lbs.	lbs	lbs	lbs
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SCIENTIFIC AND TECHNICAL DATA

Introduction.

The following chapters are intended to present to the baker and miller in a readily comprehensible form a general review of the various branches of science and technics co-related to the baking industry such as Physics, Chemistry, Microscopy and Pure Yeast Culture, Refrigerating and Electrical Engineering, Arithmetics and Mensuration.

Although in order to remain within the scope of this manual these subjects could be treated only in a somewhat brief manner, yet the information contained therein will prove of sufficient value to warrant a careful perusal and study, at the same time impressing upon the reader the importance and indeed necessity of acquiring at least a general knowledge of such scientific facts and data as are most essential for anyone whose aim it is to be a master in his vocation.

The progressive baker, however, who from reading these chapters should become desirous of developing his knowledge even more by further elucidation and more thorough instruction on these subjects, will by the careful study of this part be enabled to understand intelligently and with no difficulty, more elaborate and special works in these various branches to which he might feel inclined to refer for more detailed information.

CHAPTER VI.

Physics.

Physics is that branch of science which treats of the properties and relations of **matter** and **force** (or energy).

Properties of Matter and Force.

Everything that occupies space and possesses weight is called **matter**. A limited portion of matter is called a body.

All matter is divisible and is made up of molecules.

A **molecule** is the smallest conceivable part of a substance and it cannot be divided without destroying the identity of the substance.

Three different **states of aggregation** are known insofar all substances appear either in a solid, or liquid or gaseous form.

The state of aggregation of many substances can be changed by either adding or withdrawing heat, or changing the pressure acting upon the same.

Force does not occupy space, nor does it possess weight; it is, however, the cause of motion or of any change of motion.

Attractive forces are:

Cohesion or the attraction which unites molecules of the same kind.

Adhesion or the force which attracts molecules of different kind.

Molar Attraction is a force which acts between different bodies. A special case of molar attraction is **gravitation** or the attraction of the earth upon all bodies.

Weight and Specific Weight.

The effect of the gravitation upon matter is called weight; the same is measured by comparison with certain standards, called standard weights.

The specific weight or **specific gravity** (sp. gr.) of a body is its weight in comparison with the weight of an equal volume of water.

It is obtained by dividing the weight of the respective body by the weight of an equal volume of water.

The specific gravity of liquids can be determined by means of the picnometer or with the hydrometer.

Percentage hydrometers are used for the ready determination of the percentage of any substance contained in a solution; some of the best known percentage hydrometers are saccharometer and alcoholometer.

Hydraulics.

A liquid contained in open vessels or pipes, which are connected with each other, will have the same level in all of them.

The hydraulic pressure exerted upon a given surface, by a water column is equal to the product of the surface times the height of the column; it is independent from the size or shape of the vessel.

The pressure of a water column 1 foot high equals 0.433 pound upon every square inch, or it takes a water column closely 27¾ inches high to exert a pressure of 1 pound per square inch.

The pressure exerted by liquids lighter or heavier than water is in proportion to their specific gravity.

Air Pressure.

The pressure of the atmosphere is sufficient to support a mercury column about 30 inches high, or a water column 34 feet high. It amounts at sea-level to 14.7 pounds per square inch in the average, but varies with weather conditions and with the elevation above sea-level.

Air pressure is measured by the barometer; for measuring the pressure of other gases and vapors, f. i. the vapor of water or steam manometers or pressure gauges are used.

Heat and Temperature.

Heat is a form of energy, it is molecular motion. It can be generated by mechanical or muscular motion, by chemical processes, by means of electricity, etc.

Temperature means the state or intensity of heat, generally designated as cold and hot or warm.

If bodies having different temperatures are in direct or indirect contact heat will pass from the warmer body to the colder one, until both have acquired the same temperature.

Addition of heat generally raises the temperature of a body and expands the same; abstraction or withdrawal of heat generally lowers the temperature and causes contraction.

Thermometers.

Thermometers are instruments for measuring temperatures. The various thermometers are different either in graduation or in general construction.

The different graduations in use are the **Fahrenheit**, the **Celsius or Centigrade** and the **Reaumur scale** of graduation.

Their essential differences are as follows: On the Fahrenheit scale the temperature of melting ice is designated as 32°, that of water boiling in an open vessel at 14.7 pounds pressure as 212°.

On the Centigrade scale these two temperatures are designated as 0° and 100°, respectively, while on the Reaumur thermometers, the boiling point is indicated by 80°, the melting point being the same as on the Centigrade scale, that is 0°.*

The chief difference as far as construction is concerned is in the thermometrical medium employed, which in general is mercury. However, alcohol and pentane is also used for filling thermometer tubes, and in the so-called metallic thermometers no liquid but a strip made of two different metal serves the same purpose.

For high temperatures, such as in baking ovens, pyrometers are used; the same are either metallic or electric pyrometers, in the latter a thermo-electric current being generated by the heat of the oven.

Heat Unit and Specific Heat.

The unit used for measuring quantities of heat is called **British thermal unit** (B. T. U.), and it represents the heat required to heat 1 pound of water 1° F.

The specific heat of a substance other than water is the quantity of heat required to heat 1 pound of the respective substance 1° F. This heat differs greatly with different substances; with most substances it is less than 1 B. T. U.

To calculate the heat required to heat up a given quantity of a substance for any difference in temperature, multiply the weight of the substance by the difference in temperature and by the specific heat of the substance

*See Thermometer Table in appendix for formula for the conversion of thermometer degrees.

Melting and Latent Heat of Melting.

Many solid substances can be melted by the application of heat. This melting takes place at a constant and definite temperature, called **melting point**, which, however, is different for different substances.

This melting temperature is at the same time the temperature at which a liquid becomes solid (freezes or solidifies), when the liquid is cooled sufficiently.

Hence 32° F. which is the melting point of ice, is also called freezing point of water.

When a solid, for example ice, melts, it absorbs heat, hence the cooling effect of ice. This absorbed heat, however, has no effect upon the temperature of the ice or ice-water, and it is therefore called **latent heat.**

The latent heat of ice is closely 144 B. T. U. per pound.

Boiling and Latent Heat of Vaporization.

If a liquid is heated continuously a temperature is finally attained at which the liquid boils, that is at which it is transformed into vapors (in the case of water called steam).

This boiling takes place at a definite temperature, called **boiling point,** which for water is 212° F. while it differs for other liquids.

When a liquid is boiling it absorbs heat which has no effect upon the temperature; hence, it is called **latent heat of vaporization,** which in the case of water amounts to 966 B. T. U. per pound of water.

Vapors, formed from a liquid by boiling, will, when cooled, condense or liquify at the same temperature at which they had been formed; hence, boiling and liquifying points are identical.

Effect of Pressure on Boiling.

If a liquid is boiling in a closed vessel (boiler), in which a higher or lower pressure may be maintained, the boiling temperature of the liquid will rise as the pressure increases, and decrease under a lower pressure (respectively vacuum).

Hygrometry.

Water evaporates also at temperatures lower than its boiling point, in consequence of which the atmosphere always contains more or less water vapor in form of humidity, the amount of such humidity depending upon temperature and general weather conditions.

If air contains all the humidity it can retain at a certain temperature, it is called **saturated**, and any cooling of such air will cause the water vapor to condense and become liquid.

The degree or percentage of humidity of the air can be determined by means of the Hygrometer, of which several different kinds are in use.

Humidity being an item of importance in a bakery, a good hygrometer is of equal importance as is true of a good thermometer.

CHAPTER VII.

Chemistry.

Chemical Changes.

Chemistry is the science that treats of chemical changes, that is changes that take place in the constitution of all substances and may be explained as follows: If vinegar is poured on a piece of chalk there is at once a change. The vinegar seems to boil; a gas is given off called carbonic acid or carbon-dioxide. The chalk is dissolved and a liquid is left, which, if heated, becomes a solid totally different from the chalk.

This is what is known as a chemical change or reaction, in which both the chalk and the vinegar are changed.

This differs from a **physical change** wherein the composition of a substance is not changed by outside influences.

If water is exposed to a temperature below 32° F. it becomes a solid, ice. It has undergone a physical change insofar ice is the solid form of water, as is proven if the temperature is raised and the ice melts. If the temperature is raised to 212° F. the water becomes steam, another physical change; but steam has the same chemical composition as water since no chemical change has taken place in it.

Elements.

All substances are made up of what are known as **elements.** There are some seventy-five elements, for instance: gold, silver, iron, zinc, tin, copper, sulphur, oxygen, hydrogen, nitrogen, etc.

They form the bases of all substances in one form or another, and are like the bricks with which a mason builds a house. Certain of these elements have a great attraction for certain others. Oxygen has a great attraction for iron; if a piece of iron is exposed to air in a short time it will be found to be rusted. This rust is what is known as iron oxide, and it is the product of the chemical union of oxygen with iron, and is not oxygen or iron, but a new or different substance composed of both. It is a powder and not hard like iron or a gas like oxygen.

Some elements are called metallic, others non-metallic. Such elements as gold, silver, copper, potassium, sodium, etc., are metallic. Sulphur, carbon, phosphorus are non-metallic. Oxygen, hydrogen, chlorine, and nitrogen are gaseous elements.

Compounds and Mixtures.

When as in the illustration of the rust or iron, any two or more elements unite to form a new substance, this new substance is known as a **compound.**. The chalk referred to in a former illustration is a compound of lime and carbonic acid, although it appears like one substance. So we could show by analysis that the iron rust is a compound of iron and oxygen.

Mixtures are very different from compounds insofar as compounds are chemical unions as shown, while mixtures are not. In other words, if we put sugar and sand together, we form a mixture, but not a compound as there is no chemical union. If we dissolve salt in water we have a liquid mixture or solution, but no compound. It is true the salt disappears and it would seem that a compound is formed, but if we heat this solution the water is evaporated and the salt is left chemically unchanged.

Atoms and Molecules.

Atoms are defined as the smallest particles into which an element may be divided, and consequently they cannot be divided any further.

It has, however, been found in nature that atoms do not exist isolated or alone, but when free they unite with one another if they do not unite with atoms of some other element, and this union is called a **molecule**, and this is the smallest particle of a substance that will exist by itself, and possess all the characteristics of the respective substance. Thus a molecule of hydrogen is the union of two atoms of hydrogen; a molecule of common salt is the union of an atom of chlorine and an atom of sodium.

Chemical Symbols and Formula.

Each of the elements in chemistry has a name derived from the Latin or Greek language, and a common name by which it is generally known; for instance, the chemical name for that substance commonly known as iron, is Ferrum, the Latin name. The chemical name for copper is Cuprum, also a Latin name. Chemists to avoid writing out the full name of an element each time use a **symbol**, which is one or more letters of the chemical name. Thus, Au is the symbol for "Aurum," gold, while the symbol for iron is Fe, the first letters of the chemical name "Ferrum," H is the symbol for Hydrogen, O for Oxygen, C for Carbon, etc.

To express in a clear and distinct way a chemical fact the chemist uses what is called a **formula**. We know, for example, by experiment that a molecule of water is composed of 2 atoms of hydrogen and 1 atom of oxygen chemically combined, and to express this fact the chemist uses the formula "H_2O". In the same way the chemist uses for sulphuric acid the formula "H_2SO_4". Each distinct substance has a chemical formula.

Chemical Affinity or Attraction.

We are all familiar with the fact that iron has an attraction for a magnet; in like manner all substances have an affinity for some other substance to a greater or lesser degree.

When we put the vinegar on the chalk we found an effervescence resulting. This was because we had in the chalk an attraction of lime with carbonic acid, but this affinity is weak, and when we added the vinegar, the affinity of the lime for the vinegar was stronger than for the carbonic acid, and it went to the vinegar, and the carbonic acid was set free, and a new compound was formed.

Valence or Atomicity.

The atom of each element has a certain amount of power to unite with other atoms to form molecules, and this is known as the **valence of an element.** For instance, an atom of oxygen has the power to unite with two atoms of hydrogen, forming H_2O, hence it is called **bivalent.**

It requires then two atoms of a **univalent element** (like Hydrogen H) to unite with one atom of a bivalent element (like Oxygen O) to form a molecule of the compound. Nitrogen is a **trivalent** atom and that requires three atoms of hydrogen to form a molecule. In the case of oxygen one atom may unite with one atom of sodium "Na," leaving free one valence of oxygen, which may unite with one atom of hydrogen making the compound "NaOH" showing that the two values of oxygen have been satisfied by one atom of sodium and one atom of hydrogen.

Atomic Weights.

All substances, even air, have weight and as all elements may be divided into their smallest particles or atoms, these atoms must have weight, and this is known as the **atomic** weight.

All substances have different relative weights; some are called heavy, others light. Hydrogen which is the lightest element known, is taken as the standard of comparison, and the atomic weight of an element is the relative weight of its atoms as compared with the weight of an atom of hydrogen. Thus the atomic weight of iron is 56, of copper 63, hydrogen 1, oxygen 16, carbon 12, sulphur 32, etc.

Inorganic Chemistry.

That part of chemistry treating on minerals or anything made from or related to minerals is generally called **inorganic chemistry** in distinction to organic chemistry which treats substances derived from or related to either the animal or vegetable organism.

Metals and Metalloids.

Those elementary bodies that possess metallic qualities, such as metallic lustre, conductivity for heat and electricity are called **metals.** They are malleable, may be hammered out;

are ductile, may be drawn out. They are iron, gold, silver, lead, tin, copper, etc. They unite with oxygen, forming oxides, and with both oxygen and hydrogen, forming hydroxides, or bases.

Metalloids are unlike metals, they do not possess metallic lustre, they are not good conductors of heat or electricity; some of them are gases. They will unite with hydrogen, or oxygen and hydrogen, to form acids. Non-metals are hydrogen, chlorine, iodine, carbon, sulphur, nitrogen, phosphorus, oxygen, silica. Some compounds of non-metallic elements or metalloids, with hydrogen, or with oxygen and hydrogen, are Hydrochloric acid "HCl", Sulphuric acid "H_2SO_4", Nitric acid "HNO_3".

Alkalis, Acids; Salts.

Alkalis is the term applied to those oxides or hydroxides which are soluble in water, such as caustic soda and caustic potash. They have a soapy taste, and have a caustic effect upon organic substances such as fats and oils, with which they form soaps. They will dissolve or soften paint, varnish, cellulose, albumen and the like. The presence of free alkali may be known by turning red litmus paper blue.

Acids, as a rule, have a sour taste, like vinegar or lemon juice. If they come in contact with metals or alkalis they will dissolve them and form new compounds, called salts.

Acids contain hydrogen, "H", in combination that can be exchanged or replaced by a metal. The test for free acid is the turning of blue litmus paper red.

When an acid and an alkali are brought together in the proper proportions, the properties of each are destroyed and they are said to neutralize each other. This may be known when litmus paper will turn neither red or blue, and the sour and soapy taste are gone. To illustrate by a formula this reaction which is called neutralization, we take caustic soda "$NaOH$", an alkali, and add to it hydrochloric acid "HCl". Then we find the metal of the alkali, sodium, to change place with the hydrogen of the acid and to combine with the chlorine forming sodium chloride, "$NaCl$" Common salt, while the hydrogen of the acid unites with the oxygen and hydrogen of the alkali, forming water, H_2O.

A **salt** is the union or combination of an acid and a base, that is an alkali or a metal. Salts take the name of the acid entering into the compound, so that salts formed from sulphuric acid H_2SO_4 are called "Sulphates," those from hydrochloric acid "HCl" chlorides, etc. If in an acid that has more than one atom of hydrogen in a molecule, only part of the hydrogen is replaced by a metal, the resulting salt is known as an **acid salt.**

Air, Oxidation and Combustion.

Air is the atmosphere surrounding the earth and is a mixture of a variety of gases, but chiefly one-fifth of oxygen, and four-fifths nitrogen, with small quantities of water vapor, ammonia, carbonic acid, and other gases. Air is absolutely necessary to all life as it contains oxygen.

Oxygen has the quality of combining with many other elements and the change they undergo hereby is called **oxidation.** If in the case of wood and fuels the oxidation takes place rapidly in the form of fire, it is called **combustion.** When a match is lighted the heat of the burning head of the match is sufficient to heat the wood enough to set free the hydrogen in the wood, which unites with oxygen to form water, and make the carbon red hot. This latter unites with oxygen and forms carbonic acid.

Water.*

One of the most widely distributed natural substances is water. Chemically pure water is a compound of hydrogen and oxygen, having the formula "H_2O". It will dissolve most substances and is obtained pure by boiling and condensing the vapor, known as distillation. This is exhibited in nature by rain water; but even this is not absolutely pure as it contains ammonia and other gases.

Water that has dissolved in it Calcium (lime) or Magnesium salts, is termed a **hard** water, otherwise it is **soft.**

Water that contains carbonate of soda or potash is termed **alkaline.** Hard water is rendered soft by adding soda or ammonia. Water for baking should be to a certain extent possessed of permanent hardness, to assist in the develop-

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*See Water, Chapter II.

ment of lactic acid, but if too hard, it will retard fermentation. Water that contains too much sodium chloride (salt) will likewise arrest fermentation. Alkaline water is not adaptable for baking, as it softens and breaks up the gluten.

Organic Chemistry.

The branch of chemistry that treats of chemical compounds present in plants and animals is called organic chemistry. These compounds which all contain carbon in some form, can be gases or liquids or solids, as benzine, oil, fats, starch, sugar, protein and the like.

Hydrocarbons.

These substances are compounds of carbon and hydrogen, the simplest (CH_4), is a colorless gas, called **Methane or marsh gas.** In this one or more atoms of hydrogen may be replaced by other elements or groups of atoms forming a large number of different compounds. The lower members of this series are gases, but as the number of carbon atoms increases, they become liquids or solids.

Alcohols.

Common alcohol is a volatile colorless liquid, derived by fermentation from sugar and is obtained by distillation. It has the formula $C_2H_5(OH)$ and is known as **ethyl- or grain-alcohol** or spirit of wine and is present in wine, beer, brandy and whiskey in quantities from 2% to 70%. Good technical alcohol contains 94 to 95% of alcohol.

One hundred parts of sugar will give 51 parts of alcohol and 49 parts of carbonic acid, and therefore alcohol is also formed in the fermentation of dough. It is inflammable and has a pleasant taste, but little odor.

Ethyl-alcohol is lighter than water, it has a specific gravity of 0.79, and boils at 78° C. or 173° F. If exposed under certain circumtances to air, the oxygen of the air converts it into acetic acid or vinegar as in sour beer, wine, cider, and to a certain extent in bread baking in the oven.

From methane (CH_4) by substituting OH for one atom of hydrogen we have **Methyl- or wood alcohol** $CH_3(OH)$. This is a poison and is used to dissolve resins in the manufacture of varnishes.

Fusel-alcohol or **Amyl-alcohol** $C_5H_{11}(OH)$ sometimes called Fusel oil is formed in small quantities in fermentation.

Glycerine, $C_3H_5(OH)_3$, is a triple alcohol; it is a thick liquid with a sweet taste. With the fatty acids it forms the animal and vegetable fats and oils.

Organic Acids.

When an alcohol is oxydized, it becomes an acid. Ethyl alcohol by oxidation becomes **acetic acid,** CH_3COOH. Vinegar contains from 5 to 6% of acetic acid, and a little is formed in the baking of bread in the oven from the alcohol formed in the fermentation of the dough and gives the peculiar odor in the baking.

Butyric acid, C_3H_7COOH, forms in butter when it becomes rancid.

Palmitic acid, $C_{15}H_{31}COOH$, and **stearic acid,** $C_{17}H_{35}COOH$, are found in vegetable and animal fats and oils combined with glycerine. Boiled with soda or potash, the fats and oils form soaps.

Lactic acid, $C_3H_6O_3$, is present in small quantities in grain, hence in flour, also in milk. It increases during fermentation by lactic acid bacteria, which decompose carbohydrates and form this acid. It is present in bread from 0.12 to 0.20%, in beer about 0.1%. It occurs in larger quantities in rye bread, weiss beer, ale, sour milk and sour-kraut. It has a favorable effect on certain enzymes, such as peptase, hence its presence in dough is desirable. It assists in the keeping qualities of bread, hence rye bread keeps better than wheat bread.

Tartaric acid, $C_4H_6O_6$, is found in the juice of grapes and fruit and is deposited during fermentation in the form of a salt called potassium tartrate or cream of tartar. This salt or the tartaric acid itself is used in baking powders.

Esters.

Compounds formed by the combination of an alcohol and an acid with the elimination of water are called **Esters.** They may also be considered as derived from an alcohol in which the hydroxylic hydrogen has been replaced by an acid radical.

Esters may be prepared by heating for some hours on a water-bath a mixture of an acid and an alcohol with small quantities of hydrochloric or sulphuric acid. They have generally an aromatic odor, are neutral in reaction, and insoluble in water, but dissolve in alcohol and ether and are used as fruit-essences.

Fats and Oils.

Belonging to the group of esters is a number of substances, comprising the various **fats** and **oils** of animal or vegetable origin.

All such fats and oils are glyceryl-esters, composed of the triple-alcohol glycerine with the higher organic acids, such as lauric, palmitic, stearic, oleic acid, etc.

Carbohydrates.

Organic compounds in which carbon is united with water in certain proportions are called **carbohydrates**; they are such as the sugars $C_{12}H_{22}O_{11}$, dextrine $C_{12}H_{20}O_{10}$, starch, cellulose, etc. They differ from hydrocarbons which contain no oxygen.

Cellulose $(C_6H_{10}O_5)n$ is found in the wall of the barley grain, wheat, etc., in cotton fiber, filter paper and filtermass.

Starch $(C_6H_{10}O_5)m$ is a granular organic substance found in wheat, rye, barley, corn, rice, potatoes and other plants. It is enclosed in a cell wall, and is not soluble in water.

If the cell wall is broken by boiling it forms a viscid substance or paste. This is called **gelatinizing of starch** and takes place at 165° to 185° F. Gelatinized starch gives with iodine solution a bluish-black color. In baking some of the moist starch will gelatinize.

The action of certain enzymes as ptyalin in saliva, and amylopsin in pancreatic juice converts it into maltose and dextrine. In brewing starch is converted into maltose by the diastase of malt.

Starch heated dry to about 300° F. is converted into dextrine; this is found in the crust of bread exposed to the high heat of the oven. When boiled with a little acid starch is transformed into a sugar called dextrose.

Sugars.*

Saccharose or sucrose, $C_{12}H_{22}O_{11}$, is a sweet substance found in sugarcane, beets and the sap of the maple and birch

*See Chapter II.

trees, as also other plants. It crystallizes when the sap or juice is evaporated, but if heated to about 365° F. it loses its crystalline form and turns into caramel. It is the sweetest of all sugars, freely soluble in water, but it is not fermentable. If boiled with acids, however, or acted upon by invertase, an enzyme of the yeast, it will become fermentable. Confectioners' sugar is powdered cane sugar.

Maltose or malt sugar is the product of the mashing of malt. It is formed from the starch of malt by the action of diastase. Malt-extract contains about 60 to 65% of maltose with 20% of moisture and other substances.

Lactose or milk-sugar is present in milk from 2 to 5%, it does not ferment directly.

Dextrose, $C_6H_{12}O_6$, is contained in grapes and other fruits; it is also known as grape sugar. It is less sweet than cane sugar and readily fermentable.

Dextrine, $C_{12}H_{20}O_{10}$, is an amorphous compound found in the sap of plants and is produced by the action of heat or mineral acids on starch; it is soluble in water, practically tasteless and not fermentable.

Proteins.

Complex organic compounds containing carbon, hydrogen, oxygen and in addition nitrogen and sulphur, are found in all animal and vegetable bodies. The best known type of these substances is the white of the egg, or albumen. Similar substances are found in seeds and grains and are called **proteins or albuminoids.**

They differ from starch, sugar and cellulose as they may be decomposed by proteolytic enzymes, by putrefactive bacteria, acids and alkali. They are divided into proteins insoluble in water and proteins soluble in water, and may be still further classified as to their solubility or insolubility in salt solution, or alcohol or whether they will coagulate or not.

The protein **glutenin** is found in wheat flour, together with **gliadin,** with which it forms the "**gluten**" of the flour. The insoluble vegetable proteins are globulins, prolamins and glutelins. Some soluble vegetable proteins are coagulable, as albumin and leucosin of wheat, which will coagulate if a solution is heated to 212° F. or treated with acids. Other proteins that do not coagulate are **proteoses, peptones,** amides and **amino-acids.** Peptones are the result of the action upon the higher proteins of certain enzymes, as pepsin in the gastric juice, and peptase in malt. Peptones and amides are the chief elements of nutrition of any organism including yeast.

Enzymes.

In the animal and vegetable organisms are found a number of unorganized ferments which are called **enzymes;** they split up or destroy higher organic compounds, and decompose them into simpler ones, while they are themselves unchanged.

They are designated as **hydrolytic, diastatic, proteolytic,** etc., and they decompose or break up carbohydrates, proteins, fats, and other complex organic compounds.

Cytase which occurs in barley and malt, dissolves the cellulose of the starch cells.

Diastase in malt converts starch into maltose and dextrine, while **peptase,** also contained in malt, breaks up the higher proteins, an effect which is also characteristic for **pepsin** contained in the gastric juice of animals.

Enzymes splitting sugars are the **invertase,** the **maltase** and the **zymase** to be found in yeast, of which the first inverts cane sugar into invert sugar, that is a mixture of dextrose and levulose, while the second changes malt-sugar to dextrose. The last one, zymase, ferments dextrose and levulose and forms thereby alcohol and carbonic acid.

CHAPTER VIII.

Microscopy, Micro-Organisms, and Pure Yeast Culture.

USE OF THE MICROSCOPE.

Construction of the Microscope.*

The microscope may be considered as a magnifying glass composed of one or more lenses, the former is known as a simple and the latter as a compound miscroscope, the chief parts of which are the ocular and the objectives.

Important parts of a compound microscope;

Ocular	Axes
Objective	Stage
Draw Tube	Stagepin
Tube	Mirror
Pillar	Mirror pin
Coarse adjustment screw	Nose piece
Fine adjustment screw	Pillar
Arm	Foot or Base

The principle upon which the microscope is operated, consists in directing a ray of light by the use of the mirror, below the stage, through the object to be examined, and subsequently through the objective and ocular to the eye. The substance to be examined known as the object should be in a sufficiently fine state to allow for the transmission of light. For all microscopical purposes north light or light reflected from a white cloud or white wall is most desirable.

The Examination of Cereals.

Chief among the cereals employed in the mill or bakery, we must consider wheat, and what applies to wheat, in a general way also applies to rye. For further consideration of the structure of a wheat kernel we refer to Plates II and III as also to Chapter I.

Accordingly the following parts can be distinguished:
Epidermis, with the wheat hair,
Epicarp on body,

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* See Plate I.

Cross-cells,
Tube cells,
Outer layer of spermoderm,
Inner layer of spermoderm,
Aleurone cells,
Endosperm or Starch cells.

Identification of Starches.

Starches, either before cooking or disintegration, are identified and their origin determined by the use of the microscope. A solution of iodine in water is the chemical means of detecting starch, and this is employed when the starch has been disintegrated and its mere presence is desired to be indicated.

Chief among the starches are wheat, rye, corn, rice, potato, bean and peas-starch.

There are an endless number of other starches; however, those mentioned are the most important and suffice fully for illustration.

All these starches are readily distinguishable from one another by the shape, size, and surface configuration of their undivided cells, and sometime by their variation in size in the same starch as is indicated by the microscopical illustrations on Plate IV.

At times, in the examination of starches, the polariscope is used on account of the refraction of the light, produced by the starches; this method is resorted to only where a question of doubt arises.

MICRO-ORGANISMS.

The Cell.

In considering substances microscopically, the first subject that enters into question is the cell, which may be described as consisting of a mass of protoplasma, surrounded by a cell wall and containing a nucleus. The latter is the life of the cell, and therefore when destroyed, the cell is no longer able to exist.

Protoplasm is a complex albuminous substance, resembling somewhat in complexity egg albumen, and furnishes to the cell the nourishment, as also the energy for reproduction.

The **cell wall** is composed of a cellulose membrane, through which it receives its nourishment and performs the further function of keeping the cell contents in tact. A single cell is able to carry on all the functions of life, such as: respiration, assimilation and reproduction, the latter usually taking place in one of several ways, either direct, known as **fission,** or indirect by **sporulation** or **budding.**

Infection.

Contamination of any substance by a foreign organism is called **infection.** For example, the presence of any bacteria such as lactic acid bacteria, in pure culture yeast (from a pure yeast apparatus) would be considered as an infection, whereas the presence of the same bacteria in milk, is considered as normal.

Fermentation.

The decomposition of any organic substance by the action of ferments, such as yeast, bacteria, mould, and enzymes is called **fermentation. Enzymes** belong to the class known as unorganized ferments, and may be illustrated by such examples as invertase and peptase.

The fermentation which takes place in bread, and is brought about by the action of yeast of the cultured variety on sugar contained in the dough is known as **alcoholic fermentation,** whereas **vinous fermentation** is brought about by the action of wild yeast, and **acid fermentation** by the action of bacteria, as is exemplified in vinegar.

Putrefaction.

When fermentation is accompanied by the production of offensive gases, which in most cases consist of hydrogen sulphide (H_2S), we speak of it as a **putrefaction,** and in all cases with isolated exceptions, is brought about by bacteria.

In this connection reference should be made of **viscous fermentation** as a form of putrefaction not uncommon in the bake-shop in the form of **ropiness.**

Moulds (Hyphomycetes).

Moulds, like bacteria and yeast, are plants belonging to the lowest form of plant-life, being devoid of chlorophyll (green coloring substance) and consequently grow best in dark damp places. They consist of a mass of interlacing fibres known as **mycellium,** upon which are superimposed large interlacing threads, known as **Hyphae,** from which are produced the fruit heads and spores of the various forms of moulds. The moulds most commonly found in and about the mill or bakery, are the following: Mucor, Pencillum, Aspergillus and Oidium.

These moulds are separate and distinct from those which affect the grain on the field, such as rust mould. All of these moulds can best be explained by referring to the illustrations on Plate V. The moulds are reproduced by spores, which are produced in large numbers and distributed by the air on other objects; they have the property of reproducing plants identical with those from which they originated.

Yeast (Blastomycetes).*

Yeast, which as already stated, belongs to the lowest form of plant-life, is unicellular and reproduces itself either by indirect **fission** (budding) or else **sporulation** (spores).

The former is the manner in which reproduction is effected when the yeast is innoculated into a properly constructed medium which is sufficiently defusible to allow for proper assimilation and sufficient oxygen to admit of proper oxidation. When, however, the yeast propagates under adverse condition, it does so by the development of spores and not buds. These spores are formed by a sort of an agglutination of the protoplasm into three or four spherical objects within the cell wall, which will withstand many conditions, which would otherwise destroy the yeast. Such yeast spores when again placed under normal conditions will reproduce yeast cells such as those from which they were derived.

There are many forms of yeast cells, varying considerable in size and shape, from five to ten microns in diameter (micron is the measurement used in microscopical work, and is indicated by and represents one thousandth part of a millimeter).

To admit of a more convenient study, yeast is divided into two classes, the pure **culture yeasts,** such as is and should be used in the bakery, described technically as **Saccharomycetes.**

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* Yeast as baking material, see Chapter II.

Cerevisiae, and the **wild yeasts** which should be foreign to the bakery, with the exception of such bakeshops wherein sour doughs and barms are employed, in which case the baker if not pursuing modern practices employs not only a variety of wild yeast but also a large number of bacteria.

Bacteria (Schizomycetes).

Like yeast and mould so bacteria belong also to the lowest form of plant-life and grow practically in any substances which contain organic matter, in a sufficiently diffusible state, and are not antiseptic in action. They are universally found in the air, the amount depending upon the cleanliness of the location.

These organisms occur generally in two shapes known as **bacilli** (rod shaped) and **cocci** (dot shaped). They may be single or in chains, and the cocci also at times occur in masses. They range in size from one micron in width and length as in the cocci to one micron wide and from one and one-half micron to ten microns in length as in the bacilli. Some of these bacteria are motile, some are spore-bearing, which points are all used in the recognition of the organisms. The bacteria generally found in the bakery grow best in alkaline media, therefore differing from the yeast, which grow best in an acid medium.

Some of these organisms, as is true with the yeast, are beneficial, while most of them are detrimental to the industry.

Resume.

In considering the foregoing collective treatment as it were of the moulds, yeast and bacteria the fact must not be overlooked that in order to remain within the very limited confine of the scope of this work, the same is of necessity very brief, therefore the reader is referred to works which treat exclusively on this subject for more detailed information.

However, the illustrations on Plates V, VI and VII show exactly what is meant in the descriptive matter on moulds, yeast and bacteria. These organisms can all be grown for observation purposes on artificial culture media, prepared from the desired food substances and combined with some gelatinizing substance, such as gelatine or agar-agar.

Microscopical Examination of Yeast.

In a general way the examination of microscopical objects is pursued in approximately the same manner, and considering the fact that the yeast is the most important organism concerning the baker we submit the following outline to be adopted in such examinations:

1. Appearance of individual cells
    - (a) As to the consistency of the Protoplasm, whether Granular, Homogenous (liquid) or Vacuoled
    - (b) As to the appearance of the cell walls: thick, thin, or irregular.
2. Shape of cells (a) oval, (b) round or (c) irregular.
3. Size of cells from 5 to 9 microns; (a) large, (b) medium, (c) small.
4. Per cent of dead cells
5. Per cent of weakened cells
6. Foreign substances
7. Per cent of Bacteria
    - (a) As to shape
        1. Rod or bacilli
        2. Dot or cocci
    - (b) As to Occurrence
        1. In chains
        2. In masses
        3. In pairs
        4. In packages
8. Wild yeast of which the micoderma is probably the most common.
9. Inorganic substances, Calcium Oxalate.
10. General opinion based on the above results.

PURE YEAST CULTURE.

Pure yeast culture is the selection of a single cell, which is propagated in sterilized culture media made for that purpose. The cell and subsequent growth is thoroughly examined as to its adaptability for the particular needs, consequently the same is selected entirely upon its character to which end the following tests are made:

1. Whether it is a true or wild yeast.

2. Fermentation test is made, by which test we arrive at the following information:

(a) The energy of fermentation
(b) The reproductive power
(c) The amount of alcohol produced
(d) The amount of carbonic acid produced
(e) The attenuating properties
(f) The flavor produced in the finished product.

3. Finally determine whether the same is free from any bacterial infection.

After all the above tests are made and the yeast is found to be possessed of those characteristics that are deemed desirable for the intended purposes, large cultures are made of the same, in pure yeast apparatuses, which are especially constructed for this purpose. The objects of pure culture yeast are the absence of infection from bacteria, or wild yeast, and to maintain a uniform flavor of the product, as also assuring an exact and definite quantity of yeast required to ferment a known quantity of dough.

Culture Media.

Any substance of organic nature, which is employed for the purpose of growing or propagating all micro-organisms is known as **culture medium.** For the growth of yeast, a solution called **wort** is employed which is prepared by digesting ground malt in water at suitable temperatures. The liquid or wort drained from this digestion or mash is clarified and sterilized in properly constructed vessels. If it is desired to grow the yeast on a solid medium, a certain percentage of agar agar or gelatine is added sufficiently to maintain in a solid condition at ordinary room temperature.

For the development of bacteria for the purpose of identification, the same culture medias may be employed.

Method of Pure Culture.

A desirable yeast is selected and sufficiently diluted with sterile water, so as to have approximately one yeast cell per microscope-field under low power. When this dilution has been attained, close watch having been kept on the manner of dilution and the amounts required, sterilized wort gelatine is substituted for the sterile water, and in a proportion so that the same dilution in liquified wort gelatine is maintained as is true with sterilized water.

This is then transferred in an aseptic manner, to sterilized **moist chambers,*** which are prepared by sealing a ring of glass to the surface of a slide and placing on top of that a cover glass which has a hanging drop of the liquified wort gelatine, containing the yeast cells. The slide so prepared is placed on a level surface until the liquified wort gelatine solidifies, when it is then brought under the low power of the microscope, and examined.

When a suitable cell is found, it is brought to the center of the field, and isolated from all other yeast cells in that field, when it is marked with a marking apparatus, especially designed for that purpose.

After this is completed and several other cells have been marked in the same manner on the same cover glass, it is placed in an incubator, and allowed to grow for 72 hours, and examined from time to time to see that the cells are properly growing.

When they are sufficiently grown, so that the cultures can be seen with the naked eye, they are transferred into a flask containing sterilized wort, and allowed to grow until the wort is fermented. From there they are transferred to a large pasteur-flask, of 250 cubic centimeter capacity, and from this flask tests as to purity are made, and if the same is found to be a desirable yeast it is transferred to the pure yeast apparatus.

Pure Yeast Apparatus.**

A pure yeast apparatus is composed of two or more tanks especially adapted for this purpose and in a general way might be described as follows:

Each tank which is of a size in proportion to the amount of yeast desired, has arrangements on it so that the yeast can be transferred without contaminating it with infected air, and to allow the same to ferment freely without

* See Plate VIII.

** For illustration of pure yeast apparatus see Plate IX.

keeping it under pressure and so that sufficient yeast can be retained for subsequent fermentation, without the renewal of the cultures. All air used for aeration and pressure is filtered through a sterilized cotton filter.

CHAPTER IX.

Refrigeration.

In accordance with the scope of this book, in the following chapter only the most essential points on refrigeration are considered, although this subject is indeed a very important one for the baker as well as for the miller.*

Mechanical Refrigeration.

Mechanical refrigeration is the art of either establishing or maintaining by mechanical means, a temperature lower than the prevailing atmospheric temperature.

Methods of Producing Refrigeration.

While refrigeration can be obtained by the use of cooling water circulated through pipes or by the use of ice, which, when melting, absorbs heat whereby the temperature of the refrigerator is lowered, the most common and most efficient method employed at the present time and whereby in fact very large amounts of refrigeration can be obtained conveniently, is by the evaporation of liquids possessing a low boiling point, chiefly liquified gases.

Refrigerating Liquids.

The most commonly used refrigerating media are **liquid** or **anhydrous ammonia**, **liquid carbonic acid** and **liquid sulphur-dioxyd** which are all sold by the manufacturer in heavy iron or steel cylinders or drums, containing the liquid under a rather high pressure.

Of these three refrigerating medias, ammonia is the one mostly employed.

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*For detailed information reference should be made to the "Compend of Mechanical Refrigeration," by Dr. J. E. Siebel, Director of the Siebel Institute of Technology.

Refrigeration Obtainable.

The amount of refrigeration obtainable by the evaporation of one pound of liquid ammonia is approximately equal to the withdrawal of 475 B. T. U., the same varying somewhat with different conditions.

Hence, in order to obtain one ton of refrigeration, that is the same amount of refrigeration which would be produced by melting a ton of ice and which is equal to the withdrawal of 288,000 B. T. U. about 600 pounds of liquid ammonia must circulate and evaporate in the refrigerator coils.

Refrigerating Systems.

Referring here only to the refrigeration by means of ammonia, two different systems are widely in use, the **compression** and the **absorption** system. The same do, however, practically not differ in the method of producing the refrigeration, or, in other words, in the refrigerating part of the system, but rather in the method of regaining and re-condensing the ammonia vapors produced in the refrigerator.

Essential Parts of Refrigerating Systems.

An ammonia compression system consists essentially of the following parts: A vessel containing the liquid ammonia, the so-called **liquid receiver**; the **refrigerator** part connected to the liquid receiver by means of the **expansion** or **reduction valve.** This refrigerator consists of a number of iron pipes or coils located in the room to be refrigerated.

A third essential part in the **compressor,** frequently but wrongly called ice-machine and finally the **condensor,** which is again a series of pipes cooled either by the atmosphere or more generally by cooling water.

In an absorption system, liquid receiver, refrigerator and condensor are practically the same as in a compression system, in place of the compressor, however, there is the **absorber, exchanger** and **generator.**

Quantity of Refrigeration Required.

The quantity of refrigeration required is naturally dependent upon a number of conditions which are variable in the different cases.

In refrigerating rooms the factors determining the quantity of refrigeration required are the dimensions of the room, the heat-leakage through the walls which depends upon their construction, the temperature to be established or maintained in the room, the maximal outside temperature as also the amount of heat introduced into the room by the materials handled, the operation of machines, burning lights and soforth.

Not considering these last items, that is the heat due to materials, machines, lights and soforth, the refrigeration required will be arrived at very closely by the following calculation.

Let "A" indicate the total area of the walls, including windows and doors, ceiling and floor of the room calculated from its dimensions,

"c" the factor of heat leakage per square foot, which is usually given for 1° F. difference in temperature for 24 hours, and which varies with the construction of the building or room from 2.5 for well insulated walls to about 8 for common brick walls,

"t" the temperature to be maintained in the room,

"T" the maximal outside temperature and

"R" the amount of refrigeration in tons required per day then $R = A \times c \times (T - t) \div 288,000$.

Piping Required.

The pipes employed in refrigerating systems are usually iron pipes 1 to 2 inches diameter. They are generally fastened to the ceiling or the upper parts of the walls, in order to insure good circulation of the cooled air.

Like the quantity of refrigeration required, so the total piping necessary for distributing this refrigeration is not a definite one, but varies with conditions.

Determining in this regard are aside of the quantity of refrigeration to be distributed, the temperature of the rooms to be cooled, the method of operating the machine and others.

However, in general it can be assumed, that for the distribution of one ton of refrigeration from 100 to 125 feet of 1¼ inch pipes are required in rooms to be kept at a temperature not lower than 50° F., and from 150 to 180 feet if this temperature is around 32° F.

CHAPTER X.

Electricity.

Magnetism.

Magnetism is an invisible force which occurs in different ways and has what is known as a North and South Pole. It was known to the ancient Greeks who observed that a lodestone or natural magnet would attract and hold small pieces of iron.

If a piece of hardened steel is once magnetized, it will retain considerable of this magnetism indefinitely, and is therefore considered as a **permanent magnet.** A magnet many times stronger than a permanent magnet is formed if an electric current is sent through a wire wound on a piece of iron. This is then known as an **electro-magnet.**

Magnetic force can be represented by lines of magnetism going through the magnet. These magnetic lines tend to shorten as stretched rubber would; but they also exert a lateral crowding effect on one another, tending to push one another sideways. This is the explanation why like poles repel and unlike poles attract each other. Soft iron is the best magnetic conductor known.

Electric Pressure or Voltage.

Electricity generated or accummulated in a body exerts a certain pressure or tension, called **voltage.**

The most common ways of producing voltage are:

1. By separation, as in belts running over pulleys or when rubbing a cat's back.

2. By a thermo couple, that is a joint made from two dissimilar metals, and heating this joint. This method is largely used for determining temperatures.

3. By chemical process as in a battery in which zinc and acid are used as the active materials.

4. By cutting magnetic lines with a conductor. Extensive use of this method is made in the modern electric generator which is essentially a number of wires cutting magnetic lines.

A flow of electricity or electric current is effected if bodies having different voltage are connected with each other by means of a conducting material or conductor.

A good conductor is one that has a low resistance to currents passing through it, whereas a poor conductor has a high resistance. Substances possessing an exceedingly high resistance are spoken of as non-conductors.

Ohm's Law.

The unit of electric current is called "**ampere**" and the amount of current or the amperes that will flow through a conductor depends upon the electric pressure or voltage as well as upon the resistance of the conductor, which is measured by units designated as "**ohm.**"

This is known as Ohm's Law and its general expression is:

$$\text{amperes} = \frac{\text{volts}}{\text{ohms}}$$

For finding the resistance, that is the ohms, the formula will be:

$$\text{ohms} = \frac{\text{volts}}{\text{amperes}}$$

Like with water or steam, electric power depends upon and is the product of pressure and current. The unit of electric power being termed a "**watt**" so: watts $=$ volts$\times$amperes.

Since 1 watt per minute equals 44¼ pounds, so 1 H.P. or 33,000 foot pounds are equal to 746 watts for 1 minute.

Series Connection.

If a number of conductors are connected in one circuit, they can be arranged either in series or in parallell connection.

Assuming three devices or conductors having the resistance a, b and c respectively, are connected in a circuit in such a way that one terminal of "a" is connected to one of the terminals of "b" which again by its second terminal is connected to one terminal of "c" while the second terminals of both "a" and "c" are connected with the line, then this is termed "**series connection.**"

The total resistance of such a series circuit "r" equals the sum of the three resistances, that is: $r = a + b + c$.

Parallel or Multiple Connection.

Parallel or multiple, also called shunt connection is effected by connecting one terminal of each conductor to one side of the line, while the other terminals of all conductors are connected to the other side of the line, so that each one gets the full voltage of the line.

The combined or total resistance of such multiple circuit can be ascertained by the formula

$$\frac{1}{r}=\frac{1}{a}+\frac{1}{b}+\frac{1}{c} \text{ etc.}$$

Dynamos, Motors.

Generators or dynamos and motors have a field and an armature.

The field is that part of the machine which has a constant magnetism, whereas **the armature** is that part in which the magnetic force or magnetism is changing continually.

A **shunt dynamo** is one where the field has enough resistance to stand the full line voltage and where field and armature are placed in parallel on the line. In such a shunt generator, the voltage will drop as the load is put on, hence it should be started with the load off to let the field build up.

In a shunt motor the speed is nearly constant at all loads, for which reason they are used wherever this is required.

A **series machine** is one where the field is in a series with the armature, the same current going through both, the field having low resistance.

A series generator must have the load on to start as the field must have current to build up this magnetism.

A series motor is used where a variable speed is wanted and a heavy pull at start; hence street cars use series motors.

Most generators are built by combining the series and shunt in which case they are termed "**compound machines.**" The shunt field will build up the magnetism at start and when the load comes on the series coil will build up the magnetism and make up for the drop in voltage which would occur if the machine were only a shunt.

If a generator has enough turns in the series coil so that when the load comes on the voltage goes up, the machine is said to be over-compounded.

Direct Current; Alternating Current.

The term **direct current** is applied where the current is only in one direction as is true with all batteries and D. C. generators.

Alternating current is one where the voltage is constantly changing from positive to negative and negative to positive, etc.

The voltage of an A. C. generator generally follows a sine curve.

A complete change of direction of an alternating current is called **a cycle,** and a 60 cycle line means a line where the voltage makes 60 complete changes per second.

Ohm's law cannot be used with alternating current circuits where there is resistance.

Primary Batteries.

To obtain high voltage, connect the carbon of a battery to the zinc of the next and so forth while to obtain high current, connect all the carbons together in a series and all the zincs in another series.

CHAPTER XI.

Figuring in the Bakeshop.

1. **How much water** is required for a dough made from 1 bbl. (196 lbs.) of flour if the absorption of the respective flour is 63%?

Sixty-three per cent is equal to 0.63 for 1; hence for 196 lbs. we need $196 \times 0.63 = \mathbf{123.48}$ **lbs.** or figuring $8\frac{1}{3}$ lbs. of water as being 1 gal., this equals $123.48 \div 8\frac{1}{3} = \mathbf{14.8}$ **gal.**

2. **How many loaves** can be made out of 1 bbl. of flour, using $14\frac{1}{2}$ gal. = 120 lbs. of water, 5 lbs. of sugar, 3 lbs. of yeast, 5 lbs. of lard and 4 lbs. of salt, allowing 3% loss during fermentation and scaling the loaf at 18 oz.?

Total material $196 + 120 + 5 + 3 + 5 + 4 = 333$ lbs. Loss during fermentation is $333 \times 0.03 = 9.99$ lb. Since 1 loaf requires 18 oz. = $1\frac{1}{8}$ lb., so of the 323 lbs. of dough left after fermentation, we obtain $323 \div 1\frac{1}{8} = \mathbf{287}$ **loaves.**

3. **How much material** is required for making 2,000 loaves, scaled off at 18 ounces and using the materials as indicated in example No. 2?

Since, according to example No. 2, 287 loaves are obtained out of 1 bbl. of flour, so for making 2,000 loaves we need $2000 \div 287 = 6.97$ or in a round number **7 bbls. of flour.**

Water $120 \times 7 = 840$ lbs. or $840 \div 8\frac{1}{3} = \mathbf{100.8}$ **gal.**
Sugar $5 \times 7 = \mathbf{35}$ **lbs.** Yeast $3 \times 7 = \mathbf{21}$ **lbs.**
Lard $5 \times 7 = \mathbf{35}$ **lbs.** and Salt $4 \times 7 = \mathbf{28}$ **lbs.**

4. **What is the cost of material** for the dough in example No. 2, the prices of the respective materials being: flour $7.35 per barrel, sugar 6 cents, yeast 20 cents, lard 18 cents and salt $2\frac{1}{2}$ cents a pound and allowing 5 pounds of flour for dusting.

$$\text{Cost of material} = 7.35 + 5 \times 0.06 + 3 \times 0.20 + 5 \times 0.18 + 4 \times 0.025 + \frac{7.35 \times 5}{196} = 7.35 + 0.30 + 0.60 + 0.90 + 0.10 + 0.19 = 9.44.$$ Ans. **$9.44.**

5. **What is the cost of material for 100 loaves** in example No. 4?

The number of loaves obtainable being 287 (ex. No. 2) and the total cost of material \$9.44, so the cost for 100 loaves is $100 \times \frac{9.44}{287} =$ **\$3.289.**

6. **What must be the selling price** of these 100 loaves, assuming that cost of materials should be 60%, cost of manufacture, overhead and profit 40% of the selling price?

From the proportion X : 3.289 :: 100 : 60 we find the selling price $X = 3.289 \times \frac{100}{60} =$ **\$5.482.**

7. **How heavy must a loaf be scaled off,** if it is to be sold by the baker at 8 cents and if the dough is made from 1 bbl. of flour, 120 lbs. of water, 4 lbs. of sugar, $2\frac{1}{2}$ lbs. of yeast, $4\frac{1}{2}$ lbs. of lard and 3 lbs. of salt, allowing 6 lbs. of flour for dusting. Price of flour \$8.50 per barrel, sugar 7 cents, yeast 22 cents, lard 20 cents and salt 2 cents a pound, and assuming the cost of material to be 55%, labor, overhead and profit 45% of the selling price?

The total weight of the mix is $196 + 120 + 4 + 2\frac{1}{2} + 4\frac{1}{2} + 3 = 330$ lbs.

The total cost of material is $8.50 + 4 \times 0.07 + 2\frac{1}{2} \times 0.22 + 4\frac{1}{2} \times 0.20 + 3 \times 0.02 + \frac{8.50 \times 6}{196} = 8.50 + 0.28 + 0.55 + 0.90 + 0.06 + 0.26 = 10.55$.

Since this \$10.55 is to be 55% of the selling price, so the total selling price of all the loaves made from the entire mix must be $10.55 \times \frac{100}{55} = \$19.18$.

At 8 cents per loaf this would necessitate the making of $1918 \div 8 = 240$ loaves out of the mix.

From the weight of the total mix, 330 lbs., about $2\frac{1}{2}$% are lost during fermentation, leaving $321\frac{3}{4}$ lbs. or 5,148 ounces for scaling off; so every loaf must be scaled off at $5148 \div 240$ = **21.5 ounces.**

8. **What must be the temperature of the water** for a mix of 1 bbl. of flour and 120 lbs. of water, if the temperature of the dough should be 82° F. assuming the temperature of the flour to be 60° F. the temperature of the other ingredients,

sugar, lard, yeast and salt, the same as that of the bakeshop, 80° F.?

Let T indicate the desired temperature of the dough (82°) and t_1 the temperature of the flour (60° F.), then the temperature of the water, t_2, is to be calculated by the formula:

$t_2 = T + 0.66 \times (T - t_1)$ or closely $\frac{5 \times T - 2 \times t_1}{3}$ that is: $t_2 = 82 + 0.66 \times (82 - 60) = 82 + 0.66 \times 22 =$ **96.5°** or $\frac{5 \times 82 - 2 \times 60}{3} = \frac{410 - 120}{3} = \frac{290}{3} =$ **96.6°**.

9. **How much is the interest** on a loan of $1,800 at 5½% per annum for 2 years 3 months?

Since 2 years 3 months is 2¼ years, so the interest is 2¼ × 1800 × 0.055 = **$222.75.**

10. **How much does a discount** of 15% amount on a bill of $86.40?

86.40 × 0.15 = **$12.96.**

11. **How much is to be paid** on a bill of $103.60 allowing 20% discount?

If the discount is 20%, then the amount payable is 80% or 0.80; hence on a bill of $103.60 there is to be paid 103.60 × 0.80 = $82.88.

12. **What amount must be paid** on a bill of $219.20 allowing a compound discount of 25%, 12% and 5%?

The amount payable after allowing the first discount, 25%, would be 75% or 0.75 of the bill.

This, however, will be reduced by the second discount, 12%, to 0.88% of the amount calculated after the first discount, that is to 0.75 × 0.88.

And the third discount, 5% reduces this amount again to 0.95 or to a total of 0.75 × 0.88 × 0.95 of the original amount. Hence the amount to be paid is 219.20 × 0.75 × 0.88 × 0.95 = **$137.38.**

CHAPTER XII.

Mensuration.

Mensuration is that branch of mathematics or general geometry which pertains to the measuring or calculating of lines, areas and solids or volumes.

Measuring of Areas or Surfaces.

Since it is in general impractical if indeed not impossible to measure areas directly, their size has to be caluculated from certain dimensions referring to the respective surface.

Square (Fig. 1).*

A square is a quadrangle in which all sides as well as all angles are equal, the latter being right angles (90°).

To find the area of a square, multiply its side by itself; in other words, if the side is designated as "a" then the area of a square equals $\mathbf{a} \times \mathbf{a} = \mathbf{a}^2$.

For example: A square whose side is 15 inches, has an area of $15 \times 15 =$ **225 sq. in.**

Or: The area of a square of 8 ft. 6 in. equals $8\frac{1}{2} \times 8\frac{1}{2} =$ **72¼ sq. ft.**

Rectangle (Fig. 2).

A rectangle is a quadrilateral having 4 equal angles (90°), but in which only the opposite sides are equal, while the adjacent sides are of different length.

The area of a rectangle is obtained by multiplying its two adjacent sides; or, if these sides are designated as "a" and "b," respectively, this area is $\mathbf{a} \times \mathbf{b}$.

Ex. What is the floor space of a room 18 ft. 9 in. long and 16 feet wide? Since 18 ft. 9 in. equals 18¾ ft. so the area is $18\frac{3}{4} \times 16 =$ **300 sq. ft.**

Triangle (Fig. 3).

For calculating the area of a triangle one of its three sides is selected as the base, "b," while the vertical distance of the opposite point from the base is called height, "h."

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* See Plate X.

Then the area of the triangle is equal to ½ of the product of the base multiplied by the height; that is: area of triangle equals $\frac{1}{2} \times \mathbf{b} \times \mathbf{h}$.

Ex. A triangular piece of land is 245 feet long, while its opposite corner is at a distance of 180 ft. from the base. The area of this piece of land is $\frac{1}{2} \times 245 \times 180 =$ **22,050 sq. ft.**

Polygonal Figures (Fig. 4 and 5).

Any other figure bounded by straight lines can be calculated by dividing the same either into a number of equal triangles as in the case of a regular polygon (Fig. 4), or into unequal triangles and eventually rectangles in figures of irregular shape (Fig. 5), which are then calculated individually and the sum of which represents the total area of the respective figure.

Circle (Fig. 6).

A circle is a closed curved line, all points of which are equidistant from a point within the circle, called the centre. The distance from the centre to any point of the circumference of the circle is the radius, generally designated as "r," while a straight line drawn from any point of the circumference through the centre to the opposite side of the circumference is called diameter "d."

The diameter is double the radius, or the radius is one-half of the diameter: $d = 2 \times r$ and $r = \frac{1}{2} \times d$.

The circumference of the circle is found by multiplying the diameter by 3.14159. . . .

The factor 3.14159 . . . which is generally designated by "π" is infinite; but sufficiently accurate results are obtained by using the abbreviated value 3.14 or $\frac{22}{7}$ hence the circumference of a circle equals $\mathbf{d} \times$ "π" $= \mathbf{d} \times \mathbf{3.14}$.

The area of the circle, however, is the square of the radius multiplied by 3.14, in other words: area of circle equals $\mathbf{r} \times \mathbf{r} \times \mathbf{3.14} = \mathbf{r}^2 \times \mathbf{3.14}$.

Ex. What is the circumference and area of a round table 6 ft. in diameter?

Circumference $6 \times 3.14 =$ **18.84 feet.**

Area $3 \times 3 \times 3.14 =$**28.26 sq. ft.**

Measuring of Solids.

As with areas, so in the case of solids, their size is generally not measured directly but calculated; hollow spaces, however, form an exception insofar they can be measured by filling them with a liquid, f. i., water, the quantity of which is then determined directly.

Cube (Fig. 7).

A cube is a solid or volume having equal length, width and height; its sides are 6 equal squares.

The volume of a cube, having the side "a," is $\mathbf{a \times a \times a = a^3}$.

Ex. A cubical box has a side of 3 ft. 4 in., what is its volume?

$$\text{Volume} = 3\tfrac{1}{3} \times 3\tfrac{1}{3} \times 3\tfrac{1}{3} = \frac{10}{3} \times \frac{10}{3} \times \frac{10}{3} = \frac{1000}{27} = $$

$37\frac{1}{27}$ cu. ft.

Rectangular Prism (Fig. 8).

If a solid or a space is bounded and enclosed by 6 rectangles, which are all joined at right angles, and which may be designated as top and bottom, front and rear, right and left side, and of which each opposite pair is equal, it is termed a rectangular prism.

The volume of such a body is found by multiplying the length by the width by the height; or if these dimensions are designated by "a," "b" and "h," respectively, this volume is $\mathbf{a \times b \times h}$.

Since $a \times b$ equals the rectangle forming the base of the prism, "B," this volume can also be looked upon as being the product of base times height, or $\mathbf{B \times h}$.

Ex. A room is 24 ft. long 18 ft. wide and 12 ft. high; then the volume of air in this room is $24 \times 18 \times 12 =$ **5,184 cu. ft.**

Irregular Prism (Fig. 9).

If a prismatic space is bounded and enclosed by a number of unequal rectangles of the same length, set at right angles with reference to top and bottom, which are equal but which may be either regular polygons or else may have any shape, such a body or volume is an irregular prism.

The volume of the same is calculated according to the same formula as is the rectangular prism, that is: base times height, or $B \times h$.

Cylinder (Fig. 10).

A body or space whose top and bottom are two circles of the same size and whose side is a continuous curved surface extending along the circumference of top and bottom is called a cylinder.

Since for such cylinder the formula of a prism is equally valid, its volume is base × height; the base being, however, a circle, while by height "h" is meant the vertical distance between the centers of top and bottom, so if the radius of the bottom is designated as "r," the volume is $r \times r \times 3.14 \times h$.

Ex. A cylindrical tank is 8 ft. wide and 10 ft. high. How many gallons of water will it hold?

The volume is $4 \times 4 \times 3.14 \times 10 = 502.4$ cu. ft. or since 1 cu. ft. is very closely equal to $7\frac{1}{2}$ gal. this tank holds $7\frac{1}{2} \times 502.2 = 3{,}768$ gal.

Pyramid (Fig. 11).

A pyramid is a body terminating at the top in a point, its sides being triangles while the bottom may be any figure bounded by straight lines.

The volume of a pyramid is one-third of the volume of a prism having the same base and the same height as the pyramid; hence the formula is $\frac{1}{3} \times B \times h$, where "B" indicates the base and "h" the height of the pyramid, that is the vertical distance of the top point from the base.

Cone (Fig. 12).

A body which like the pyramid ends at the top in a point, but whose base is a circle, is called a cone, and its volume is one-third of the volume of a cylinder having the same base and the same height as the cone, hence the volume of cone $= \frac{1}{3} \times r \times r \times 3.14 \times h$.

Frustum of Cone (Fig. 13).

Cutting off the upper part from a cone by a plane parallel to its base, a tub-shaped body is left, which is called a "frustum.'' Its top and bottom are circles of different diameter, while its height is to be taken as the vertical distance between top and bottom.

The volume of such a ''tub'' can be calculated approximately from its mean radius or diameter, that is, the width in the center and its height, ''h.''

The mean radius equals one-half of the sum of top and bottom radius, or if the same is designated by ''m,'' $m = \frac{1}{2} \times (r + R)$, where ''r'' is the radius at the top and ''R'' that at the bottom or $m = \frac{1}{4} \times (d + D)$ if ''d'' and ''D'' are the respective diameters.

Then the volume of the frustum equals **$m \times m \times 3.14 \times h$.**

Ex. A tub is 5 ft. 6 in. wide at the top and 6 ft. 6 in. at the bottom, height being 5 ft., what is its volume?

Since its top diameter is 5 ft. 6 in.; so the top radius is 2 ft. 9 in. and that at the bottom is 3 ft. 3 in.; hence the mean radius $m = \frac{1}{2} \times (2\frac{3}{4} + 3\frac{1}{4}) = 3$ ft., and the same value is obtained from top and bottom diameter as $\frac{1}{4} \times (5\frac{1}{2} + 6\frac{1}{2})$.

Hence the volume is $3 \times 3 \times 3.14 \times 5 =$ **141.3 cu. ft.**

Sphere (Fig. 14 and 15).

The volume of a sphere having the diameter ''d'' $= 1/6 \times d \times d \times d \times 3.14 = 1/6 \times d^3 \times 3.14$, while that of a hemisphere is one-half of this amount or $\frac{1}{12} \times d \times d \times d \times 3.14$.

Appendix

MEASURES AND WEIGHTS.

U. S. SYSTEM.	METRIC OR DECIMAL SYSTEM.

Length Measure:

1 mile	= 5280 feet	1 kilometer	= 1000 meters
1 mile	= 1760 yards	1 meter	= 10 decimeters
1 yard	= 3 feet	1 decimeter	= 10 centimeters
1 foot	= 12 inches	1 centimeter	= 10 millimeters
1 nautical mile	= 1.15 statute miles	1 meter	= 100 centimeters
		1 micron	= 0.001 millimeters

Area or Square Measure:

1 square mile	= 640 acres	1 hektare	= 10000 sq. meters
1 acre	= 4840 square yards	1 are	= 100 sq. meters
1 square yard	= 9 square feet	1 square meter	= 100 sq. decimeters
1 square foot	= 144 square inches	1 sq. decimeter	= 100 sq. centimeters
		1 sq. centimeter	= 100 sq. millimeters

Volume or Cubic Measure:

1 cubic yard	= 27 cubic feet	1 cubic meter	= 1000 cub. decimeters
1 cubic foot	= 1728 cubic inches	1 cub. decimeter	= 1000 cub. centimeters
1 cord	= 128 cubic feet	1 cub. centimeter	= 1000 cub. millimeters

a. Liquid Measure.		**Capacity:**	
1 gal.	= 4 quarts	1 hektoliter	= 100 liters
1 quart	= 2 pints	1 liter	= 10 deciliters
1 pint	= 4 gills	1 deciliter	= 10 centiliters
1 gal.	= 128 fluid ounces	1 centiliter	= 10 milliliters
1 gal.	= 231 cubic inches	1 liter	= 1 cubic decimeter
1 cub. ft.	= 7.48 gal.	1 liter	= 1000 cubic centimeters
b. Dry Measure.			
1 bushel	= 4 pecks	1 cubic meter	= 1000 cubic decimeters
1 peck	= 8 quarts	1 cubic meter	= 1000 liters
1 quart	= 2 pints	1 cubic meter	= 10 hektoliters
1 bushel	= 2150.4 cub. in.	1 hektoliter	= 100 liters
1 bbl. of flour	= 3¾ cub. feet.		

Avoirdupois (commercial).		**Weight:**	
1 ton	= 2000 pounds	1 ton	= 1000 kilograms
1 long ton	= 2240 pounds	1 kilogram	= 1000 grams
1 hundred weight	= 100 pounds	1 gram	= 10 decigrams
1 pound	= 16 ounces	1 decigram	= 10 centigrams
1 ounce	= 437.5 grains	1 centigram	= 10 milligrams
1 pound	= 7000 grains	1 gram	= 1000 milligrams

1 gram is the weight of 1 cub. centimeter of distilled water at 39° F.

Comparison of U. S. and Metric Units.

Length Measure:

1 mile = 1.6094 kilometers	1 kilometer = 0.6214 miles
1 yard = 0.9144 meters	1 kilometer = 1093.6 yards
1 foot = 0.3048 meters	1 meter = 1.0936 yards
1 foot = 30.48 centimeters	1 meter = 3.2808 feet
1 inch = 2.54 centimeters	1 meter = 39.37 inches
1 inch = 25.4 millimeters	1 decimeter = 3.937 inches
	1 centimeter = 0.3937 inches

Area or Square Measure:

1 acre = 0.4047 hektares	1 square kilometer = 247.1 acres
1 acre = 4047 square meters	1 hektare = 2.471 acres
1 square yard = 0.8361 square meters	1 are = 1076.4 sq. ft.
1 square foot = 9.29 square decimeters	1 square meter = 1.196 sq. yds.
1 square foot = 929 square centimeters	1 sq. decimeter = 15.5 sq. inches
1 square inch = 6.45 square centimeters	1 sq. centimeter = 0.155 sq. inches.

Volume and Capacity:

1 cubic foot = 28.32 cub. decimeters	1 cubic meter = 35.314 cubic feet
1 cubic inch = 16.39 cub. centimeters	1 cub. decimeter = 61.0 cubic inches
1 gallon = 3.7854 liters	1 cub. centimeter = 0.061 cubic inches
1 quart = 0.9464 liters	1 hektoliter = 26.42 gallons
1 pint = 0.4732 liters	1 liter = 1.0568 quarts
1 bushel = 35.239 liters	1 hektoliter = 2.838 bushels
1 peck = 8.810 liters	1 liter = 0.9081 dry quarts
1 quart, dry = 1.101 liters	

Weight:

1 pound = 453.6 grams	1 kilogram = 2.205 pounds
1 ounce = 28.35	1 gram = 0.0353 ounces
1 grain = 64.8 milligrams	1 gram = 15.432 grains

BAUME DEGREES (AMERICAN STANDARD) AND SPECIFIC GRAVITY AT 60° F.

a. Liquids Heavier Than Water.

Degrees Baume	Specific Gravity	Degrees Baume	Specific Gravity	Degrees Baume	Specific Gravity
0	1.000	18	1.142	36	1.330
1	1.007	19	1.151	38	1.355
2	1.014	20	1.160	40	1.381
3	1.021	21	1.169	42	1.408
4	1.028	22	1.179	44	1.436
5	1.036	23	1.189	46	1.465
6	1.043	24	1.198	48	1.495
7	1.051	25	1.208	50	1.526
8	1.058	26	1.219	52	1.559
9	1.066	27	1.229	54	1.593
10	1.074	28	1.239	56	1.629
11	1.082	29	1.250	58	1.667
12	1.090	30	1.261	60	1.706
13	1.099	31	1.272	62	1.747
14	1.107	32	1.283	64	1.790
15	1.115	33	1.295	66	1.835
16	1.124	34	1.306	68	1.883
17	1.133	35	1.318	70	1.933

b. Liquids Lighter Than Water.

Degrees Baume	Specific Gravity	Degrees Baume	Specific Gravity	Degrees Baume	Specific Gravity
10	1.000	28	0.886	46	0.796
11	0.993	29	0.881	48	0.787
12	0.986	30	0.875	50	0.778
13	0.979	31	0.870	52	0.769
14	0.972	32	0.864	54	0.761
15	0.966	33	0.859	56	0.753
16	0.959	34	0.854	58	0.745
17	0.952	35	0.849	60	0.737
18	0.946	36	0.843	62	0.729
19	0.940	37	0.838	64	0.722
20	0.933	38	0.833	66	0.714
21	0.927	39	0.828	68	0.707
22	0.921	40	0.824	70	0.700
23	0.915	41	0.819	72	0.693
24	0.909	42	0.814	74	0.686
25	0.903	43	0.809	76	0.680
26	0.897	44	0.805	78	0.673
27	0.892	45	0.800	80	0.667

SPECIFIC GRAVITY AND STRENGTH OF SUGAR SOLUTION IN PERCENTS (BALLING).

Percents Balling	Specific Gravity	Weight of 1 gallon in pounds	Pounds of sugar in 1 gallon	Percents Balling	Specific Gravity	Weight of 1 gallon in pounds	Pounds of sugar in 1 gallon
.2	1.0007	8.345	0.017	12.2	1.0493	8.750	1.067
.4	1.0015	8.352	0.033	.4	1.0502	8.758	1.086
.6	1.0023	8.359	0.050	.6	1.0510	8.765	1.104
.8	1.0031	8.365	0.067	.8	1.0519	8.772	1.122
1.0	1.0038	8.371	0.084	13.0	1.0527	8.779	1.141
.2	1.0046	8.377	0.100	.2	1.0536	8.786	1.160
.4	1.0054	8.384	0.117	.4	1.0544	8.793	1.178
.6	1.0062	8.391	0.134	.6	1.0553	8.801	1.197
.8	1.0070	8.397	0.151	.8	1.0561	8.808	1.215
2.0	1.0077	8.403	0.168	14.0	1.0570	8.815	1.234
.2	1.0085	8.410	0.185	.2	1.0578	8.822	1.253
.4	1.0093	8.417	0.202	.4	1.0587	8.829	1.272
.6	1.0101	8.423	0.219	.6	1.0596	8.836	1.291
.8	1.0109	8.430	0.236	.8	1.0604	8.843	1.309
3.0	1.0117	8.437	0.253	15.0	1.0613	8.850	1.328
.2	1.0125	8.443	0.270	.2	1.0621	8.857	1.346
.4	1.0133	8.450	0.287	.4	1.0630	8.864	1.365
.6	1.0141	8.457	0.304	.6	1.0639	8.872	1.384
.8	1.0149	8.463	0.322	.8	1.0647	8.879	1.402
4.0	1.0157	8.470	0.339	16.0	1.0656	8.886	1.421
.2	1.0165	8.477	0.356	.2	1.0665	8.894	1.440
.4	1.0173	8.484	0.373	.4	1.0674	8.902	1.458
.6	1.0181	8.490	0.390	.6	1.0682	8.909	1.479
.8	1.0189	8.497	0.408	.8	1.0691	8.916	1.498
5.0	1.0197	8.504	0.425	17.0	1.0700	8.923	1.517
.2	1.0205	8.511	0.442	.2	1.0709	8.930	1.536
.4	1.0213	8.517	0.459	.4	1.0717	8.937	1.555
.6	1.0221	8.523	0.477	.6	1.0726	8.944	1.574
.8	1.0229	8.530	0.495	.8	1.0735	8.952	1.594
6.0	1.0237	8.537	0.512	18.0	1.0744	8.960	1.613
.2	1.0245	8.543	0.529	.2	1.0753	8.967	1.632
.4	1.0253	8.550	0.546	.4	1.0761	8.974	1.651
.6	1.0261	8.557	0.564	.6	1.0770	8.981	1.670
.8	1.0269	8.564	0.582	.8	1.0779	8.989	1.690
7.0	1.0277	8.570	0.600	19.0	1.0788	8.997	1.709
.2	1.0286	8.578	0.618	.2	1.0797	9.004	1.729
.4	1.0294	8.585	0.635	.4	1.0806	9.012	1.748
.6	1.0302	8.591	0.652	.6	1.0815	9.020	1.768
.8	1.0310	8.598	0.670	.8	1.0824	9.027	1.787
8.0	1.0318	8.605	0.688	20.0	1.0832	9.034	1.807
.2	1.0327	8.612	0.706	.2	1.0841	9.041	1,826
.4	1.0335	8.619	0.724	.4	1.0850	9.048	1.846
.6	1.0343	8.625	0.742	.6	1.0859	9.055	1.865
.8	1.0351	8.632	0.760	.8	1.0868	9.063	1.885
9.0	1.0359	8.639	0.777	21.0	1.0877	9.070	1.905
.2	1.0368	8.646	0.795	.2	1.0886	9.078	1.925
.4	1.0376	8.653	0.813	.4	1.0895	9.086	1.944
.6	1.0384	8.660	0.831	.6	1.0904	9.094	1.964
.8	1.0393	8.667	0.849	.8	1.0914	9.102	1.984
10.0	1.0401	8.673	0.867	22.0	1.0923	9.110	2.004
.2	1.0409	8.680	0.885	.2	1.0932	9.117	2.024
.4	1.0418	8.687	0.903	.4	1.0941	9.124	2.044
.6	1.0426	8.695	0.922	.6	1.0950	9.131	2.064
.8	1.0434	8.701	0.940	.8	1.0959	9.139	2.084
11.0	1.0443	8.708	0.958	23.0	1.0968	9.147	2.104
.2	1.0451	8.715	0.976	.2	1.0977	9.154	2.124
.4	1.0459	8.721	0.994	.4	1.0986	9.162	2.144
.6	1.0468	8.730	1.013	.6	1.0996	9.170	2.164
.8	1.0476	8.736	1.031	.8	1.1005	9.177	2.184
12.0	1.0485	8.743	1.049	24.0	1.1014	9.185	2.204

COMPARISON OF THERMOMETER SCALES.

C.	F.	R.	C.	F.	R.	C.	F.	R.
260	500	208	79	174.2	63.2	26	78.8	20.8
255	491	204	78	172.4	62.4	25	77.0	20.0
250	482	200	77	170.6	61.6	24	75.2	19.2
245	473	196	76	168.8	60.8	23	73.4	18.4
240	464	192	75	167.0	60.0	22	71.6	17.6
235	455	188	74	165.2	59.2	21	69.8	16.8
230	446	184	73	163.4	58.4	20	68.0	16.0
225	437	180	72	161.6	57.6	19	66.2	15.2
220	428	176	71	159.8	56.8	18	64.4	14.4
215	419	172	70	158.0	56.0	17	62.6	13.6
210	410	168	69	156.2	55.2	16	60.8	12.8
205	401	164	68	154.4	54.4	15	59.0	12.0
200	392	160	67	152.6	53.6	14	57.2	11.2
195	383	156	66	150.8	52.8	13	55.4	10.4
190	374	152	65	149.0	52.0	12	53.6	9.6
185	365	148	64	147.2	51.2	11	51.8	8.8
180	356	144	63	145.4	50.4	10	50.0	8.0
175	347	140	62	143.6	49.6	9	48.2	7.2
170	338	136	61	141.8	48.8	8	46.4	6.4
165	329	132	60	140.0	48.0	7	44.6	5.6
160	320	128	59	138.2	47.2	6	42.8	4.8
155	311	124	58	136.4	46.4	5	41.0	4.0
150	302	120	57	134.6	45.6	4	39.2	3.2
145	293	116	56	132.8	44.8	3	37.4	2.4
140	284	112	55	131.0	44.0	2	35.6	1.6
135	275	108	54	129.2	43.2	1	33.8	0.8
130	266	104	53	127.4	42.4	0	32.0	0
125	257	100	52	125.6	41.6	— 1	30.2	— 0.8
120	248	96	51	123.8	40.8	— 2	28.4	— 1.6
115	239	92	50	122.0	40.0	— 3	26.6	— 2.4
110	230	88	49	120.2	39.2	— 4	24.8	— 3.2
105	221	84	48	118.4	38.4	— 5	23.0	— 4.0
100	212	80	47	116.6	37.6	— 6	21.2	— 4.8
99	210.2	79.2	46	114.8	36.8	— 7	19.4	— 5.6
98	208.4	78.4	45	113.0	36.0	— 8	17.6	— 6.4
97	206.6	77.6	44	111.2	35.2	— 9	15.8	— 7.2
96	204.8	76.8	43	109.4	34.4	—10	14.0	— 8.0
95	203.0	76.0	42	107.6	33.6	—11	12.2	— 8.8
94	201.2	75.2	41	105.8	32.8	—12	10.4	— 9.6
93	199.4	74.4	40	104.0	32.0	—13	8.6	—10.4
92	197.6	73.6	39	102.2	31.2	—14	6.8	—11.2
91	195.8	72.8	38	100.4	30.4	—15	5.0	—12.0
90	194.0	72.0	37	98.6	29.6	—16	3.2	—12.8
89	192.2	71.2	36	96.8	28.8	—17	1.4	—13.6
88	190.4	70.4	35	95.0	28.0	—18	— 0.4	—14.4
87	188.6	69.6	34	93.2	27.2	—19	— 2.2	—15.2
86	186.8	68.8	33	91.4	26.4	—20	— 4.0	—16.0
85	185.0	68.0	32	89.6	25.6	—21	— 5.8	—16.8
84	183.2	67.2	31	87.8	24.8	—22	— 7.6	—17.6
83	181.4	66.4	30	86.0	24.0	—23	— 9.4	—18.4
82	179.6	65.6	29	84.2	23.2	—24	—11.2	—19.2
81	177.8	64.8	28	82.4	22.4	—25	—13.0	—20.0
80	176.0	64.0	27	80.6	21.6			

Formula for the Conversion of Thermometer Degrees.

°C. to °F. multiply by 9, divide by 5, then add 32.
°C. to °R. multiply by 4 and divide by 5.
°F. to °C. subtract 32, then multiply by 5 and divide by 9.
°F. to °R. subtract 32, then multiply by 4 and divide by 9.
°R. to °C. multiply by 5 and divide by 4.
°R. to °F. multiply by 9, divide by 4, then add 32.

DEGREE OF HUMIDITY.

(In Percents of Saturated Condition, as Determined by Wet and Dry Bulb Hygrometer.)

Difference between dry and wet bulb.	DRY BULB (AIR TEMPERATURE °F.)									
	55°	60°	65°	70°	75°	80°	85°	90°	95°	100°
20°	2	7	13	19	25	30	33	36	39	41
19	4	10	16	22	28	32	36	39	42	44
18	7	13	19	25	31	35	38	41	44	46
17	11	17	23	29	34	38	41	44	47	49
16	15	21	27	33	37	41	44	47	49	51
15	20	26	31	36	40	44	47	49	51	54
14	25	30	35	40	43	47	50	52	54	56
13	30	34	39	44	47	50	53	55	57	59
12	35	39	43	48	51	54	56	58	60	62
11	40	43	47	51	54	57	59	61	63	65
10	45	48	52	55	58	61	63	65	66	68
9	50	53	56	60	62	64	66	68	69	71
8	55	58	61	64	66	68	70	71	72	74
7	60	63	65	68	70	71	73	74	76	77
6	65	68	70	72	74	75	76	78	79	80
5	70	73	75	77	78	79	80	81	82	83
4	76	78	80	81	82	83	84	85	86	86
3	82	83	84	85	86	87	88	88	89	89
2	88	89	89	90	90	91	92	92	93	93
1	94	94	94	95	95	96	96	96	96	96
0	100	100	100	100	100	100	100	100	100	100

Dictionary and Definitions of Technical Terms.

With reference to this dictionary, it must be stated that the same is confined chiefly to such terms as are only touched upon briefly in the text of this Manual, and therefore in its compilation no attempts towards completeness have been made. Nevertheless the same repeats explanation of some of the most important subjects even though they are already included in the text of this Manual.

Absorption — A characteristic property of flour to absorb and retain water. It is measured by the quantity of water obsorbed by the flour in order to produce a dough of normal consistency, and it is expressed in percents.

Acid — Compounds of various elements, containing hydrogen which is replaceable by a metal. Acids have a sharp, acrid taste and possess the property of turning blue litmus paper red (see Litmus Paper).

Acidity — Indicates the extent to which any one or a mixture of acids are present in a substance. (See acid.)

Aeration — The supplying or the charging of a body with air.

Albumen — Nitrogenous constituents of the animal and vegetable organisms, such as the white of an egg or the protoplasm of a cell. (See proteins.)

Albuminoids — A term formerly applied to certain nitrogenous compounds similar to albumen, occuring in the vegetable organism. Albuminoids are now generally termed protein. (See protein.)

Aleurone cells — A layer of the wheat berry, next to the starch cells, consisting of a row of practically cubical cells containing protein.

Alkali — Substance capable of neutralizing an acid. Among alkalies caustic soda, potash and lime water (slacked lime) are the most common.

Amino-Compounds — Organic substances containing nitrogen and hydrogen in combination. Amino-compounds are frequently products of the decomposition of proteins.

Ampere — The unit of electric current.

Analysis — The process whereby the composition of a material is determined.

Ash — The mineral residue left after complete burning of a substance and composed mainly of potash, soda, lime, magnesia, sulphuric and phosphoric acid and silica.

Atom	Finest division or smallest particle of elementary matter.
Average value	When applied to flour depends upon the amount and quality of bread produced, and is composed of four factors: the color of the flour, loaves to barrel, size of loaf and quality of loaf. The sum of these four factors divided by four gives the average value.
Bacteria	Lowest form of plant life, microscopic in size, consisting of a single cell of protoplasm and to be found in the soil, in water and in many materials throughout nature.
Bicarbonate of soda	The acid sodium salt of carbonic acid, commonly known as baking soda. With acids or acid substances it gives off carbonic acid gas.
Bran	The skin of the wheat berry, removed in milling. Consists essentially of epidermis, epicarp, endocarp and the spermoderm or testa.
Break rolls	The corrugated rolls employed in milling for breaking up the wheat berry into middlings.
British Thermal Unit	Amount of heat required to raise the temperature of one pound of water one degree Fahrenheit; generally indicated as B. T. U.
By-Products	Secondary products of an industry; so is cotton seed-meal a by-product of the cotton oil industry; skimmed and buttermilk are by-products of butter-making.
Calorie	The amount of heat required to raise the temperature of one kilogram of water one degree Centigrade.
Carbohydrates	Substances composed of carbon, hydrogen and oxygen, the latter two in the proportion in which they exist in water. Hence their name: carbo (carbon), hydrate (water).
Carbon Dioxide	(See carbonic acid gas).
Carbonic Acid Gas	Carbonic acid gas is one of the products of fermentation. It is also a common constituent of the air, used by plant life in building up starch and other substances.
Casein	A principal nitrogenous component part of milk and the essential constituent of cheese.
Cell	The smallest living unit of the animal or plant body; such as a yeast cell or blood corpuscle.

Cellulose The substance which makes up the cell-wall and the fibrous matter of plants. Cotton fibre is almost pure cellulose.

Clear Flour The flour made from that part of the middlings which is left after the patent flour has been extracted.

Cold water extract The total of the substances that can be extracted from a material by cold water.

Compound In chemistry any substance composed of two or more elements.

Technically or commercially certain mixtures of fats and oils are termed compounds.

Conditioning The process of treating wheat by the addition of a small percentage of water for the purpose of making it adaptable for milling.

Congealing point (See Solidifying point).

Corn Flakes A flaky product made from corn by steaming and pressing it by means of rollers.

Cover Glass A small flat, circular or square, piece of very thin glass used for covering microscopic objects.

Cream of Tartar Potassium bitartrate; frequently used in baking powders.

Crude Fibre The woody frame-work of all vegetable organisms. (See cellulose.)

Cuticle (See Epidermis).

Decinormal Solutions of acids or alkalis of 1/10 of the strength of normal solutions. (See normal solutions.)

Dextrine A gum-like substance produced from starch by certain chemical processes; also known as British gum.

Dextrose A fermentable sugar naturally occuring in various fruits; can also be made from starch. (See glucose.)

Diastase An enzym of malt which has the property of converting starch into dextrine and maltose. (See enzyme.)

Diastatic power The numerical indication of the capability of malt or malt products to convert starch into sugar; usually expressed as degrees Lintner. (See Diastase.)

Element In chemistry any substance which cannot be decomposed.

Embyro (See Germ.)

Endocarp The inner layer of the skin of the wheat berry, between epicarp and testa.

Endosperm	The inner part of the wheat berry, containing starch cells and gluten.
Enzyme	An unorganized ferment of animal or vegetable origin, e. g. pepsin (from the animal stomach) diastase of malt, etc. Enzymes have, even in small quantities, the power to convert or transform large quantities of complex substances into simpler ones.
Epicarp	The middle layer of the skin of the wheat berry, immediately underneath the epidermis.
Epidermis	The outer layer of the skin of the wheat berry; also called cuticle.
Ferment	A substance, organized or unorganized, which is capable of producing fermentation. (See yeast.)
Fermentation	A chemical decomposition of an organic compound, due to living organisms, or rather to their secretions (enzymes).
Fermenting period of flour	The time of fermentation in which a flour will give the best results. Since this is dependent upon various conditions, among which is the actual character of the flour, so different flours require different periods of fermentation.
Flakes	(See Corn Flakes).
Flavor	A characteristic property of bread comprising taste and odor.
Fuel Value	When used as a measure of food value, it means the heat that can be generated by the digestible part of the respective food. It is expressed either in British Thermal units or Calories.
Gelatinizing of starch	The formation of a jelly-like mass or paste from moistened starch by the effect of heat.
Germ	Or embryo; that part of a seed from which the new plant develops.
Gliadin	That portion of the gluten which is the cause of its elasticity.
Glucose	A sugar made from starch by certain technical methods; is identical with dextrose.
Gluten	In wheat or flour it is that portion of the protein which gives elasticity to the dough in bread making.
Gluten, Dry	The dry substance obtained by drying the wet gluten. (See wet gluten.)

Gluten, Wet — The residue obtained by washing a weighed quantity of flour made into a dough under a stream of water, until all starch is removed.

Glutenin — That part of the gluten which causes its strength.

Grading — The process of separating the middlings obtained from wheat into different fractions according to their sizes which is accomplished by means of sifters or reels.

Graham Flour — An unbolted grade of flour containing all the bran, (similar to whole wheat flour) or a regular flour to which bran has been added.

Gypsum — Calcium sulphate or, if calcined, Plaster of Paris; formerly sometimes used as adulterant in flour. Very valuable for improving the quality of the water used for doughing.

Hardness of water — A term indicating the fact that water contains calcium and magnesium salts. (Lime and Magnesia.) Permanent hardness is caused by the sulphates, temporary hardness by the carbonates of these two substances.

Humidity — The water vapor or moisture contained in air.

Humidity, relative — The amount of moisture in air as compared with the amount of vapor that air at the same temperature, would contain if saturated.

Hydrometer — An instrument for the determination either of the specific gravity of liquids, or, if a percentage hydrometer, of the percentage strength of solutions.

Hygrometer — An instrument for determining the humidity of air (also called psychrometer).

Indicator — In chemistry substances which by a change in color indicate the presence of certain substances (acids, alkalis) or the end-point of a chemical process. The more common indicators are litmus (see litmus), methyl-orange, phenolphtalein, etc.

Infection — The presence in a material of micro-organisms which are foreign to the respective material.

Invertase — An enzyme associated with yeast and capable of inverting cane sugar into invert sugar.

Invert Sugar — Is a mixture of dextrose and levulose.

Kilowatt — A measure of electric power; it is equal to one thousand watts. (See watts.)

Kilowatt hour	One thousand watts per hour.
Lactometer	A hydrometer for determining the specific gravity of milk.
Lactose	Principal sugar contained in milk.
Levulose	A sugar occuring naturally in many fruits.
Litmus	The coloring matter obtained from various species of lichens. In acid solutions litmus has a red color, in alkaline solutions it turns to blue. Used to detect acid or alkali in solutions.
Litmus paper	Either blue or red, prepared by treating paper with either a blue or red extract of litmus.
Malt	Germinated and dried barley.
Maltase	Maltase is an enzyme of the yeast that is able to convert maltose into dextrose. (See enzyme.)
Malt extract	A thick syrup-like liquid representing the concentrated extract obtained from malt by mashing the same in a ground condition with water at certain temperatures, straining off the resulting liquid (wort) and evaporating the greater part of the water.
Maltose	A sugar obtained from starch by the action of diastase.
Melting Point	That temperature at which a solid substance changes into a liquid. It is identical with solidifying point.
Middlings	The coarse particles of the endosperm of wheat obtained by the wheat passing through the break rolls of the mill.
Milk Solids	Total solid matter contained in milk.
Milk Sugar	(See Lactose).
Moisture	Water contained in or held by an apparently dry substance. (See also Humidity.)
Molecule	A combination or group of atoms which is characteristic for any substance.
Nitrogenous matter	Organic substances containing nitrogen in combination, such as the proteins, etc.
Normal acid	A solution of acid, containing in 1000 cc. the equivalent weight of the acid in grams (Normal sulphuric acid contains 49 grs. of chemically pure sulphuric acid in 1 liter).

Normal alkali	A solution of alkali (generally caustic potash or caustic soda) containing in 1000 cc. the equivalent weight of the alkali in grams. (Normal caustic soda contains 40 grs. of pure sodium hydroxide in 1 liter.)
Objective	A combination of lenses; in the compound microscope at the end nearest to the object, respectively to the slide.
Ocular	(Also called eye-piece). A combination of lenses; in the compound microscope at the end nearest to the eye.
Ohm	The unit of electric resistance.
Ohm's Law	The expression of the fact that an electric current in a circuit is in direct proportion to the electric pressure (voltage) and in inverse proportion to the resistance of the circuit.
Organic substances	All compounds containing carbon, hydrogen, oxygen ,etc. Frequently derived from or related to organisms.
Patent Flour	The flour made from the best fraction of the middlings selected and separated from the total of the middlings by means of sieves, sifters or reels.
Patent Flour, long	A patent flour comprising a relatively high percentage of the middling (80% and more).
Patent Flour, short	A patent flour comprising the smallest percentage of the middlings (less than 80 and as low as 65%).
Pepsin	An enzyme of animal origin which has the power of converting insoluble albuminoids into simpler and readily soluble ones. (See proteolytic enzyme and peptase.)
Peptase	An enzyme of vegetable origin contained chiefly in malt or malted cereals, which has in general an effect similar to that of pepsin.
Permanent hardness	(See Hardness).
Phosphates, acid	Acid potassium phosphate as well as acid calcium phosphate are some of the ingredients of some baking powders.
Potash, caustic	A compound of the elements of potassium and oxygen; in form of its salts important as plant food.
Protein	Important nitrogenous, animal and vegetable compounds of great chemical complexity.

Proteolytic Enzymes	Enzymes which have the power of converting complex proteins into simpler ones.
Protoplasm	The slimy, homogenous or granular semi-fluid portion of the contents of an animal or vegetable cell.
Pyrometer	An instrument employed for measuring a high temperature such as that of a baking oven or a furnace.
Red Dog	Is essentially the bran removed in fairly small particles together with a very small percentage of endosperm particles in form of dust.
Reduction rolls	The smooth rolls in a mill by means of which the middlings are gradually reduced to flour.
Rope or ropiness	An infection in bread caused by certain bacteria.
Saccharometer	A percentage hydrometer indicating the percents of sugar in a sugar solution.
Salt	In chemistry any compound of a metal and an acid.
Salt, common	A more or less pure grade of sodium chloride.
Scalping	The process of removing the particles of epidermis and epicarp, endocarp and spermoderm (bran) loosened by the effect of the rollers in the mill.
Scourer	A machine employed in milling for the purpose of removing particles of dirt and dust clinging or adhering rather persistently to the wheat berry.
Separator	A machine used for removing from wheat foreign loosened particles, such as oats, barley, cockle grains, also strings, straws, etc.
Slide	A flat thin, generally rectangular strip of glass, about 1x3 in., upon which the object is placed for microscopic examination.
Soda, baking	Sodium bicarbonate. (See bicarbonate.)
Soda, caustic	A compound also known as Sodium hydroxide, and composed of sodium, oxygen and hydrogen.
Soda, common or washing	Sodium carbonate of technical purity. Differs from baking soda by its lower percentage of carbonic acid contained therein.
Solidifying point	The temperature at which by abstraction of heat, a substance changes from the liquid to solid state. Also called congealing point or freezing point.
Straight flour	A flour milled from the entire contents of the endosperm available for milling, excluding only the bran (about 3 to 5%).

Sugars — Sweet compounds chiefly of vegetable origin, belonging to the group of carbohydrates.

Tempering — (See Conditioning).

Temporary Hardness — (See hardness of water).

Testa — A layer in the wheat berry below the epidermis and pericarp, consisting of two separate strata and enveloping the endosperm proper. It contains the coloring matter of the wheat.

Texture of bread — The sponge-like appearance of the surface of cut bread with reference to the larger or smaller cavities.

Volt — The unit of electric pressure or potential.

Watt — The electric unit for work, equals the product of ampere × volt.

Whole wheat flour — A flour milled from wheat without removing the bran. (See Graham Flour.)

Yeast — A microscopic plant belonging to the class of fungi, that possesses the property of causing fermentation.

Yeast, compressed — Culture yeast of which a great part of the water has been removed by pressure, hence of semi-dry condition.

Yeast, pure culture — Yeast propagated under steril conditions from selected single cells.

Yeast food — Any material which is absorbed and partly or fully assimilated by yeast during the life and propagation.

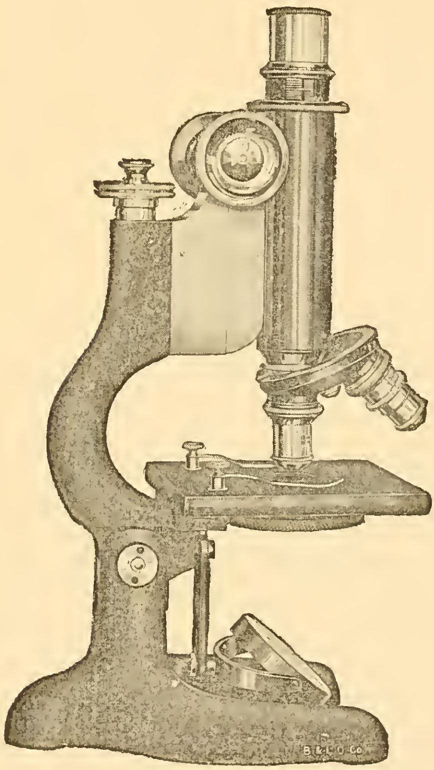
Zymase — An enzyme of yeast which has the property of splitting up certain sugars into carbonic acid and alcohol. (See enzyme and fermentation.)

Plates

For further explanation of the illustrations shown on the following plates, reference should be made to the respective subjects in the text of the book.

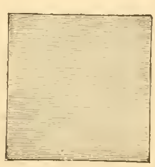
PLATE I.

MICROSCOPE AND ACCESSORIES.

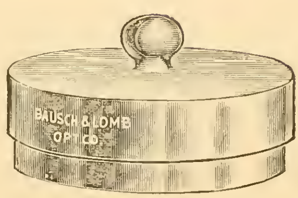


Compound Microscope.

Round Cover Glass.



Square Cover Glass.

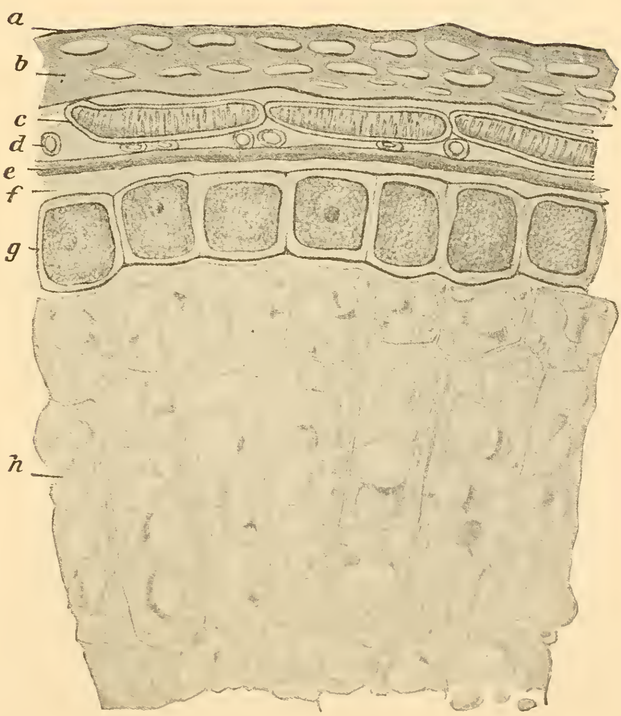


Petri Dish.

PLATE II.

WHEAT.

Wheat Berry.
(Magn.)

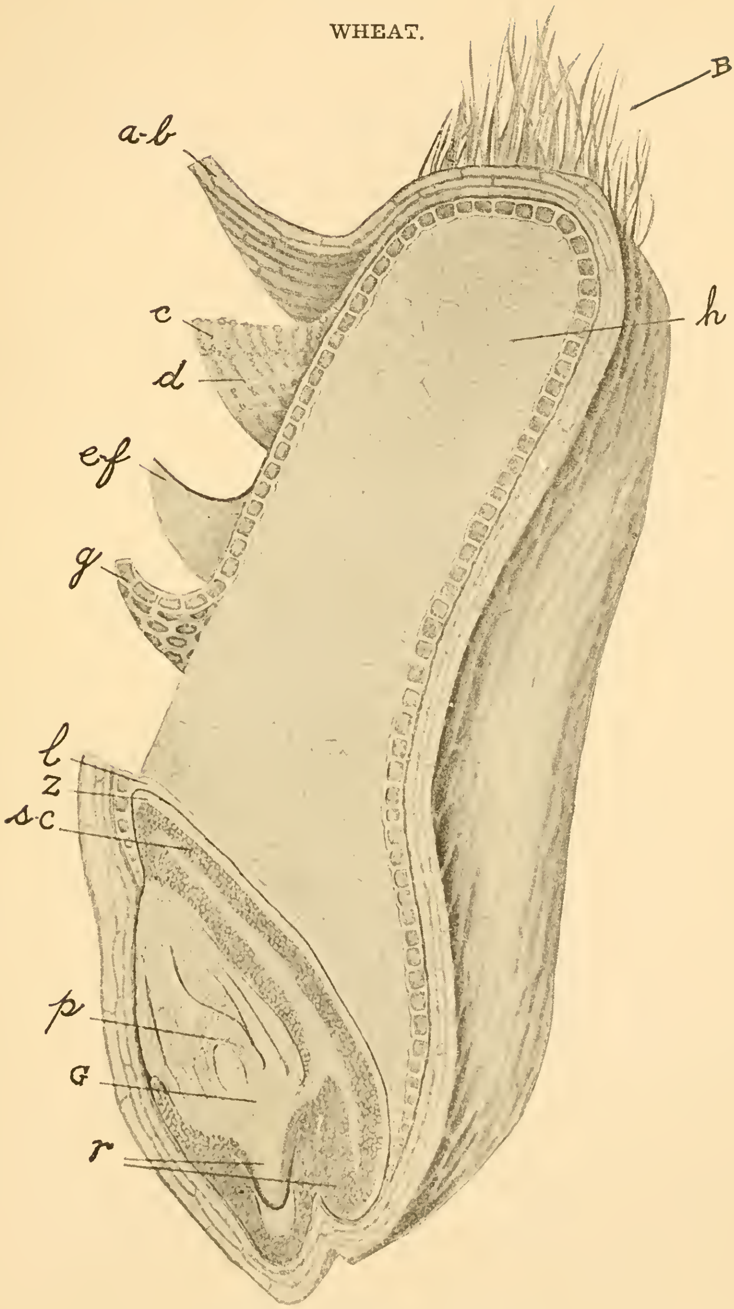


Transverse Section of Wheat (Magn. 200 ×)

a, Epidermis; b, Epicarp; c, Cross cells; d, Tube cells; e, Outer layer of spermoderm; f, Inner layer of spermoderm; g, Aleurone cells; h, Endosperm with starch cells.

PLATE III.

WHEAT.



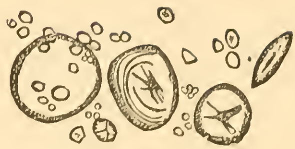
Longitudinal Section of Wheat Berry.

a—b, Epidermis and Epicarp; c, Cross cells; d, Tube cells; e—f, Spermoderm (testa); g, Aleurone cells; h, Endosperm, starch cells; l, Endosperm, empty cells; p, Plumula; r, Radicle, sc, Scutellum; z, Absorptive epithelium; B, beard or hair; G, Germ or Embryo.

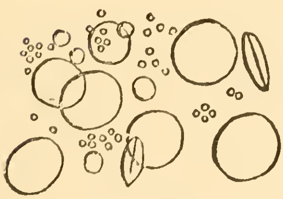
PLATE IV.

STARCHES.

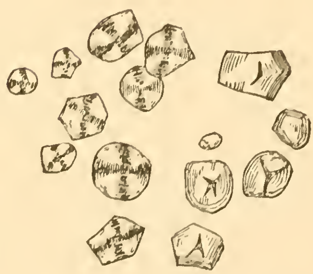
Wheat Starch.



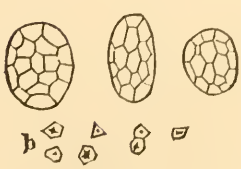
Rye Starch.



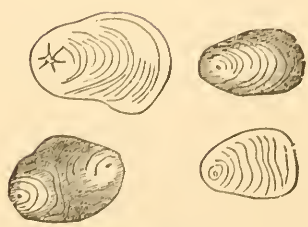
Barley Starch.



Corn Starch.



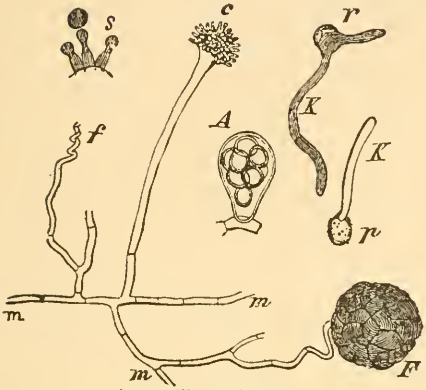
Rice Starch.



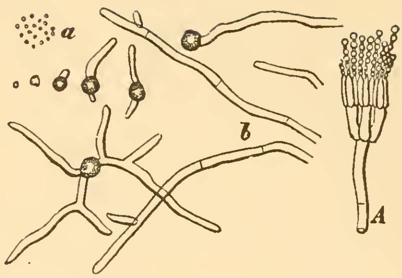
Potato Starch.

PLATE V.

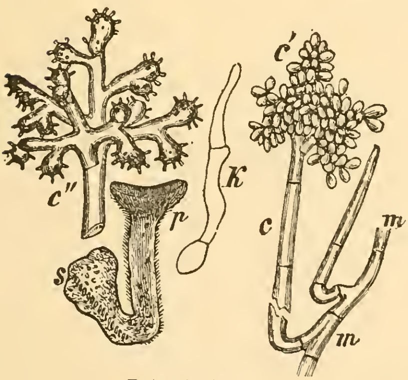
MOULDS.



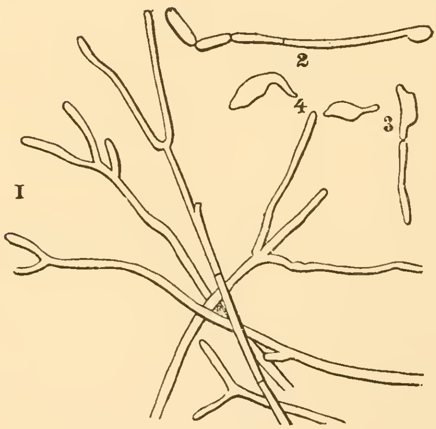
Aspergillus Glaucus.



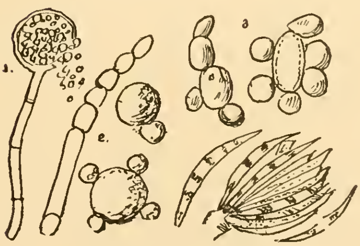
Pencillium Glaucum.



Botrytis Cinerea.



Cidium Lactis.

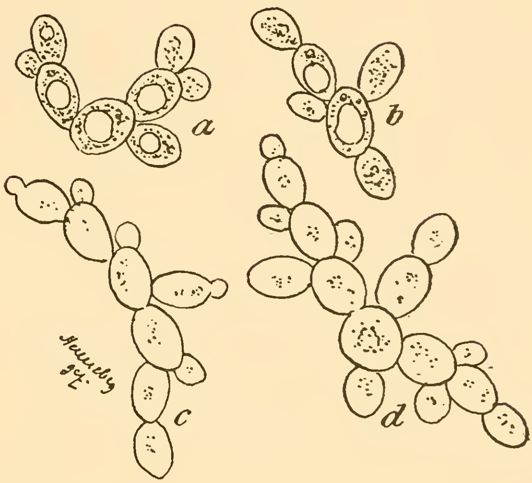


Mucor Racemosus.

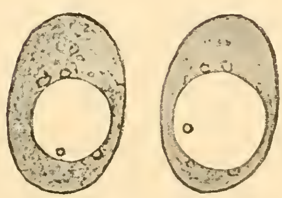
Mucor Circinelloides.

PLATE VI.

YEAST.



Compressed Yeast (Magn. 1000 ×).

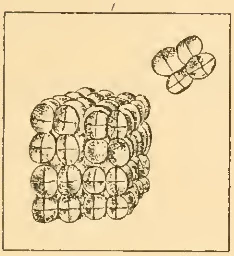


Yeast Cells (Magn. 2500 ×).

PLATE VII.

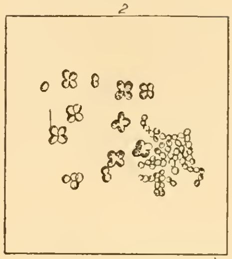
BACTERIA.

1



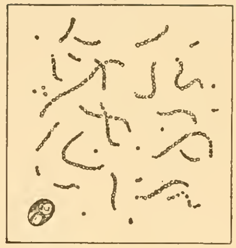
Sarcina Maxima $\frac{1100}{1}$
(after Lindner)

2



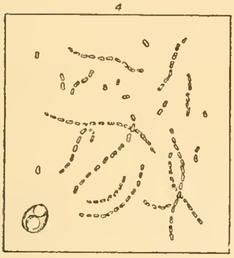
Ped Acidi Lactici ($? \times \frac{1000}{1}$)
(after Lindner)

3



Viscous Ferment $\frac{400}{1}$
(after Pasteur)

4

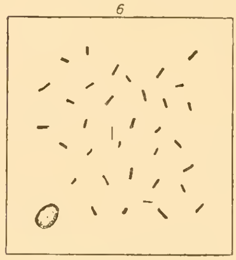


Bacterium Aceti $\frac{400}{1}$
(after Pasteur)

5

Lactic Ferment $\frac{400}{1}$
(after Pasteur)

6

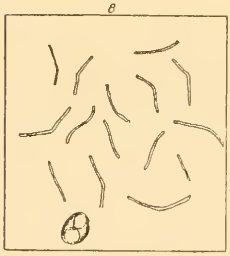


Bact. Lactis $\frac{300}{1}$

7

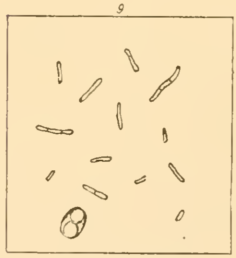
Bacterium Butyricum $\frac{350}{1}$

8



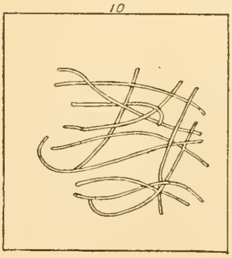
Bac Subtilis $\frac{400}{1}$

9



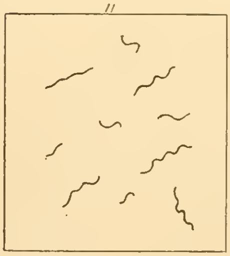
Bac Ulna $\frac{400}{1}$

10



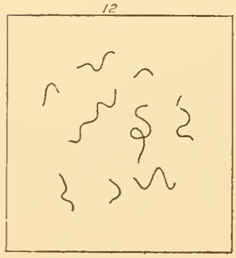
B Leptathrix $\frac{400}{1}$

11



Spirillum Tenue $\frac{400}{1}$

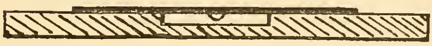
12



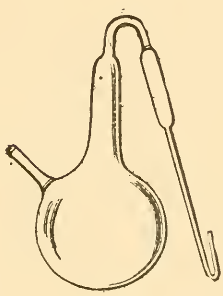
Spirillum Undula $\frac{400}{1}$

PLATE VIII.

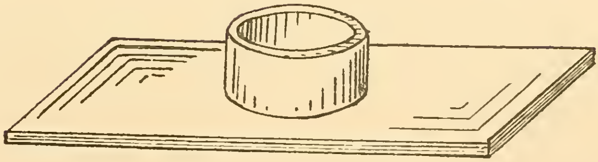
PURE YEAST CULTURE ACCESSORIES.



Drop Culture Slide.



Pasteur Flask.



Slide with Moist Chamber.

PLATE IX.

PURE YEAST APPARATUS.

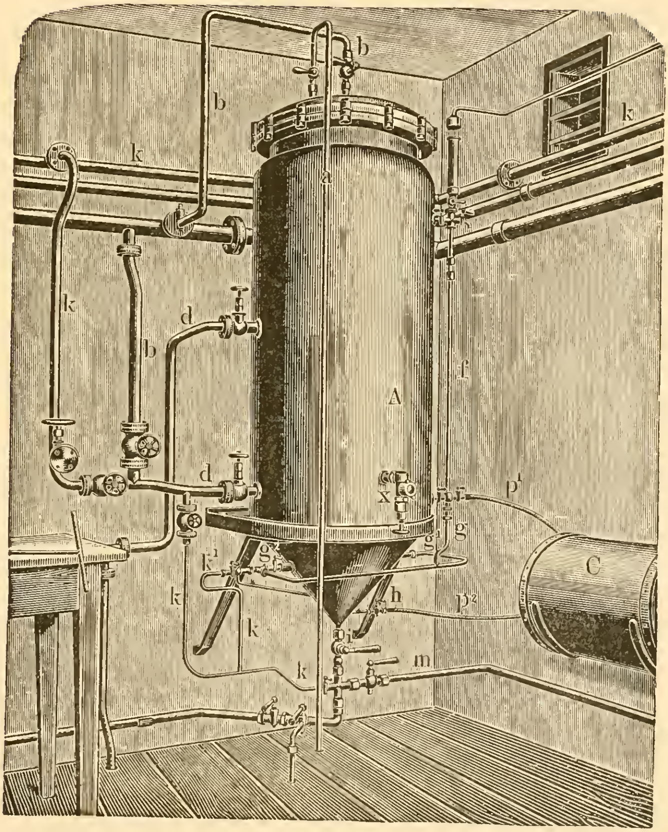


PLATE X.

MENSURATION.

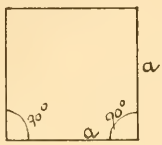


Fig 1. Square.

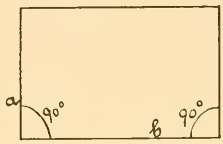


Fig 2 Rectangle

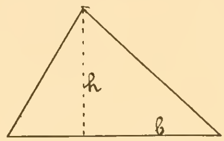


Fig. 3. Triangle.

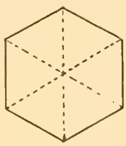


Fig 4. Polygon

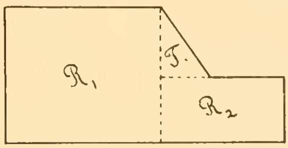


Fig. 5 Irregular Figure

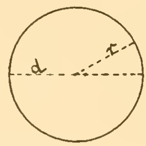


Fig 6 Circle.

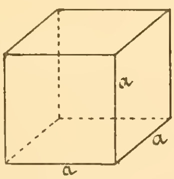


Fig 7. Cube.

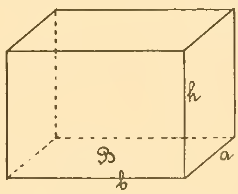


Fig 8. Rectangular Prism.

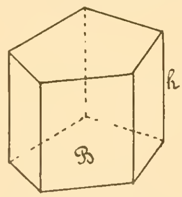


Fig. 9 Polygonal Prism

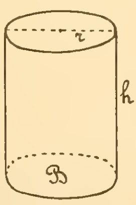


Fig. 10 Cylinder

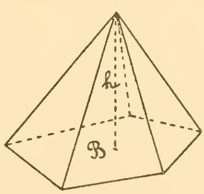


Fig. 11. Pyramid

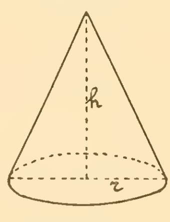


Fig. 12. Cone.

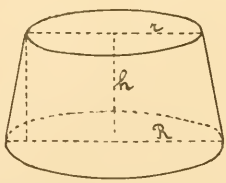


Fig 13. Frustum of Cone.

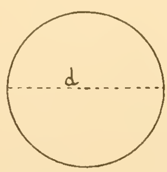


Fig 14. Sphere.

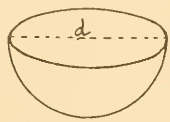


Fig. 15.-Hemisphere.

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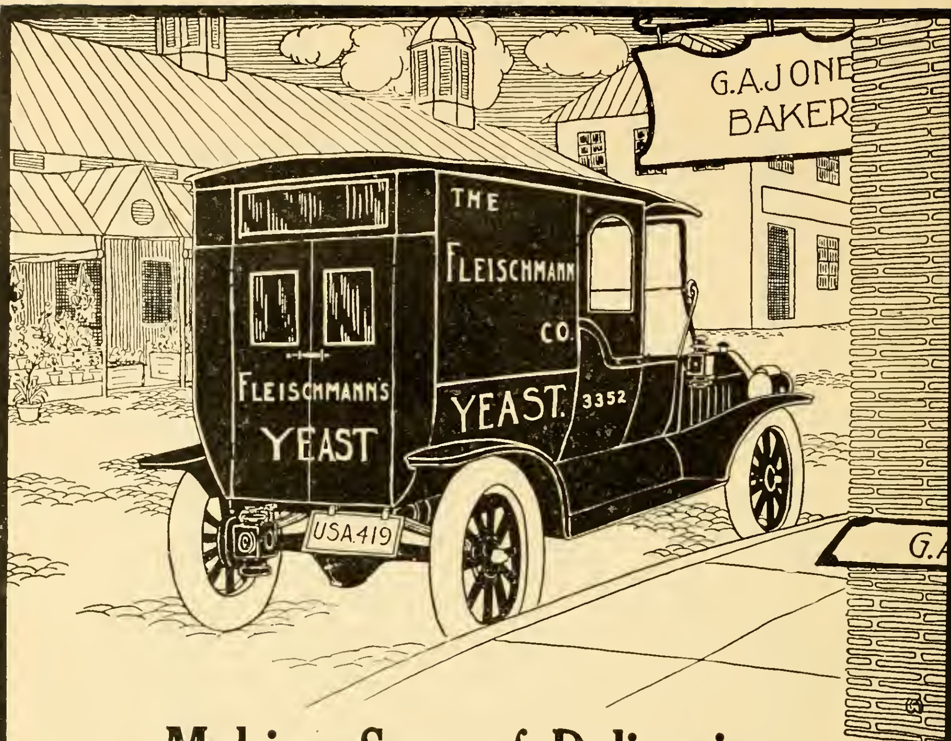

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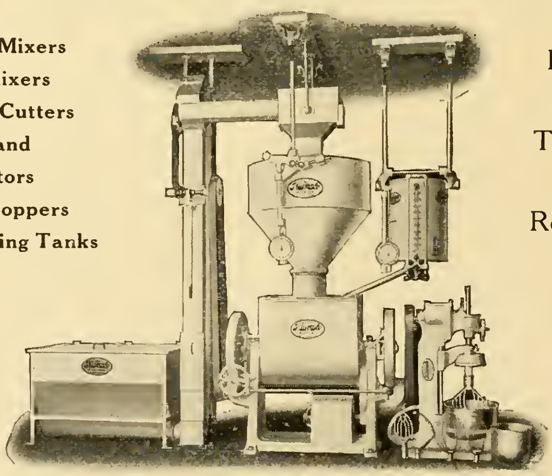

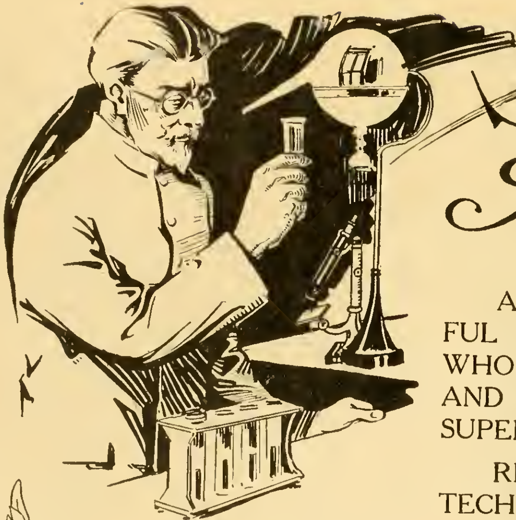

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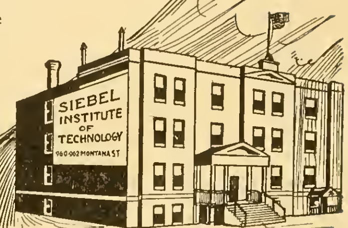

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