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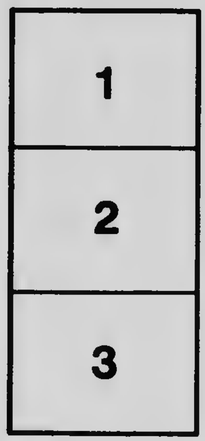
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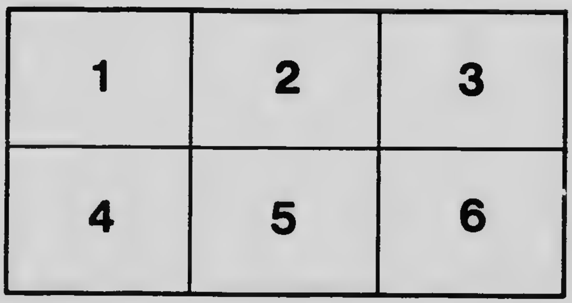
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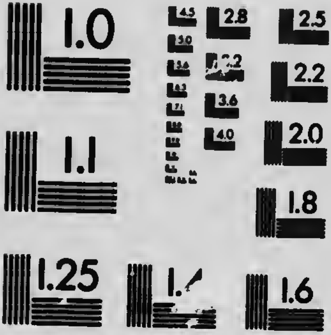

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DEPARTMENT OF AGRICULTURE

CENTRAL EXPERIMENTAL FARM
OTTAWA, CANADA

QUALITY IN WHEAT

PART I

BY

CHAS. E. SAUNDERS, Ph. D.,
Cerealist.

PART II

BY

FRANK T. SHUTT, M. A.,
Chemist of the Dominion Experimental Farms.

BULLETIN No. 57

OCTOBER, 1907.

...direction of the Hon. SYDNEY A. FISHER, Minister of Agriculture, Ottawa.

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Published by direction of the Hon. SYDNEY A. FISHER, Minister of Agriculture, Ottawa.

To the Honourable

The Minister of Agriculture.

Sir,—I have the honour to submit for your approval Bulletin 57 of the Experimental Farm series, on Quality in Wheat. It consists of two parts. Part I. has been prepared by the Cerealist, Dr. C. E. Saunders, and Part II., by the Chemist of the Experimental Farms, Mr. Frank T. Shutt.

In Part I. the chief subjects discussed are the breeding of new sorts of wheat of high quality, especially early ripening varieties, suitable for the northern parts of Canada and the determination of the quality of the different sorts now in cultivation with special reference to their relative value in bread-making. The crossing and the selecting of wheats are dealt with, also the methods of milling the different sorts and of conducting baking tests from the samples so obtained. In the baking the proportion of water taken up and retained by the several varieties is recorded. Accurate measurements have been obtained of the volume of the loaves of bread made and the texture, colour and other peculiarities of each sample noted. A method has been devised for estimating the baking strength of each flour from a baker's standpoint, and the relative value of the different flours for the making of bread ascertained. These tests include spring wheats, winter wheats, durum wheats, also several commercial flours, the latter being introduced for comparison. The relative points of merit also the deficiencies found in the different sorts are fully discussed, and the value of mixed flours in bread making considered. The results here presented of the research work carried on by the Cerealist in this important line of investigation are highly interesting, and the methods devised for solving some of the difficult problems encountered are ingenious and original.

In Part II. the chemical aspects of this work are presented, the chemical composition of wheats is discussed and the value of their different characteristics referred to. Most of the samples which have been milled and baked by the Cerealist have been submitted to analysis by the Chemist and much information is thus given as to their composition. The important part played by the nitrogen compounds in the making of bread is also dwelt on, and the total percentages of albuminoids in each sample given, also the proportions of gliadin, sugar and ash found in each case. This bulletin is most instructive and will commend itself to those who desire information on this important subject.

I have the honour to be, sir,

Your obedient servant,

WM. SAUNDERS,

Director of Experimental Farms.

CONTENTS.

QUALITY IN WHEAT.

PART I.

By Chas. E. Saunders, B.A., Ph.D., Cerealist.

The fact that both wheats and flours differ considerably in their characteristics has long been known, although the ideas generally prevalent in regard to these differences have not been very definite and there has been comparatively little effort made to discover the relationship between the peculiarities of the wheat kernels and those of the flour produced from them. As a rule, too little attention has been paid by farmers to the question of quality in flour, the varieties of wheat giving the largest yield being usually grown, regardless of any other considerations. Of late years, however, more thought has been given to this question of quality, and the price of wheat is now regulated to a certain extent by the opinion which the buyer forms as to the probable quality as well as the quantity of the flour which can be obtained from the grain.

In the new wheat districts of central and western Canada the importance of raising wheat of high quality has usually been recognized. The great distance of some of these areas from the sea coast makes it essential to produce wheat of high quality so that the cost of transportation to the centres of commerce shall not be too great in proportion to the value of the grain. Some sections of the prairie country have too short a season to ripen regularly the later maturing varieties of wheat, and it is clearly imperative, in breeding new sorts of early-ripening habit for these districts, to keep the question of quality constantly in mind. In the older parts of Canada, where farming has been carried on for many years, the tendency to sacrifice quality to yield has been instrumental in reducing the average value of the wheat below the high standard which it might have retained had more attention been paid to this question.

It will be seen, therefore, that there are two chief problems included in the subject of this bulletin, the first being the breeding of new sorts of wheat of high quality (especially for some of the more northern sections of our country), and the second being the determination of the quality of the varieties now in cultivation so as to be able to give to farmers in all parts of Canada definite advice as to the best sorts for them to grow. The first of these problems, the breeding of new varieties of high quality, though of prime importance and occupying a very large part of the writer's attention, does not require lengthy treatment in this bulletin. Most of the space will therefore be taken up with the question of testing wheat for quality under the usual conditions when a fair quantity of pure seed is available.

The investigations reported in this bulletin are by no means complete, some of the problems having, as yet, only been touched upon. The results reached, however, are of some importance and it has been felt that it would be unwise to delay the publication of them for an indefinite period. It is expected that this work will be continued for a considerable time yet, as many important questions have still to be studied.

SIGNIFICANCE OF THE TERM 'QUALITY' IN REGARD TO WHEAT AND FLOUR.

In discussing the quality of wheat, one has to consider both the miller's and the baker's point of view. These two are often confused and the term 'milling quality' or 'milling value,' is sometimes employed in the same sense as 'baking quality.' The miller desires primarily a large yield of flour of good appearance; while the baker is not directly interested in the yield but requires the flour to be of such appearance and strength as will suit his particular purposes. It might happen therefore that a sample of wheat of excellent milling quality might yield flour quite unsatisfactory to the consumer; and on the other hand a poor, somewhat shrivelled sample of wheat, might give a small yield of flour possessing admirable baking qualities.

In referring to flour, the terms 'quality' and 'strength' are often used as if they had the same significance, which is not strictly true. The term 'strength' conveys a fairly definite idea even though slightly different meanings may be attached to it at various times. 'Quality,' however, obviously signifies suitability for the purpose intended. A flour of high quality for pastry is a flour of low strength, whereas a flour of high quality for the production of very light bread or for mixing to improve the strength of weak flours, must be of high strength.

PURPOSES FOR WHICH WHEAT IS USED.

It may be well before going further to mention some of the different purposes for which wheat is used. Of these, bread-making is no doubt the chief, and for this purpose strong flour is most popular, both because it will usually give light bread, even in the hands of a careless worker, and because its water absorption is generally high, a distinct advantage to the baker who sells his bread by weight. For household purposes, where only one kind of flour is used, varieties of the very highest strength are certainly not to be preferred. Very good bread can be made from flour of moderate strength, and such flour is also fairly well adapted for the making of biscuits, cakes and pies, which are usually rather tough and indigestible when made from very strong flour. Flour of really low strength is however undoubtedly the best for pastry. For the making of cereal breakfast foods, many of which consist chiefly, or altogether, of rolled wheat, the manufacturers prefer varieties with plump, round kernels and a yellow skin. The presence of a considerable quantity of gluten is said to be also an advantage from the manufacturer's, as it certainly is from the consumer's, point of view. Wheat is also used for the production of macaroni, for which purpose very hard glutinous sorts are found most satisfactory. Occasionally wheat is grown for the purpose of feeding chickens, in which case, no doubt, highly glutinous varieties are to be preferred.

The consideration of these different uses makes it clear that it is not strictly accurate to refer to the strongest wheat or flour as the best. It is the best only for certain purposes. For other purposes weaker flours are best. Farmers who grow wheat, should, therefore, consider the use to which it is to be put and should select the variety to be cultivated just as they would select an animal for the particular purpose for which it is required.

BREEDING NEW VARIETIES OF WHEAT OF HIGH QUALITY.

From the very inception of the Dominion Experimental Farms a good deal of attention was given to the breeding of wheats of high quality and early maturing habit. This work was, for some years, under the personal supervision of the Director, whose many duties, however, made it impossible for him to devote as much time to it as seemed desirable. Other causes also operated to make progress in those days somewhat more difficult than it is at present. One of the great difficulties was due to the large amount of wheat required for a milling test and to produce flour for baking purposes. During the last few years, since the establishment of the Cereal Division, the installation of suitable apparatus for grinding small quantities of wheat and for conducting baking tests with the flour so obtained makes it possible to determine accurately the quality of any variety, even when only a very small amount of seed is available. Considerable knowledge has also been gained by plant breeders during the last twenty years and the problems can now be attacked with greater assurance of success than was possible two decades ago. From the outset of this work efforts were made principally to combine the high quality of Red Fife wheat with the early maturing habits of other varieties, the quality of which was usually unknown. The system of selection following the cross-breeding was less rigid at first than that which is now employed. For the last few years the method of selection by single plants only has been used on this farm. The seed of every plant saved is always sown separately until after it has been found that the characteristics of each particular strain are quite fixed.

From the beginning it was found to be extremely desirable to have some method of estimating the quality of the grain produced by individual plants. It has been well known for a long time to practical wheat buyers that some rough idea of the baking strength of flour can be obtained by chewing for about four or five minutes a few of the kernels of the wheat from which the flour is to be made and then examining in the fingers the gluten thus obtained. After having carried out this simple test for a large number of times, the writer found that it was possible to acquire considerable facility for judging quality by this method and for the last two or three years he has used it very extensively, chewing, usually, about ten or a dozen kernels from the crop of each plant which is being considered as a possible mother plant. As a general rule, it may be said that the strongest flour will be obtained from those wheats which produce gluten having the greatest ability to recover its shape after being squeezed between the fingers. The variations in the quality of the gluten observed in different plants of the same pedigree are often very great, and it is not claiming too much to say that this simple and apparently inefficient method of testing enables one to select with a fair degree of certainty a few of the best plants each season and thus enormously reduces the labour which would otherwise be involved in multiplying a large number of strains, most of which would ultimately be rejected. That this crude method of testing is infallible one cannot maintain. The writer has, however, shown by actual baking trials that it possesses sufficient accuracy to be worthy of the very serious attention of all wheat breeders, though an investigator may have to perform the test several hundred times before acquiring any proficiency in it. It is not really a very difficult matter to judge in this way, as a rule, with fair accuracy, both the gluten strength and the colour of the flour which would be produced from the wheat in question, and if time were taken to weigh the wheat used and the globule of gluten produced it would certainly be possible to form a rough estimate of the proportion of gluten which the wheat would yield. The writer does not know whether this method of judging the quality of individual plants has been used by other investigators or not, but he would strongly recommend it as imperatively necessary for anyone attempting to breed wheat for high quality. It requires some patience and a fairly good set of teeth, but these two attributes may be considered essential to all breeders of wheat. A study of the later sections of this bulletin will make it clear to anyone that the usual observations on the colour and hardness of the kernels are almost useless for estimating flour strength in breeding new wheats. The chewing test is certainly of great value, though it should always be confirmed by actual baking trials as soon as sufficient wheat is obtainable for that purpose.

By the use of this method, combined with observations on earliness, productiveness, &c., the writer has reselected all the important cross-bred varieties of wheat produced from the crosses made by Dr. Wm. Saunders, by Mr. W. T. Macoun and by Dr. A. P. Saunders, as well as those made by himself some years ago. These new, selected strains have been propagated in every case from selected single plants and show a degree of uniformity which is quite remarkable. Among them are some very promising sorts.

The progeny of the new cross-bred wheats produced by the writer during the last few years have all been subjected to the chewing test and selections made accordingly.

A special instance of the usefulness of this test may be of interest. Some years ago an experiment was tried in order to obtain if possible a natural cross between two varieties of wheat. Red Fife (beardless) and Rio Grande (bearded) were sown mixed in a small plot. When the grain was ripe a few heads of Red Fife, which were borne on rather short straw, were selected, and from these the next season about 200 kernels were sown. Among the plants produced from these seeds, one was found on which the awns were somewhat better developed than is usual in true Red Fife. When some of the seeds of this plant were chewed it was found that the gluten quality was altogether distinct from, and decidedly inferior to that of Red Fife. In this way it was proved that the plant was a cross, the pollen from the Rio Grande having fallen on the head of Red Fife during the blossoming period in the year previous. As this proof, however, would not perhaps be accepted by other observers without confirmation, the seeds from this cross-bred plant were sown the following year. They produced mixed types, bearded, partly bearded and beardless. The seeds as well as the heads showed the influence of the Rio Grande, being, in many cases, larger than those of Red Fife. These observations of course completed the proof of the cross-bred nature of the parent plant, and demonstrated the value of the chewing test as a means of distinguishing similar varieties of wheat.

METHODS OF ESTIMATING STRENGTH OF FLOUR.

The commonest methods of estimating the strength of flour should perhaps be mentioned here before proceeding further. Buyers of wheat often attempt to judge the quality of the flour by the appearance of the grain: hardness, colour, plumpness and condition of the skin being the points most commonly considered. These characteristics are however very uncertain guides as to quality and are sometimes altogether misleading. When the wheat has been ground an attempt is sometimes made to estimate the strength of the flour by its colour or by its granularity or softness. These methods of judging are also of comparatively little value. The mechanical gluten test by washing the starch out of a small quantity of dough is certainly of some value in determining the quality of the gluten. Similar to this is the chewing test; particulars of which have just been given. Efforts to estimate the expansive force of gluten under the influence of heat have been made by the use of the aleurometer, an instrument which has not given satisfactory results. The baker's sponge test is perhaps a better method. It depends on observing the height to which a certain quantity of dough will rise in a cylindrical vessel under the influence of yeast fermentation. No system of chemical analysis yet devised seems to give conclusive and satisfactory estimates of the strength of flour for bread-making purposes. After considering all the methods above mentioned, it becomes quite clear that nothing can yet take the place of the actual baking trials. For this reason much attention has been given to these tests in preparing this bulletin, and they have been carefully repeated several times in each case, so that the results obtained might be quite trustworthy.

EARLY MILLING AND BAKING TESTS.

Before the system was devised, according to which most of the tests reported in this bulletin were carried out, a considerable amount of preliminary research was necessary. During this period some valuable results were obtained, but most of the work has since been repeated in a better form and the earlier determinations need not, therefore, be mentioned here. One rather important variety of wheat, however, has not been studied during the last couple of years as the first tests sufficiently demonstrated its inferiority. The variety referred to is commonly known as Club wheat, and has a small thickened head with red chaff. The grain itself is sometimes very fine looking, and has an attractive red colour when well ripened. In some cases it can scarcely be said to be inferior in appearance to Red Fife. The flour produced from it is, however, of a dark, unattractive yellow colour and is decidedly wanting in strength, producing bread which is by no means acceptable. It seems necessary to call attention again to the poor quality of this wheat as it has been grown for some years in certain sections of Canada. Its cultivation is to be deprecated in any part of the country from which wheat is exported for the production of strong flour.

In Bulletin No. 50 of the Experimental Farm series on the Milling and Chemical Value of the Grades of Wheat in the Manitoba Inspection Division (Crop of 1904) careful details were given as to the milling qualities of the various grades. Baking tests of the 'straight' flour produced from each grade were also made but most of the results of these tests were stated only in general terms. The conclusion was drawn that there was no difficulty in making excellent bread from almost all the grades, but no attempt was made to determine exactly the strength of the flour in each case, the object of the investigation being primarily to determine the value of the wheat for milling purposes.

PREPARATION OF WHEAT FOR MILLING.

As it is well known that wheat improves with age, for some little time after harvesting, the milling tests in connection with the present investigation, have not usually been begun until the month of December. For some weeks before grinding, the samples of grain are stored together under uniform, dry conditions. The greatest care is taken to study only fixed, pure varieties of wheat. Commercial sorts, being seldom quite pure, are usually avoided. The quantity of wheat ground is usually about 600 grammes. Previous to grinding it is carefully sifted and cleaned by hand until free from very small kernels and all foreign matter. About 4 per cent, by weight, of water, is then added, the grain being thoroughly mixed and allowed to stand in a small, covered vessel for about half an hour before the milling is commenced. The practice of millers in regard to the moistening of wheat previous to grinding varies very much but the method just mentioned has been found to be quite satisfactory. If the wheat is allowed to stand for a longer period than half an hour the moisture seems to penetrate too far. The object of the moistening is of course simply to reduce the brittleness of the bran so that it may not be broken up into very small particles by the break rolls.

DESCRIPTION OF EXPERIMENTAL FLOUR MILL AND METHOD OF MILLING.

The apparatus used for the milling of the samples of wheat to be examined was made by the Allis-Chalmers Company of Milwaukee, Wisconsin, and consists of two small mills, one having a pair of corrugated rollers and the other a smooth pair. The machine is also provided with a sifting apparatus and a set of twelve sieves running from No. 16 wire gauze, with meshes of about one-sixteenth of an inch, up to No. 14 silk, which has approximately 140 meshes to the running inch. Large commercial mills are of course always equipped with several kinds of rollers as well as a middlings purifier, where the purification of the partly reduced wheat is assisted by a blast of air. For experimental purposes, however, working with necessarily very small quantities of wheat, there is an obvious objection to multiplying the pieces of apparatus employed and the simple form of mill just described is quite satisfactory.

As a rule four 'breaks' are given, the material which has passed through being sifted after each break to remove the flour and fine middlings produced. Afterwards, several reductions are made with the tailings from the different sieves until all the flour of comparatively high grade has been obtained. One or two further reductions for low grade flour are then carried out last of all. No attempt is made, as a rule, with this apparatus to produce patent flour, the flour used for analysis being in all cases what is called 'straight grade' and includes all the flour suitable for the making of bread. It is of course quite impossible, in a small experimental mill, to produce flour of the very finest colour. This will be easily understood when it is remembered that it is necessary to run all the materials through to the very end in each operation and then to stop the machinery and to thoroughly brush out the inside of each mill and the sifting apparatus. The impossibility of obtaining the best colour does not, however, interfere with the accuracy of the results, because all the samples are treated alike and are judged by their relative instead of their absolute colour.

The percentage of flour produced from any sample of wheat can be estimated by this apparatus with considerable accuracy. In Bulletin No. 50, details were given as to the milling value of the different grades of wheat in the Manitoba Inspection Division. But in order to obtain trustworthy results of this character it is necessary to use very great care and to perform each milling test at least twice. This requires a large amount of time and consumes more wheat than is sometimes available. In the present instance, therefore, the percentage of flour obtained from the different varieties was not determined for publication. The percentage of break flour, however, is given in one of the tables, because, as a rule, this is a trustworthy figure even from one determination, and it will serve a useful purpose in giving some idea of the hardness of each variety of wheat. The percentage of break flour is calculated by taking the total weight of the flour, shorts and bran produced as 100. In using a mill of this character, the total products obtained usually show a loss of about 2 per cent as compared with the weight of wheat taken. All the flour is sifted through a No. 10 silk sieve. This of course does not give an extremely fine product but has proved quite satisfactory for the comparative tests here recorded. After the flour has all been produced it is sifted again through No. 9 silk in order to mix it thoroughly. The separation of the bran from the shorts and the quantitative estimation of these were considered unnecessary in the present investigation.

DESCRIPTIVE TERMS FOR FLOUR.

There are two well recognized classes of flour, though of course they do not include all samples, as specimens with intermediate characteristics are occasionally found. For the description of these two classes different terms are used. One type of flour may be conveniently described as soft, smooth, velvety, or light. Such flour is usually produced by the milling of soft, starchy wheat. The peculiar smooth and velvety feeling of this flour is quite characteristic and forms a striking contrast to that of the other class. The second class of flour is described as hard, granular, heavy or, sometimes, lively. Even though it has been sifted through as fine a sieve as that used in producing the softer kinds of flour, it nevertheless feels somewhat gritty between the fingers and may be poured from one vessel to another more easily than soft flour. Altogether it distantly suggests extremely fine sand. The terms used in this bulletin for these two types of flour will be *soft* and *granular*, as these two words perhaps most conveniently express the striking characteristics of each class. It is generally understood that soft flour is weak and is therefore suitable for the production of pastry, biscuits, &c., and that granular flour is strong and adapted to the making of extremely light bread. While this is true in many cases, an examination of the following tables will show that numerous exceptions occur. Several distinctly granular flours are here mentioned which were found very unsatisfactory for bread-making while good bread was produced in some instances from distinctly soft flour.

The descriptive terms used for colour refer in every case to the flour in its natural, dry condition. The observations were made when the flour had been kept for about two weeks after milling. Not very much importance is attached to the colour because, as is well known, it varies a good deal with the age of the flour and also because the introduction of bleaching processes makes colour a matter of somewhat less significance than it was some years ago. As already explained, the colour of the flours produced by a small experimental mill cannot be very good, but it gives a fair idea of the relative values of the different samples in this respect. The colour after moistening and drying the flours was also studied, but the results obtained in this way did not seem to be of very much importance in view of the fact that the colour of each sample was being carefully studied in the bread. This is undoubtedly the point of most significance, and, therefore, no attempt was made to record with great precision the colour of the different samples of flour.

METHOD OF CONDUCTING BAKING TESTS.

The milling tests are usually made in the month of December and the samples of flour obtained are placed in paper bags and all kept together in an ordinary (heated) room for about two weeks or more before being baked. The baking tests are performed in midwinter, usually in the months of January and February, in order to secure uniform conditions of dryness in the flour, except in so far as it may be natural for flours to differ in moisture content. This very important point has not always received sufficient attention from scientific investigators. Comparisons made between flours which have not been kept and studied under uniform conditions in regard to moisture are usually of very little value. The atmosphere in a laboratory in this climate is extremely dry and comparatively uniform for the winter months, during which time, of course, constant artificial heat is maintained. It is, therefore, possible to make satisfactory comparisons between tests carried out in different years without the necessity of considering the moisture content as a variable factor, provided the tests are all made in midwinter. The difference in moisture content of flour between our midwinter and midsummer conditions has been shown by Mr. Frank T. Shutt to be usually about 4 per cent or even more, an amount so great as to destroy the value of any analyses or tests which might be made without this being taken into consideration.

The fermenting cupboard used in the bread-making is of wood with a glass front and is divided by a central shelf in which are numerous holes to allow free circulation of air. The cupboard is provided with a thermometer and heated by electric lights placed below the shelf and so arranged as to give an evenly distributed heat. When in use it is kept at a temperature of 33 to 35 degrees centigrade (92 to 95 degrees Fahrenheit). As it is essential in working with small quantities of dough that the atmosphere of the fermenting cupboard should be very moist in order to prevent the formation of a crust on the surface of the dough, a low zinc pan is placed under each electric light, and in this a quantity of water is kept which becomes quite warm and gives off a large amount of vapour. In order to observe carefully the height of the dough during fermentation, wires are passed through the top of the cupboard in such a way as to be controlled from outside and so arranged that they can be moved upward from time to time and kept a short distance above the top of the rising dough.

For a test loaf 50 grammes of flour are used. This amount might perhaps be advantageously doubled if the quantity of flour on hand permitted, but in using large amounts of flour there is no apparent gain to counterbalance the obvious objections. It is of the utmost importance to repeat the baking tests several times with each sample of flour and on that account the use of a comparatively small quantity for each loaf is essential when the total quantity on hand is small. In this work as a rule four loaves were made from each sample of flour, each loaf being baked in a separate batch. The results given in the tables represent the averages of the observations made on the four loaves. In the case of strong flours, the different bakings usually agreed very closely, but with weak flours it was found much more difficult to obtain uniform results, owing to the tendency of the dough to fall when allowed to ferment a little too long, or when disturbed by the transferring of the tin to the oven.

To 50 grammes of flour seven-tenths of a gramme of salt are added. The flour is then placed in the fermenting cupboard to become slightly warm. To 20 cubic centimetres of tepid water, one and two-tenths grms. of moist, compressed yeast are added and six-tenths of a gramme of cane sugar. This mixture is placed in the fermenting cupboard for about 20 to 30 minutes, until a rapid evolution of gas is observed. Exactly 20 cubic centimetres of this liquid are then added to the flour and the kneading is commenced. This amount of liquid is reckoned as 20 cubic centimetres of water, which though not strictly accurate, introduces no appreciable error, all the flours being treated in the same way. The exact quantity of water in 20 cubic centimetres of the yeast mixture at this stage is of course unknown. As much additional tepid water as is required to bring the dough to a proper consistency is added from a burette. The first kneading is completed in about five minutes. The dough is then placed in a glass vessel and returned to the cupboard. When the dough has risen to about two and a half times its original volume, it is taken out and kneaded in the hands for three minutes. It is then placed in a small round tin having sides 27 millimetres high (about 1 inch) and a diameter of 80 millimetres (about 3¼ inches). The tin is returned to the cupboard and the dough allowed to rise as high as possible without spreading too much over the sides of the tin. In most instances the dough rises to about twice the height of the sides of the tin. When it is judged that the dough will not gain further volume by prolonging the fermentation, it is placed in the oven and baked for about twelve minutes at 225-230 degrees centigrade (437-446 degrees Fahrenheit). The oven is heated with gas and provided with a thermometer and a rotating shelf to insure uniformity in the baking of the loaves. A perfectly uniform time of baking cannot fairly be used, as the lighter loaves bake more quickly than those that are compact. The heavier loaves are therefore left in somewhat longer.

It is quite a difficult matter to judge when the dough should be transferred from the fermenting cupboard to the oven and the practice of different investigators varies much in this regard. Some give a uniform time for fermentation while others require the dough to rise to a certain uniform height before being baked; but these methods are both open to rather serious objections and it seems to the writer that the plan here adopted gives to each kind of flour the best possible chance to show fully the strength it possesses. Of course, if a weak dough be left too long in the fermenting cupboard it may fall, especially when being transferred to the oven; and in some cases the loaf so produced may be much less in volume than that obtained in other bakings. This falling, however, would certainly occur occasionally in ordinary baking, and the average volume obtained by the writer's method is no doubt as great as that which would be obtained by ordinary bakers, except when they use tins with high sides. In the case of strong doughs there is very little difficulty in manipulation, since even though they may be spreading somewhat over the sides of the tin when put into the oven or may be showing some slight tendency to fall they will usually recover their shape and sometimes gain in height under the influence of the high temperature. The difference in the conduct of various kinds of dough when put into the oven is one of the most striking features observed in the baking tests and appears to be entirely due to the differences in the quality of the gluten at the close of the fermenting period.

When the bread is baked the height of the loaf is compared with the height of the dough before it was put into the oven, and a note is made as to whether there was any gain or loss in height during the baking. The loaf is allowed to cool for an hour and is then examined. The nature of the observations made on each loaf will be seen in the tables headed 'Baking Tests.' Some explanation of the significance of each of the columns of figures included under this general heading will now be given.

WATER ADDED TO 100 GRAMMES OF FLOUR.

Some writers use the term 'strength' to designate the ability of flour to take up water in making dough of a standard viscosity, and an instrument called a 'viscometer' has been devised for the purpose of making careful comparisons between different samples of dough. Flours differ, however, so much that, as a matter of fact, they cannot all be worked up into the same kind of dough. Some doughs are sticky while still very stiff, and others do not become sticky at all unless made very slack. The information obtained by the use of the viscometer is of comparatively little value, because in some instances a slack dough will give a loaf of good shape, even after long fermentation, and, in other cases, a very stiff dough will ultimately spread over the sides of the baking tin if these are not very high and produce a loaf of a very poor shape. A baker needs to know how much water can be added to the flour without spoiling the shape of the loaf. Other things being equal, he will prefer the dough which takes up the largest quantity of water, as such dough is usually the most slack and the easiest to work.

Though the test loaves are made from 50 grammes of flour it is preferable to express the results in terms of 100 grammes. This simple form is so obviously the best that it seems strange that some investigators prefer to express the water absorption in such terms as 'quarts per sack.' The figures given in this column can be converted into quarts (of 40 ounces) of water per sack (of 280 lbs.) of flour by multiplying by 1·12.

WATER RETAINED BY 100 GRAMMES OF FLOUR.

The proportion of water retained by the bread when cool is of very great importance to the baker, the advantage to him of disposing of water at several cents per pound being quite obvious. It is a mistake, however, to regard flour as particularly valuable for ordinary household purposes when it has unusual power of retaining water. There is often more economy in purchasing flour which is rather weak in this respect and which, being less popular, can be bought at a lower price.

Although the figures given in this column would seem to be of great importance from a commercial point of view, it must be explained that they are necessarily quite inaccurate. Very light loaves of bread dry out more rapidly in the oven than loaves which are of medium or rather heavy character. It appears quite impossible to overcome this experimental difficulty, for, though it is evident that the lighter loaves should, for purposes of comparison, be left in the oven a shorter time, one cannot tell just what allowance to make in each case for the difference in volume. The percentage of water retained is not, therefore, a figure of much value except when comparing loaves of approximately equal value. It should be explained that the figures in this column indicate the amount of water retained by the bread in addition to that which was naturally present in the flour. The figure 40, for instance, signifies that 100 parts of flour by weight produced 140 parts of bread. These figures may be converted into 'loaves per sack' (4-lb. loaves per sack of 280 lbs.) by adding 100 to them and then taking seven-tenths of the total thus obtained; or they may be converted into 'loaves per barrel' (4-lb. loaves per barrel of 196 lbs.) by adding 100 and taking 49/100 of the total thus obtained.

VOLUME OF LOAF.

In this column is given the average volume of bread in cubic centimetres produced from 100 grammes of flour, this appearing to be the best method for the expression of volume. Opinions will no doubt differ very much as to the degree of lightness which is desirable in bread and it is to be noted that some kinds of flour produce bread of fair quality when the volume is quite small; while other flours, which make bread of a tougher character, yield a loaf which is undesirable unless it is of rather large volume. There cannot, therefore, very well be any standard volume for a loaf of good bread. Roughly speaking, however, it may be said that bread which has a volume of less than 400 cubic centimetres (for each 100 grammes of flour) is distinctly heavy. Bread having a volume of 400 to 429 cubic centimetres may be classed as rather too compact, though one occasionally finds desirable loaves within these limits. From 430 to 449 cubic centimetres the bread is of medium lightness, sometimes very good in quality. From 450 to 509 cubic centimetres we have bread which is rather light; from 510 to 550 cubic centimetres it is very light; while any bread reaching a volume of more than 550 cubic centimetres may be regarded as unnecessarily light. When baking tins with high sides are used, bread can sometimes be produced having a considerably larger volume than that indicated by this latter figure.

The volume of each loaf is observed by determining the amount of flax seed displaced by it, using a vessel of known capacity. This is much more accurate than any system of measuring. The volume attained depends primarily on two factors which are somewhat distinct from each other: the first being the ability of the dough to rise in the fermenting cupboard and the second being its ability to hold or to increase its volume when transferred to the oven. Some doughs stop rising when only a medium volume has been reached, but show very good ability to maintain that volume; while others may rise to a fair height but exhibit a decided tendency to fall in the oven. Very strong doughs rise well during fermentation and hold or increase their volume in the oven.

In this connection it seems necessary to refer to the interesting theory recently advanced by Mr. T. B. Wood, M.A., (Journal of Agricultural Science, April, 1907) that the volume of a loaf depends upon the amount of gas evolved during the later stages of the fermentation, the quantity of gas being itself dependent on the amount of yeast food available. Among the proofs advanced in favour of this idea may be mentioned the experiments in which a quantity of sugar was added to the dough at the final kneading. It was found that a greater volume of loaf was reached by those doughs to which sugar had been added. It may however be pointed out that the apparent value of this test is somewhat lessened by the fact that the doughs were allowed to rise for only 30 minutes after the addition of the sugar and that nearly all the loaves produced were heavy (below 400 cubic centimetres volume from 100 grammes of flour). This experiment therefore gives very little clue as to what might have been the relative rank of the doughs if each had been allowed to attain its best volume for the production of really light bread. Some cases which have come under the writer's observation lead him to believe that Wood's theory is of value in explaining certain unusual phenomena, but he cannot accept it as by any means covering the whole question of volume. One cannot lose sight of the fact that while some doughs rise in the oven, others fall. The difference in conduct in this respect is often extremely striking and as it is all brought out within a period of about three minutes (under the baking conditions of these experiments) it seems clearly to be due to the inherent qualities of the gluten and not to any differences in the volume of gas produced by the yeast in so short a period of time.

HEIGHT OF LOAF DIVIDED BY DIAMETER.

In carrying out these tests it has been recognised that flour from Canadian wheat is baked under two radically different conditions, sometimes in tins with high sides and at other times without any support, in the form known in England as the cottage loaf. Since it was known that exactly the same results as to volume would not be obtained by these two different methods of baking and since it was impracticable to carry out all the tests in both forms an intermediate type of loaf was adopted, the bread being baken in a tin having sides approximately half the height of an average loaf. In this way some indication was given as to the ability of the dough to rise when supported while some information was also obtained as to its tendency to spread when unsupported. Under such conditions the shape of the loaf depends partly on the strength of the flour. The weak flours produce dough which has a tendency to run over the sides of the tin, while the dough made from strong flours holds itself well together and rises without any appreciable spreading. A loaf made from flour of what might be called ideal strength would have a height approximately equal to its diameter and would be in the form of a sphere. A loaf made from extremely weak flour would of course rise scarcely at all above the edges of the tin so that its height would be about the same as that of the tin while its diameter would be equal to or greater than that of the tin. In practice it is found that the height of the loaf divided by the diameter, using the kind of tin here described, usually gives a figure ranging between .60 and .73, the loaves varying from about 42 to 60 millimetres in height and from about 75 to 88 millimetres in diamter.

FORM OF CRUST.

The figures in this column are determined by inspection, the ideal crust being taken to be one which is perfectly uniform and of a regular, dome shape. Cracks in the crust or an irregular wavy form are considered objectionable. A mark of 100 indicates a strictly first-class crust but is not taken as indicating perfection. Occasionally a mark as high as 105 may be given. A mark of 70 indicates an extremely poor crust; while the marks between 70 and 100 indicate various degrees of excellence between these two extremes.

TEXTURE.

The mark for texture is also necessarily empirical, owing to the obvious difficulty of accurately measuring and recording the average size of the minute holes in the bread. The ideal texture is regarded as one which is extremely fine and perfectly even. Bread with such texture would be comparatively easy to cut and to spread with butter, even when made extremely light. The size of the cells in bread is not always a good indication of the lightness of it, because the large cells frequently have very heavy walls, while, when extremely strong flours are used, though the cells may be quite small, the walls are so thin that very little dough is required to produce a loaf of large volume. Texture is a matter of considerable importance and one in regard to which very great differences are observed.

INSIDE COLOUR.

The inside colour of the bread is recorded on an empirical scale somewhat similar to that used for form of crust and for texture. Observations under this heading are necessarily difficult when great accuracy is required, but the figures given in this column can be relied upon to a large extent, as they represent in each case the average of several independent observations. As a rule 8 or 10 kinds of flour were baked each day, so that the observations on colour as well as those on texture and on form of crust (all of which depend on comparisons and not on measurements of any kind) were made fairly trustworthy.

TIME OF FERMENTATION.

The figures given in this column are of comparatively little value, since various causes operate to alter the length of the fermentation period in different cases. In some instances long fermentation is necessary in order that a very strong dough may have time to rise to its largest possible volume, while in other cases a long period may be necessary, owing to the comparatively slow rising of a dough which cannot, in the end, reach any great volume. The greater the quantity of water added, the shorter is the time of fermentation required, that is, when the two tests are made with the same flour. A stiff dough usually rises very slowly, and, in some cases, a larger quantity of water cannot be added on account of the tendency of the dough to spread over the edges of the tin when made rather slack. With other flours a slack dough can safely be made, thus causing a more rapid action of the yeast.

BAKING STRENGTH.

The desirability of expressing in a numerical way the baking strength of every flour is clearly evident after the inspection of the following tables containing several columns of observations on the different characteristics of the various flours. It is a common custom to adopt some one flour as a standard and refer all others to that, often ignoring the fact that the strength of the standard flour itself may change as it becomes older. Sometimes one sample is taken as a standard for spring wheats and another for winter wheats without making any attempt to bring both types to the same standard of measurement and without recognizing the fact that within each of these groups there are very great variations. The experiments here recorded show very clearly these variations and also prove that flour from winter wheat is in some instances stronger than that produced from spring wheat, a fact which serves to emphasize the futility of the old classification. It appears to the writer imperative to establish a scale of strength, based on such figures as are given in the tables headed 'Baking Tests,' so that the baking strength of any sample of flour can be definitely recorded for future reference, that the values of different flours may be readily compared and that the use of standard flours may be discontinued. As has already been pointed out, the term 'strength' is sometimes used in relation to water absorption only. The more general usage, however, includes perhaps all of the factors of which use is made in this bulletin. 'Strength' in flour may be roughly defined as the ability to take up and to retain water and to produce a large high loaf (even when unsupported by the tin) with a regular, even crust and fine texture. Such a definition may be somewhat more broad than is generally recognized, but it expresses with fair accuracy the characters which influence an ordinary baker in passing judgment on the strength of any flour. In estimating baking strength the first six columns of figures, under the heading 'Baking Tests' are used: that is to say, water added, water retained, volume of loaf, shape of loaf, form of crust and texture. Inasmuch as the figures in these columns are sometimes unrelated, simple addition would give to some of them so subordinate a place that they would scarcely influence the resultant figure at all. In order, therefore, to bring them to the relative prominence which they should have, the following method is used: The figure in the first column (water added) is multiplied by two, that in the second (water retained) by five. The figure for volume is taken as it stands. The figure for the shape of the loaf is multiplied by 500, that for form of crust by two, and that for texture by three. The sum of the figures thus obtained is usually between 1,500 and 1,700. Any scale of strength dealing with such large figures would be very clumsy, and, therefore, for the purpose of bringing the figures to a scale of moderate proportions and for the sake of emphasizing somewhat the differences between the different kinds of bread, the writer has adopted the arbitrary practice of subtracting 700 from the total obtained and dividing the remainder by 10. This gives a scale of points for flour strength which runs usually from about 70 to 100, but is not limited in either direction. One hundred represents not perfection but simply a flour very high in strength. Seventy represents a flour very low in strength. Exceptional flours may obtain a mark above 100 or below 70, but these figures are the usual limits.

As has already been partly explained, excessive strength in flour is not really very desirable except for mixing purposes. It may safely be said that the very strongest flours, owing to the toughness of the dough made from them, do not always produce the best quality of bread; while for the making of pastry, cake, soda crackers, &c., they are not suitable. Much of the so-called pastry flour sold in Canada is identical with the flour sold for bread-making and contains gluten of very strong character. This partly accounts for the fact that Canadian pastry has not a high reputation for quality. Some millers even go so far as to advertise a particular brand of strong flour as of the highest quality both for bread and for pastry—about as accurate a statement as if one were to claim for a horse that he was unexcelled both for racing and for draft purposes. The actual facts need to be emphasized: that the strongest wheats such as hard Canadian Red Fife, are of great value for mixing with other sorts which are too low in strength but that the best and most wholesome bread is made from wheats, or mixtures, somewhat below the highest strength, while pastry and cakes require rather weak, starchy flours, such for instance as are made in Ontario from Dawson's Golden Chaff wheat and other winter varieties not specially strong in character.

Flour of great strength is usually somewhat scarce in the world's markets and therefore commands as a rule a very high price. Instances occur, however, when distinctly weak kinds of wheat or flour are sold at higher prices than those of great strength. It is purely a question of supply and demand; and it is important to remember, therefore, that although the strongest wheat or flour usually brings the highest price, this fact proves its relative scarcity and its value for mixing purposes, but does not establish its worth for general household use.

The scale of strength here used needs a few further words of explanation. In some cases flours are given about the same figure for strength when they are really different in character. But this seems unavoidable. For instance, a weak flour which contains a large proportion of starch and not very much gluten is quite distinct from a weak flour which contains a considerable amount of gluten of very feeble character; though the two may earn the same mark for strength. The latter type of flour is often less desirable than the former. A starchy flour yields products which have a decided tendency to crumble and are often quite delicious and wholesome, even though somewhat compact; but a flour which contains a large amount of very poor gluten gives rather tough products, and cannot be made into bread of sufficient lightness to overcome this defect. A specific illustration will make this clearer.

It will be seen in the tables that Goose wheat (No. 123) gained 81 marks for strength while Dawson's Golden Chaff (No. 102) gained only 76. The Goose wheat flour yielded 15·86 per cent of dry gluten and the Dawson's Golden Chaff 9·55 per cent. The bread made from these two kinds of flour was almost identical in volume but that from the Dawson's Golden Chaff was of much better quality than the other. It may be stated as a general rule that when two flours are of equal strength better bread can be made from the flour containing the smaller amount of gluten. There are exceptions to the rule, however.

BREAD VALUE.

This term is to be understood in a commercial sense only. The ideal flour from a commercial point of view must possess great strength and a very pale colour; hence a flour of only medium or rather good strength and with a somewhat deep yellow colour would have commercially quite a low value for breadmaking, though it might actually produce better bread than some of the strongest and palest flours. The recent adoption of bleaching methods by many of the millers makes it very difficult to judge what importance should be attached to colour in flour, since flour of a pronounced yellow tint can now be much modified by the bleaching. The figures given for bread value in this bulletin are obtained by dividing by four the difference between the figure for baking strength and that given for inside colour. The product is then added to, or subtracted from, the figure for baking strength according to whether the figure for inside colour was greater or less than that for strength. Whether in this way too much or not enough value is given to the colour of the bread may be decided by each individual for himself.

FLAVOUR AND NUTRITIVE VALUE OF BREAD.

While it might be supposed that the flavour and the nutritive value of bread would be the two points of chief importance in determining its selling price, it must be admitted that this is by no means the case. Bread, like many other commercial articles is judged chiefly by appearance. Its nutritive value has apparently no influence whatever on the price and its flavour too is usually of little importance, provided it be not extremely sour. The natural supposition that bread is eaten either for pleasure or for the profit of one's body seems incorrect. At all events, flavour is so elusive a factor, so difficult to observe accurately and so dependent on the physical condition of the observer, that no attempt has been made to determine it, as a rule, in preparing this bulletin. Reference to the second part of the bulletin will show some interesting variations in the food value of the different flours. Undoubtedly, other things being equal, those which contain the largest proportion of albuminoids are the most valuable for bread-making, since albuminoids are a more expensive form of food than starch. The flours particularly rich in albuminoids produce loaves with a darker crust colour than those which contain a larger proportion of starch. As has been pointed out, however, when the gluten is of poor quality and very light bread cannot therefore be produced a somewhat too firm and rather undesirable kind of bread is apt to be made from flours exceptionally rich in gluten. Bread that is of only moderate lightness should be somewhat friable, so that when being eaten it may easily be divided into small particles suitable for digestion. In spite therefore of their superior theoretical food value, those weak flours which are high in gluten are probably of less value for ordinary uses (unless employed in mixtures) than some of the more starchy flours.

Although it cannot, perhaps, be laid down as a definite rule, it certainly appears to be true in many cases, that the flours containing the largest proportion of albuminoids also possess the highest flavour.

VARIETIES ARRANGED IN SERIES ACCORDING TO BAKING STRENGTH, VOLUME OF LOAF AND SHAPE OF LOAF.

An inspection of the two tables which have this heading shows that there is, as a rule, a fair degree of agreement between the figures for baking strength and those for volume and for shape of loaf. It may be worth while, therefore, to attempt a rough classification of the samples of flour according to their strength and volume, so that anyone who may not wish to use the method of determining strength here described may be able to see the relationship between his own results and those here published by reference to the figures for volume only. The following groups, necessarily very roughly defined, may be given:—

Very Weak.—Baking strength under 70 or volume under 400. If starchy, such flours may be very useful for crackers or other special purposes. If glutinous or if they are to be used for bread-making they should be mixed with a considerable proportion of stronger flour.

Weak.—Baking strength 70 to 79 or volume 400 to 429. Often of the highest quality for cakes, pastry, crackers, &c. Also suitable for mixing with very strong flours for bread-making purposes.

Medium.—Baking strength 80 to 86 or volume 430 to 449. Usually good for most purposes, except for the production of very light bread.

Strong.—Baking strength 87 to 93 or volume 450 to 509. General purpose flours, suitable for households where only one kind of flour is used. The strongest flours in this group are somewhat useful for mixing with weaker kinds.

Very Strong.—Baking strength 94 to 100 or volume 510 to 550. Suitable for the production of very light bread and for mixing with weak flours.

Of Remarkable Strength.—Baking strength over 100 or volume over 550. Chiefly useful for mixing purposes. If employed unmixed for bread-making the bread should be made extremely light to avoid toughness.

TABLES.

The tabulated results of the observations on the various samples of wheat and flour here follow. It has been thought most convenient to bring the tables together in two groups.

FIRST GROUP OF TABLES.

The first group of four tables gives the figures obtained during the winter of 1905-1906.

MILLING TESTS, December, 1905-January, 1906.

Milling Number.	Variety.	Where and when Grown.	Weight per measured bushel.†	Percentage of break flour.*	Remarks.
			Lbs.		
95	Advance (Yellow).	Ottawa.........1905	....	10	Flour, granular, yellowish.
87	Assiniboia........	Neepawa, Man., "	64¼	9	Kernels rather hard, plump, dark red, bright. Flour granular, yellowish.
81	Aurora.	Ottawa........ "	61½	6½	Kernels hard, not very bright. Flour granular, yellowish.
99	Colorado, No. 50...	Colorado..........	63	... ...	Kernels rather soft, plump, yellow, dull. Flour soft, pale.
90	Gatineau........	Ottawa.........1905	....	10½	Flour somewhat granular, cream colour.
88	Huron (Selected)..	" "	62	10	Kernels hard, red, moderately plump but not bright. Flour granular, deep cream colour.
98	Laurel..........	" "	59	13	Flour soft, pale.
83	Red Fife H.......	" "	61½	10½	Kernels hard, fairly plump but not bright. Flour granular, cream colour.
85	Red Fife, Soft....	Neepawa. ...... "	62½	15	Kernels very soft, pale red, bright, plump. Flour somewhat granular.
86	Red Fife, Hard...	" "	63½	10	Kernels very hard, dark red, bright, plump. Flour granular, cream colour.
93	Red Preston......	Ottawa.... .... "	....	.....	Flour granular, deep cream colour.
84	Yellow Cross....	" "	64¾	9½	Kernels plump and rather hard. Flour soft, pale.
91	9 J 3............	" "	59½	13	Kernels large, soft, dull in colour. Flour rather soft, pale.
92	Turkey Red . ..	Kansas......	60¾	11	Kernels small, hard, dull in colour. Flour granular, dark cream colour.

† One pound (avoirdupois)=453.59 grammes. One bushel (imperial)=36.328 litres.
* The total weight of mill products obtained is taken as 100.

In addition to the samples of wheat mentioned in the table, baking tests were also made with flour produced in 1904 (Milling No. 3) from Red Fife wheat grown at Ottawa in 1902. This wheat was plump but rather soft and weighed 61½ pounds to the measured bushel. The flour produced from it was of a granular character and of a fine creamy-white colour.

BAKING TESTS, January-March, 1906.

Milling Number.	Variety.	Water added to 100 grammes of flour.	Water retained by 100 grammes of flour.	Volume of loaf from 100 grammes of flour.	Height of loaf divided by diameter.	Form of crust.	Texture.	Inside colour.	Time of Fermentation.	
		Grms.	Grms.	Cubic C.					Hrs.	Min.
	Spring Wheats.									
95	Advance (Yellow)	63·5	40	526	·64	85	88	84	3	12
87	Assiniboia	62·5	38	504	·66	89	95	81	3	23
81	Aurora	62·5	38	516	·66	90	88	78	3	8
99	Colorado No. 50	61 5	41	473	·69	103	96	98	3	33
90	Gatineau	58	35	514	·70	105	95	97	3	25
88	Huron (Selected)	63	39	490	·62	88	91	89	3	9
98	Laurel	58·5	38	428	·62	90	78	95	3	24
3	Red Fife (1902)	65·5	39	550	·74	99	104	105	3	51
83	Red Fife H	65	40	538	·68	99	93	98	3	9
85	Red Fife, Soft	64	38	504	·65	80	93	99	3	20
86	Red Fife, Hard	65·5	38·5	560	·69	90	98	101	3	20
93	Red Preston	63	39	502	·66	90	93	94	3	10
84	Yellow Cross	59	36	486	·63	85	85	85	3	10
91	9 J 3	56	35	454	·62	95	80	83	2	53
	Winter Wheat.									
92	Turkey Red (Kansas)	63·5	38	550	·68	102	98	97	3	2

BAKING STRENGTH and Bread Value, as determined by Baking Tests, January-March, 1906.

Milling Number.	Variety.	Where and when Grown.		Baking Strength.	Bread Value.	Remarks.
	Spring Wheats.					
95	Advance (Yellow)	Ottawa	1905	91	89	Bread somewhat yellowish inside.
87	Assiniboia	Neepawa	1905	91	89	Bread was rather dark inside.
81	Aurora	Ottawa	1905	91	88	Bread rather dark inside.
99	Colorado, No. 50	Colorado	....	94	95	Crust rather pale. Dough would not rise very high but showed no tendency to fall.
90	Gatineau	Ottawa	1905	95	96	Low in water absorption; crust rich brown in colour.
88	Huron (Selected)	"	1905	87	88	Shape of loaf not very good.
98	Laurel	"	1905	76	81	Low in water absorption; crust pale.
3	Red Fife	"	1902	106	106	High in water absorption; crust rather pale.
83	Red Fife H.	"	1905	99	99	High in water absorption.
85	Red Fife, Soft	Neepawa	1905	89	91	Crust pale and not of good form.
86	Red Fife, Hard	"	1905	100	100	High in water absorption.
93	Red Preston	Ottawa	1905	91	92	....
84	Yellow Cross	"	1905	82	83	Gained little or no volume in oven.
91	9 J 3	"	1905	78	79	Crust colour very good, not pale; very low in water absorption.
	Winter Wheat.					
92	Turkey Red	Kansas		101	100	....

VARIETIES arranged in Series according to Baking Strength, Volume of Loaf and Shape of Loaf.

Variety.	Baking Strength.	Variety.	Volume of Loaf.	Variety.	Height of Loaf divided by diameter.
Red Fife, 1902	106	Red Fife, Hard	560	Red Fife, 1902	·74
Turkey Red	101	Red Fife, 1902	550	Gatineau	·70
Red Fife, Hard	100	Turkey Red	550	Red Fife, Hard	·69
Red Fife H	99	Red Fife H	538	Colorado, No. 50	·69
Gatineau	95	Advance (Yellow)	526	Red Fife H	·68
Colorado, No. 50	94	Aurora	516	Turkey Red	·68
Advance (Yellow)	91	Gatineau	514	Assiniboia	·66
Assiniboia	91	Assiniboia	504	Aurora	·66
Aurora	91	Red Fife, Soft	504	Red Preston	·66
Red Preston	91	Red Preston	502	Red Fife, Soft	·65
Red Fife, Soft	89	Huron (Selected)	490	Advance (Yellow)	·64
Huron (Selected)	87	Yellow Cross	486	Yellow Cross	·63
Yellow Cross	82	Colorado, No. 50	473	Huron (Selected)	·62
9 J 3	78	9 J 3	454	9 J 3	·62
Laurel	76	Laurel	428	Laurel	·62

SECOND GROUP OF TABLES.

The second group of four tables gives the figures obtained during the winter of 1906-1907.

MILLING TESTS, December, 1906.

Milling Number.	Variety.	Where and When Grown.	Weight per measured bushel.	Percentage of break flour.	Remarks.
	Spring Wheats.		Lbs.		
140	Bishop A	Ottawa ... 1906	58¾	13	Kernels rather hard but dull and not plump. Flour yellowish, granular.
138	Bobs	" ... 1906	61½	13½	Kernels rather hard, yellow, not bright. Flour pale cream colour, granular.
101	Campbell's White Chaff	" ... 1906	58¾	12	Kernels rather soft, not plump, not bright. Flour pale cream, rather soft.
139	Chelsea	" ... 1906	60½	9½	Kernels hard, red but not very bright. Flour pale cream, granular.
125	Colorado	" ... 1906	62	15½	Kernels soft, dull red. Flour pale cream, soft.
105	Downy Riga D.	" ... 1906	62½	8½	Kernels very hard, bright deep red. Flour cream colour, granular.
119	Early Russian	" ... 1906	62¾	14	Kernels not very hard. Flour pale, soft.
112	Ebert	" ... 1906	63½	9	Kernels very hard, red, rather bright. Flour yellowish, granular.
114	Gatineau	" ... 1906	60	12	Kernels hard, red; not plump or bright. Flour cream colour, granular.
141	Grant	" ... 1906	61½	10½	Kernels hard, red, but not very bright. Flour cream colour, granular.
135	Haynes' Blue Stem	" ... 1906	58	12	Kernels not plump, dull, rather hard. Flour cream colour, granular.
134	Herisson Bearded	" ... 1906	63¾	20	Kernels soft, plump, dull red. Flour cream colour, soft.
133	Hungarian White	" ... 1906	61½	14	Kernels not very hard. Flour pale cream, granular.
131	Huron (Selected)	" ... 1906	61½	11	Kernels fairly hard, not very bright. Flour cream colour, granular.

Milling tests, December, 1906—*Continued.*

Milling Number.	Variety.	Where and When Grown.	Weight per measured bushel.	Percentage of break flour.	Remarks.
			Lbs.		
108	Ladoga.........	Ottawa 1906	60½	11	Kernels hard, deep red, rather bright. Flour yellow, granular.
145	Laurel............	" 1906	59½	16	Kernels rather soft, very dull red, not plump. Flour pale cream, soft.
129	Marquis	" 1906	61¾	11	Kernels rather hard and moderately bright. Flour pale cream, rather granular.
148	Outlook.........	" 1906	59	12½	Kernels rather hard but not bright or plump. Flour cream colour, granular.
120	Percy A..........	" 1906	60¾	10	Kernels hard; dark red in colour and rather bright. Flour cream colour, granular.
115	Preston A........				
126	Pringle's Champlain..........	" 1906	61	11	Kernels rather hard and moderately bright. Flour yellowish, granular.
147	Pringle's Champlain..........	" 1906	61½	13	Kernels rather hard. Flour cream colour, granular.
		Indian Head. ..1906	63	....	Kernels hard, red, bright. Flour yellowish, granular.
110	Prospect.	Ottawa...... 1906	58½	14	Kernels rather soft, dull red, not plump. Flour pale cream, soft.
136	Red Fern.........	" 1906	60¾	12½	Kernels moderately hard, dull red. Flour cream colour, somewhat granular.
149	Red Fife.........	" 1902	61½	14½	Kernels rather soft but plump and moderately bright. Flour cream colour, granular.
109	Red Fife H.......	" 1906	59	13	Kernels rather hard, but not plump or bright. Flour pale cream, granular.
146	Red Fife.	Indian Head....1906	63	......	Kernels hard, red, rather bright. Flour granular, cream colour.
132	Red Preston......	Ottawa.........1906	59½	11	Kernels hard; dark red but not very bright. Flour cream colour, granular.
143	Riga M........	" 1906	60	18	Kernels rather soft and of a dull colour. Flour pale cream, rather soft.
113	Spence Yellow....	" 1906	64	12	Kernels hard, yellow, rather bright, plump. Flour cream colour, granular.
106	Stanley A........	" 1906	59	12½	Kernels rather soft, dull in colour, not plump. Flour pale cream colour, granular.
107	Stanley C,........	" 1906	60	11	Kernels hard, not very plump but moderately bright. Flour yellowish and very granular.
150	White Fife C.....	" 1906	60¾	13	Kernels hard, yellow, moderately bright. Flour cream colour, granular.
117	White Russian....	" 1906	60½	16½	Kernels rather soft and of a dull red colour. Flour pale, soft.
144	Yellow Fife	" 1906	61	13	Kernels moderately hard. Flour yellowish, somewhat granular.
130	Yellow Queen.....	" 1906	62	14	Kernels rather soft, but plump and bright. Flour pale, soft.
	Durum Wheats.				
123	Goose				
122	Kubanka (= Washington No. 5,639)	" 1906	63½	4	Kernels very hard, yellow. Flour yellow, very granular.
		" 1906	63	5½	Kernels very hard, yellow. Flour yellow, very granular.
	Winter Wheats.				
102	Dawson's Golden Chaff..........				
100	Padi.............	" 1906	61¾	17½	Kernels soft. Flour pale cream, soft.
		" 1906	61½	21	Kernels soft, pale red but bright. Flour pale cream, soft.
104	Tasmania Red ..				
103	Turkey Red (No. 380)........	" 1906	62	15	Kernels large, soft. Flour pale cream, somewhat granular.
151	Turkey Red	" 1906	63¾	14	Kernels plump, rather soft. Flour cream colour, granular.
		Lethbridge, Alberta, 1906	64½	11½	Kernels plump, hard, red, bright. Flour cream colour, granular.

In addition to the samples of flour made in December, 1906, baking tests were carried on (in January and February, 1907) with three different kinds of commercial flour, and also with a small quantity of the flour from Yellow Cross wheat, milling No. 84, which had been tested the previous winter. This latter flour was placed in a glass stoppered bottle in March, 1906, and kept over in that way. In January, 1907, it was transferred to a paper bag and was kept for some time with the new samples of flour before being baked. The results of the baking tests with these four kinds of flour will be found at the end of the table.

BAKING TESTS, January-February, 1907.

Milling Number.	Variety.	Water added to 100 grammes of flour.	Water retained by 100 grammes of flour.	Volume of loaf from 100 grammes of flour.	Height of loaf divided by diameter.	Form of crust.	Texture.	Inside colour.	Time of fermentation.	
	Spring Wheats.	Grms.	Grms.	Cubic C.					Hrs.	Min.
140	Bishop A	59	37·5	488	·67	96	93	89	2	50
138	Bobs	59·5	36	517	·70	91	102	101	3	5
101	Campbell's White Chaff	58	37	485	70	88	98	93	3	33
139	Chelsea	61	38·5	524	72	94	101	101	3	14
125	Colorado	56·5	36	422	·67	92	78	95	3	30
105	Downy Riga D	62	42	419	·61	97	82	97	2	53
119	Early Russian	60	39	511	73	95	99	102	3	7
112	Elbert	61	41	375	.53	80	75	88	3	..
114	Gatineau	58	36	534	·69	94	98	98	3	16
141	Grant	61	41·5	372	·57	81	74	97	2	58
135	Haynes' Blue Stem	60	36·5	546	·71	96	100	100	3	8
134	Herisson Bearded	58	39	434	·69	99	84	83	3	29
133	Hungarian White	60·5	37	528	·72	92	101	100	3	11
131	Huron (Selected)	59·5	39	429	64	97	86	85	3	11
108	Ladoga	57	37·5	418	·61	96	79	77	3	4
145	Laurel	56	36	417	·64	90	83	96	3	36
129	Marquis	61	39	521	·70	93	101	100	3	6
148	Outlook	60	37	537	·70	97	101	99	3	5
120	Percy A	61	41	429	·66	94	85	96	3	33
118	Preston A	60	40	438	·66	91	90	84	3	23
126	Pringle's Champlain	61·5	39·5	501	·67	90	97	96	3	10
147	Pringle's Champlain (I.H.)	58	38	445	·60	91	88	95	2	52
110	Prospect	59	38	469	·72	97	87	99	3	23
136	Red Fern	57·5	34·5	535	·70	95	100	99	3	10
149	Red Fife (1902)	62·5	39	570	·73	98	105	105	3	18
109	Red Fife H	62	38	567	·69	96	101	101	3	1
146	Red Fife (I.H.)	58	35·5	532	·67	98	99	100	3	11
132	Red Preston	61	41	445	·62	91	87	94	3	4
143	Riga M	57	37	407	·64	95	79	90	3	47
113	Spence Yellow	58·5	40·5	438	60	83	78	99	2	55
106	Stanley A	61.5	40·5	454	·65	91	94	101	3	15
107	Stanley C	57·5	36	505	·65	93	94	80	3	3
150	White Fife C	59	36.5	559	·68	96	102	100	3	9
117	White Russian	59·5	40	434	·66	91	95	101	3	2
144	Yellow Fife	59	37	495	·65	93	91	86	3	6
130	Yellow Queen	60	40	443	68	91	84	99	3	52
	Durum Wheats.									
123	Goose	61·5	41	435	·64	90	83	78	4	..
122	Kubanka	59·5	39	530	.69	98	101	78	3	33
	Winter Wheats.									
102	Dawson's Golden Chaff	56	34	436	·62	78	91	101	3	25
100	Padi	58	37	470	·71	90	96	78	3	28
104	Tasmania Red	60·5	39·5	489	·68	93	99	100	2	57
103	Turkey Red (No. 380)	64	40	519	·68	91	102	103	3	4
151	Turkey Red (Alberta)	[illegible]	37	487	·64	83	97	98	3	15

Baking tests, January-February, 1907—*Continued.*

Milling Number.	Variety.	Water added to 100 grammes of flour.	Water retained by 100 grammes of flour.	Volume of loaf from 100 grammes of flour.	Height of loaf divided by diameter.	Form of crust.	Texture.	Inside colour.	Time of fermentation.	
		Grms.	Grms.	Cubic C.					Hrs.	Min.
	Milled January, 1906.									
84	Yellow Cross	62	39·5	559	·70	93	100	95	2	50
	Commercial Flours.									
	'Monarch'	55·5	34·5	448	63	90	90	....	3	23
	'Queen City'	58	37	487	·67	94	96	.....	3	27
	'White Clover'	61·5	13	500	·67	87	101	......	3	16

Baking strength and Bread Value, as determined by Baking Tests, January and February, 1907.

Milling Number.	Variety.	Where and when Grown.	Baking Strength.	Bread Value.	Remarks.
	Spring Wheats.				
140	Bishop A.	Ottawa... 1906	90	90	Crust somewhat dark brown.
138	Bobs	" ...... "	98	99	Texture of loaf extra good.
101	Campbell's White Chaff	" .... "	91	92	Crust pale.
139	Chelsea	" .. .. "	99	99	Crust rich brown.
125	Colorado	" .... "	77	81	Low in water absorption. Dough had a decided tendency to fall during fermentation.
105	Downy Riga D	" .... "	80	84	High in water absorption, but low in volume and poor in shape.
119	Early Russian	" .... "	98	99	Loaves excellent in shape.
112	Ebert	" .... "	65	68	Very low in volume and poor in shape and texture.
114	Gatineau	" .... "	96	96	Crust rich brown. Excellent bread.
141	Grant	" ...... "	57	67	Very low in volume and poor in shape and texture.
135	Haynes' Blue Stem	" .... "	100	100	....
134	Herisson Bearded	" .... "	84	84	Good bread but unattractive in colour inside.
133	Hungarian White	" .... "	98	99	....
131	Huron (Selected)	" ...... "	82	83	....
108	Ladoga	" .... "	75	76	Dough had a decided tendency to fall during fermentation.
145	Laurel	" .... "	76	81	Low in water absorption.
129	Marquis	" .... "	98	98	....
148	Outlook	" ...... "	99	99	....
120	Percy A	" .... "	83	86	Crust of a rich brown colour. Bread of very good quality.
118	Preston A	" .... "	84	84	....
126	Pringle's Champlain	" .... "	93	94	....
147	Pringle's Champlain	Indian Head.... "	80	84	....
110	Prospect	Ottawa......... "	89	91	Crust pale.
136	Red Fern	" .... "	96	97	Excellent bread.
149	Red Fife	" 1902	107	106	High in water absorption and in volume Texture extra good.

Baking strength and Bread Value—*Continued.*

Milling Number.	Variety.	Where and when Grown.	Baking Strength.	Bread Value.	Remarks.
	Spring Wheats.				
109	Red Fife H. . . .	Ottawa........1906	102	102	High in water absorption.
146	Red Fife	Indian Head.... "	95	96	....
132	Red Preston......	Ottawa......... "	83	86	....
143	Riga, M....... ...	" ... ... "	75	79	....
113	Spence Yellow.. .	" ... ... "	76	82	Crust rather deep brown.
106	Stanley, A.	" .. .... "	87	90	Dough did not spread over sides of pan. Crust rather pale.
107	Stanley C..... ...	" . ..... "	89	87	Dough had to be made very stiff to prevent spreading over sides of pan.
150	White Fife C. ...	" ... . "	100	100	Texture extra good.
117	White Russian ..	" .. ... "	82	87	Crust pale.
144	Yellow Fife	" . . ... "	88	88	....
130	Yellow Queen.....	" .... "	84	88	Crust pale.
	Durum Wheats.				
123	Goose. ..-.......	" .... "	81	80	Crust very dark brown.
122	Kubanka.	" ... ... "	99	94	Crust very rich brown. Bread very good.
	Winter Wheats.				
102	Dawson's Golden Chaff........ ..	" .... "	76	82	Low in water absorption. Crust pale and cracked but quality of bread was good.
100	Padi.............	" .... "	89	86	Bread of a very poor, greenish-yellow colour inside. Crust very pale.
104	Tasmania Red....	" .... "	93	95	....
103	Turkey Red (No. 380.)..	" .... "	98	99	Remarkably high in water absorption.
151	Turkey Red	Alberta. ... . "	87	90	... .
	Milled Jan. 1906.				
84	Yellow Cross	Ottawa.. . . .1905	102	100	High in water absorption. Gained much in volume in the oven. Crust rather rich brown in colour.
	Commercial Flours.				
	'Monarch'	....	80	.. ..	Very low in water absorption.
	'Queen City'.. ..	....	90	....	Water absorption about medium.
	'White Clover' . ..	....	96	... ..	Remarkably high in water absorption.

VARIETIES arranged in Series, according to Baking Strength, Volume of Loaf and Shape of Loaf.

Variety.	Baking strength.	Variety.	Volume of loaf.	Variety.	Height of loaf divided by diameter.
Red Fife, 1902	107	Red Fife, 1902	570	Red Fife, 1902	·73
Red Fife H.	102	Red Fife H.	567	Early Russian	·73
Yellow Cross, 1905	102	Yellow Cross, 1905	559	Chelsea	·72
Haynes' Blue Stem	100	White Fife C	559	Hungarian White	·72
White Fife C	100	Bobs	547	Prospect	·72
Chelsea	99	Haynes' Blue Stem	546	Haynes' Blue Stem	·71
Outlook	99	Outlook	537	Padi	·71
Kubanka	99	Red Fern	535	Bobs	·70
Bobs	98	Gatineau	534	Campbell's White Chaff	·70
Early Russian	98	Red Fife (I.H.)	532	Marquis	·70
Hungarian White	98	Kubanka	530	Outlook	·70
Marquis	98	Hungarian White	528	Red Fern	·70
Turkey Red (No. 380)	98	Chelsea	524	Yellow Cross, 1905	·70
Gatineau	96	Marquis	523	Gatineau	·69
Red Fern	96	Turkey Red (No. 380)	519	Herisson Bearded	·69
Red Fife (I.H.)	95	Early Russian	511	Red Fife H	·69
Pringle's Champlain	93	Stanley C	505	Kubanka	·69
Tasmania Red	93	Pringle's Champlain	501	White Fife C	·68
Campbell's White Chaff	91	Yellow Fife	495	Yellow Queen	·68
Bishop A	90	Tasmania Red	489	Tasmania Red	·68
Prospect	89	Bishop A	488	Turkey Red (No. 380)	·68
Stanley C	89	Turkey Red (Alberta)	487	Bishop A	·67
Padi	89	Campbell's White Chaff	485	Colorado	·67
Yellow Fife	88	Padi	470	Pringle's Champlain	·67
Stanley A	87	Prospect	469	Red Fife (I.H.)	·67
Turkey Red (Alberta)	87	Stanley A	454	Percy A	·66
Herisson Bearded	84	Red Preston	445	Preston A.	·66
Preston A	84	Pringle'sChampl'in(I.H.)	445	White Russian	·66
Yellow Queen	84	Yellow Queen	443	Stanley A	·65
Percy A	83	Preston A	438	Stanley C	·65
Red Preston	83	Spence Yellow	438	Yellow Fife	·65
Huron (Selected)	82	Dawson's Golden Chaff	436	Huron Selected	·64
White Russian	82	Goose	435	Laurel	·64
Goose	81	Herisson Bearded	434	Riga M	·64
Downy Riga D	80	White Russian	434	Goose	·64
Pringle'sChampl'in(I.H.)	80	Percy A	429	Turkey Red (Alberta)	·64
Colorado	77	Huron Selected	429	Red Preston	·62
Laurel	76	Colorado	422	Dawson's Golden Chaff	·62
Spence Yellow	76	Downy Riga D	419	Downy Riga D	·61
Dawson's Golden Chaff	76	Ladoga	418	Ladoga	·61
Ladoga	75	Laurel	417	Pringle's Champ'n(I.H.)	·60
Riga M.	75	Riga M	407	Spence Yellow	·60
Ebert	65	Ebert	375	Grant	·57
Grant	57	Grant	372	Ebert	·53
White Clover	96	White Clover	500	White Clover	·67
Queen City	90	Queen City	487	Queen City	·67
Monarch	80	Monarch	448	Monarch	·63

NOTES ON SOME VARIETIES OF WHEAT.

Some remarks on a few of the most important varieties of wheat mentioned in the foregoing tables may be of interest.

VARIETIES TESTED 1905-1906.

Assiniboia.—This is the common bearded wheat with red chaff, usually found mixed with Red Fife in the western fields. It should be noted that the flour obtained from this wheat was of good strength although distinctly inferior to that produced by Red Fife wheat of equal hardness. The yellow colour of the flour is another point of inferiority.

Red Fife.—The two samples grown near Neepawa, Man., were subjected to essentially the same climatic conditions, but the soft wheat was grown as the second crop after the breaking of 'scrub' land, that is, land which had been covered with a growth of shrubs and trees; while the hard wheat was grown on a field which had been cultivated for some years and which had been in Timothy sod the previous season. The Red Fife H [illegible] early strain multiplied from a single selected plant. The Red Fife of 1902 [illegible]ts the ordinary crop obtained from the plot grown at Ottawa in that season [illegible] doubt ov[illegible]s its high baking strength partly to age. It is interesting to notice t[illegible] the Red Fife H grown at Ottawa is only one mark for strength behind the hard Red Fife [illegible]own at Neepawa.

Red Preston.—This is a selected strain obtained from Preston wheat and possessing red chaff as well as red kernels. It gives flour of good colour and in the tests under consideration it showed a strength slightly greater than that of soft Red Fife, although distinctly less than that of any sample of Red Fife of equal hardness.

Turkey Red.—The flour from this sample was of very good strength although the wheat itself was unattractive. The age of this wheat is, however, uncertain. Its very high strength may be partly due to age.

VARIETIES TESTED IN 1906-1907.

Attention is called to the following varieties all of which produced flour of high strength:—

Bobs.—This wheat was received from the late Mr. William Farrer of Australia. It is rather early in ripening and is said to resist rust very well in some parts of Australia.

Chelsea and *Marquis* are new cross-bred sorts produced at the Central Experimental Farm. They both resemble Red Fife rather closely but are distinctly earlier in ripening.

Early Russian is a selected strain of wheat produced by the writer from a sample of Russian origin, supposed to be the variety called Ghirka. It resembles, in many ways, White Russian but is earlier and produces flour of much greater strength.

Gatineau is from a cross, made by the writer, between Red Fife and Goose wheat. It combines many of the good qualities of the two parents and, though not an early variety, may prove of value in dry districts where the season is fairly long.

Haynes' Blue Stem.—This is a selected type of Blue Stem which was sent to the Central Experimental Farm from the Minnesota Agricultural Experiment Station under the designation Minnesota No. 169. It is rather too late in maturing to be quite satisfactory in most parts of Canada.

Outlook is a new variety produced by the writer by crossing Red Fife with Rideau, an early sort which was itself a Red Fife cross.

Hungarian White.—This is a rather early, bearded wheat obtained from Germany. It may prove of great value if not found too susceptible to rust.

Red Fern.—As will be seen this old variety takes a high rank for flour strength, and indeed the bread produced from it surpassed in quality, according to the writer's opinion, that made from almost all of the other sorts.

White Fife C is a selected strain of White Fife which is, however, not strikingly different from ordinary pure White Fife. It is practically identical in all respects with Red Fife except in regard to the colour of the bran which is yellow.

In addition to the wheats just mentioned, which are of interest on account of t strength of their flour, attention should be drawn to some well-known varieties whi are of rather low strength and are therefore not suitable for the production of e tremely light bread or for export to countries desiring strong flour. The well-know sorts Colorado, Herisson Bearded and White Russian (the latter being practical identical with Wollman's Fife, Monarch, McKendry's Fife, Minnesota No. 181 a Minnesota No. 163) all fall in this group.

Ladoga wheat produced flour of distinctly weak character, and it is notewort that most of the varieties produced by crossing Ladoga with Red Fife showed a bakin strength which is about midway between the two parents.

Pringle's Champlain.—This is one of the rather promising early wheats which a now being tested in different parts of the North-West provinces. Although it on showed medium strength as grown at Indian Head, the sample grown at Ottawa gav decidedly strong flour.

Red Fife.—Of the two samples examined this year that grown at Ottawa showe decided superiority in baking strength over that grown in Saskatchewan, although a may be seen by reference to the second part of this bulletin the Saskatchewan sampl contained a larger proportion of gluten.

Stanley.—The two selected strains of this variety, under the letters A and C, ar of rather particular interest, as they were commenced some years ago by the selectio of two heads, some of the kernels of each of which had been tested by the method o chewing already described. The gluten in A was considered much superior to tha in C and of distinctly better colour. This difference was observed every season, an when the amount of wheat on hand was sufficient for a baking test, the essential ac curacy of the conclusions drawn from the chewing was shown. Stanley A gives flou of very good colour, and although, as may be seen by reference to the chemical analy sis, it does not contain nearly so much gluten as Stanley C, nevertheless, the bakin strength of A is almost equal to that of C, and when the question of colour is brough into consideration, A ranks distinctly above C. Better results are expected from A i other seasons, as it was not grown beside C in 1906, and appeared to suffer somewhat from the unsuitability of the soil conditions, the sample being much inferior in ap pearance to C. A peculiarity of Stanley C to which considerable weight must be given, should be mentioned. The dough produced from this variety, although able to give bread of very good volume, has so strong a tendency to spread over the sides of the tin that only a very small quantity of water can be added, the dough being therefore very stiff, so stiff indeed that this flour would be extremely unpopular among bakers. By referring to the tables, it will be seen that Stanley A absorbed and retained about 4 per cent more water than Stanley C, in spite of the fact that it contained a much smaller quantity of gluten. Stanley A also showed scarcely any tendency to spread. It is clear, therefore, that the gluten in this strain is much superior to that in the other. So many considerations, however, enter into the determination of baking strength that the valuable indications obtained from the chewing test need confirmation by actual baking trials.

Durum Wheats.—The two Durum wheats examined, show conclusively that the common custom of regarding these as all of one quality is absurd. They are often spoken of as 'Macaroni' or 'Goose' wheats, as if they were all the same as Goose wheat, and useful only for the making of edible pastes. While the ordinary Goose (or Wild Goose) cannot be recommended for bread-baking, the Kubanka produced admirable bread, which, however, differs in some ways from that produced from most of the other wheats. The Kubanka dough must be made rather stiff in order that it may not be too sticky to handle conveniently. It rises very well, producing a large loaf of very fine texture and of good form. The crust is somewhat unusual, being of a rich brown colour and having a tendency to be thin and tough. The inside colour of the bread is quite yellow, but this gives an appearance of richness and can only be objected to on the grounds of prejudice. Taking all its characteristics into consideration, I have no hesitation in saying that the bread produced from this sample of wheat was of excellent quality.

Winter Wheats.—Among winter wheats Dawson's Golden Chaff may be mentioned as a variety rather low in strength but producing good bread of pale appearance and rather compact character. Padi seems unworthy of general cultivation, especially on account of the peculiar greenish-yellow colour of the inside of the loaf, which is all the more remarkable when compared with the very pale character of the crust. The two samples of Turkey Red are of interest from many points of view, and serve to show the strength of this wheat as grown at Ottawa. The Ottawa sample is a selected, pure strain obtained originally, under the number 380, from the Kansas State Agricultural Experiment Station. The Alberta sample was obtained in commerce and may not have been strictly pure.

COMMERCIAL FLOURS.

The three kinds of commercial flour studied were obtained from Canadian mills. The samples were all kept for some time under uniform, dry conditions before being tested, and no doubt held less moisture when the baking tests were made than they would contain as ordinarily found in commerce. 'Monarch' is a flour made from Ontario winter wheat. 'Queen City' is a mixture containing flour from Ontario winter wheat and Northwestern spring wheat. 'White Clover' is made entirely from Northwestern spring wheat. Although there is some doubt as to the exact age of the wheats used in the production of these flours, and though none of them represents a single variety only, it is interesting to notice that, in regard to baking strength, they stand in the order which would be expected, the 'Queen City' coming almost exactly midway between the other two. Not only is this true in regard to baking strength (the summing up of the various properties of the flours), but it is true also in regard to nearly all the details noted in the tables. Of these three flours 'Monarch' was found to be much the best for the production of pastry and cakes, 'White Clover' the best for the making of very light bread (being also highest in water absorption) while 'Queen City' occupied an intermediate position, representing what may be termed general purpose flour.

INFLUENCE OF AGE ON WHEAT AND FLOUR.

It is generally admitted that wheat improves in quality for some time after being harvested and that age has also a beneficial effect on the colour and strength of flour. There are however differences of opinion on these matters, especially as to the length of time during which improvement takes place. Some writers claim that deterioration begins in flour, in regard to strength at any rate, before a very long period of time has elapsed. The experimental evidence in support of any of these opinions is fragmentary and so very unsatisfactory that the whole subject needs much further work of a more thorough character, before any trustworthy conclusions can be drawn.

In the present investigation great care has been taken to compare as a rule only such flours as were of the same age and made from wheat of the same harvest and kept under similar conditions. The question of the effect of age is of such great importance that the writer hopes to give considerable attention to it in the near future. Up to the present he has only been able to touch the subject in one or two ways. There are however a few interesting facts mentioned in the preceding tables to which attention may be called. It is noteworthy that the Red Fife wheat grown at Ottawa in 1902 and made into flour in 1904, stands much higher in the baking tests of 1906 than any other variety examined. In 1907 the same wheat is again at the head, the flour in this instance having been produced in December 1906. There appears to have been a slight improvement between January 1906 and January 1907, but this is probably quite within the limits of the possible experimental error. One may certainly say, however, that the flour is fully maintaining its remarkable strength, although the wheat, at the time of the last baking tests was about four and a half years old. While it is possible that the extremely high rank of this wheat may be due in part to some peculiarly favourable conditions of the season of 1902, it is probable that it has been brought about partly by improvement due to age.

A still more striking instance is that of Yellow Cross wheat. This now cross-bred variety was milled and baked in midwinter 1906, being than about six months old. It showed a rather low baking strength (82) and was, therefore, considered undesirable for bread-making. However, as the variety had some claims to attention on account of its possible suitability for the production of rolled wheat, it was not rejected from our experimental plots, and a sample of the flour was kept over until the next winter. When the baking tests were carried out the second time (1907), it was found that an astonishing improvement in strength had taken place during the twelve months, 102 being the mark earned for baking strength at the second series of tests. It will be seen on carefully comparing the figures obtained in the two years that the flour improved in every respect, taking up a larger amount of water, retaining more, giving a loaf of larger volume and of better shape, crust, texture and colour. The behaviour of the dough in the oven was most remarkable. While in the first tests, with a water absorption of 59 per cent the dough had a tendency to fail, after the twelve months' keeping, although the water was increased to 62 per cent, the dough had the ability to rise to a most remarkable degree when put into the oven. The sample of flour was kept for the twelve months under dry conditions in a glass-stoppered bottle. It would appear that this astonishing change in baking strength must have been due to an improvement in the quality of the gluten, as it could scarcely be explained on any other supposition. If further tests should show that the baking strength of this wheat can always be raised to approximately 102 by keeping it over for one year, it may prove very valuable for some sections of our country.

VARIATIONS IN FLOUR STRENGTH DUE TO SOIL AND CLIMATE.

A few determinations of the strength of flour have been made upon the same varieties grown under different conditions. In the first table three samples of Red Fife are mentioned. That under the designation of Red Fife H is an early strain of fine quality selected at the Central Experimental Farm. The other two samples, designated Red Fife Soft and Red Fife Hard, were collected near Neepawa, Man., the hard sample being such as would have been graded Extra No. 1 Hard and the soft one, consisting almost entirely of soft kernels, would have been graded no doubt as low as No. 3 Northern. In both cases, I picked all the heads and threshed the grain myself so as to be sure of its purity. These two samples were of course quite extreme and represented almost the maximum of hardness and softness possible in this variety. The only conspicuous difference noticed when grinding the three samples was that the soft Red Fife produced about half as much break flour again as either of the others. The baking tests, however, showed very great differences, the Red Fife H having a baking strength of 99, the soft Red Fife 89 and the hard Red Fife 100. The inferiority of the soft Red Fife was noticeable in almost every respect in which the flours were compared. It is interesting to observe that the Ontario grown sample, though considerably inferior in appearance to the hard sample from Manitoba, produced flour practically equal in quality. These tests show clearly that great differences in baking strength are found when samples of the same variety are examined which differ radically in hardness, the softer wheat giving weaker flour. When such variations as these occur, it is plain that we cannot make any rigid classification of varieties of wheat into hard and soft, although it is true that some sorts have more tendency than others towards hardness or softness.

Some other comparisons between Ontario wheats and those grown further west may be of interest. Red Fife grown at Indian Head, Sask., in 1906, though showing greater weight per bushel and superior hardness and brightness, produced flour having a baking strength of only 95 as compared with 102 earned by the Red Fife II grown at Ottawa. While it is true that the Ottawa sample is a selected strain, I do not think that the whole of this difference can be attributed to that fact alone. By reference to the second part of this bulletin, it will be seen that the Indian Head sample was distinctly richer in gluten than that grown at Ottawa. In this case increased gluten content does not imply increased baking strength.

The variety known as Pringle's Champlain gives another interesting opportunity for comparisons. The Ottawa sample earned thirteen marks for strength more than that grown at Indian Head, though the former weighed only 61½ lbs. per bushel while the latter weighed 63.

Among the winter wheats, it will be noticed that the Turkey Red grown at Ottawa in 1906, surpassed by eleven marks that grown the same season near Lethbridge in southern Alberta. In this case, however, we are dealing with a selected Turkey Red as compared with a commercial sample which may not be strictly pure. This difference in breeding and purity may account for part of the superiority of the Ottawa wheat.

It is interesting to compare the results obtained when one variety has been examined for two successive seasons from the same farm. In such cases it is customary to say that the samples have been grown in the same kind of soil and climate. This is, however, quite inaccurate as it is impossible on most farms to obtain two pieces of land of exactly the same character, and, besides, each season has its own peculiarities. Indeed not only is the climate different every year, but even in one season different varieties in the same field are subjected to different climatic conditions. For instance, if many days of hot, dry weather occur lasting just long enough to ripen a very early variety and then the weather suddenly changes and remains wet and cool until the later maturing varieties are ripe, in such a case it is obvious that the early ripening varieties can fairly be said to have matured in an entirely different type of season or climate from that in which the later sorts were ripened. The expression 'uniform soil and climate,' should, therefore, always be understood in a very rough and crude sense only. Referring to the tables, it may be noticed that Gatineau earned one more mark for baking strength the second season than the first. Huron Selected and Red Preston earned several marks less the second season than the first. Laurel had the same mark both seasons, while Red Fife II showed a gain of three marks in the second season. These instances are too few to enable one to draw any conclusions of importance, except that the average baking strength of any variety of wheat cannot be established by the examination of one sample. What may be the greatest limits of variation possible between different samples of the same variety in different seasons or in different climates, it is impossible to say. The baking strength of the samples of Red Fife studied varied from 89 to 102 considering only the wheat of the current season. But if the old samples are considered also the limits of variation are still greater.

APPEARANCE NOT A TRUSTWORTHY INDICATION OF QUALITY.

Although as has just been shown, very hard Red Fife may be expected to give stronger flour than soft Red Fife, and no doubt as a general rule two samples of the same variety differing in hardness will also differ in the strength of flour produced from them, nevertheless, when comparing different samples of unknown varieties, very little value indeed is to be attached to their relative hardness or softness. Sometimes the softer sample will yield the stronger flour. Soft Red Fife, for instance, gave stronger flour than Huron Selected, which was a hard wheat, and Tasmania Red (soft) produced much stronger flour than Ebert (hard). Reference to the tables will reveal many cases of wheats of about equal hardness which yielded flours quite different in strength. A similar uncertainty pertains to the other characteristics by which wheat is usually judged. It is not always true, as very commonly supposed in some sections of Canada, that a dark red wheat with a bright skin is good for the production of strong flour. Some wheats with a yellow skin (Bobs, White Fife, Kubanka) give distinctly stronger flour than others, which have a red skin, and some of the dark wheats (Assiniboia, Aurora, Downy Riga, Ebert) are by no means in the first rank for strength. There is no doubt some justification for the preference of bright samples of grain, that is, those which are free from blemishes, usually caused by frost or rain; but it is quite uncertain in many cases to what extent the actual quality of the interior of the kernel has been lowered when there is evidence of injury to the bran. It is often highly probable that the interior of the berry is in essentially perfect condition even though the bran may be dull and unattractive.

For further confirmation of some of the statements just made, attention is drawn to a few of the most striking instances in the preceding tables. Among the samples tested in the winter of 1905-1906, should be noticed Assiniboia, the kernels of which were rather hard and plump and of a bright, deep red colour. This sample may be compared with Colorado No. 50 (a variety quite distinct from the ordinary Colorado), the kernels of which were rather soft and of a dull yellow colour but which produced flour three points better in baking strength than the Assiniboia. Red Fife H was eight points better than Assiniboia though the kernels were not so plump or bright. Still more striking examples of the untrustworthiness of the appearance of wheat as an indication of its quality are found in the tables dealing with the wheats studied in the winter of 1906-7. Among the weakest samples of flour obtained may be mentioned those from Downy Riga D which had very hard kernels of a bright, deep red colour, Ebert which had very hard kernels of rather a bright colour, Grant which had hard red kernels not very bright in colour, and Ladoga the kernels of which were hard, deep red and rather bright. On the other hand, very strong samples of flour were obtained from Bobs, the kernels of which were rather hard but of a yellow colour and not bright, from Early Russian, the kernels of which were not very hard or bright, from Gatineau which had hard, red kernels, not plump or bright, from Haynes' Blue Stem with rather hard kernels which were not plump and were dull in colour, from Red Fern which had moderately hard, dull red kernels, from Red Fife H, which though rather hard, was not plump or bright, and from White Fife C and Kubanka, both of which had yellow skin.

The tables also make it clear that different samples of the same variety, though somewhat similar in appearance, may differ considerably in flour strength when they have been grown in different parts of the country. The two samples of Pringle's Champlain, Nos. 126 and 147, illustrate this very well. Though they are much alike in appearance the sample No. 147 would be considered by most buyers as superior to the other; but from a baker's point of view it is actually much inferior.

The prejudice in Canada in favour of dark wheats is very strong. It is true that a pale colour due to starchiness of the kernel is often an indication of lack of strength in the flour, but when the pale tint is only in the bran there is no reason (unless the sample is weathered) to suppose that the wheat in question will yield flour of lower strength than a darker sample. Natural paleness in the bran is no indication at all of weakness in the flour. It is strange that wheat buyers and others who are interested in the valuation of wheat seem so often to be unable to perceive the difference between paleness due to a pale skin and paleness due to a pale interior of the kernel.

Though not exactly pertinent to the subject under consideration, attention is called to another common but erroneous opinion in regard to wheats: namely that early-ripening spring varieties are usually soft. This idea seems to have no foundation whatever. The following hard wheats mentioned in the foregoing tables are of early-ripening habit: Aurora, Chelsea, Downy Riga, Ebert, Ladoga, Percy, Preston and others.

MIXED FLOURS.

As some investigators have reported rather peculiar results obtained by the mixing of flours, the baking strength of the mixture being in some cases quite different from the mean between the two flours employed, it seemed important to make a few tests with mixtures of some of the flours mentioned in the preceding tables. Seven different mixtures were tried. In no case, however did the tests prove of any special interest, the mixed flours giving results when baked which were very close to the mean between the two flours mixed. Each of the mixtures studied contained two kinds of flour in equal proportions. The most interesting of these was a mixture of Red Fife H and Ladoga. The flour produced by mixing these two samples was strikingly like that made from the wheats (Preston, Stanley, Huron and Percy) obtained by crossing Ladoga with Red Fife or White Fife. The observations on the four cross-bred wheats mentioned show that their baking qualities are, as a rule, intermediate between those of the two parents. This will be clearly seen by a study of the tables. While it is no doubt possible that in some cases a cross-bred wheat may possess baking qualities the same as those of one of the parents, the results given here seem to show conclusively that baking strength is not a Mendelian character, that is to say, is not always inherited from one or the other parent in pure condition. It should be mentioned that the various strains of cross-bred wheats reported upon in these tables were all of quite fixed character and cannot, therefore be regarded in any sense as mixtures.

VARIATIONS IN THE METHODS OF BREAD-MAKING.

Inasmuch as there is no standard method for the making of bread and since the system employed by the writer involves the use of a larger proportion of yeast and a somewhat higher temperature for fermentation than are usual, it seemed a matter of importance to determine whether the strength of flour as ascertained by this method would remain essentially the same when the dough was treated in other ways. The following modifications were therefore tried: The first period of fermentation was in some cases made shorter by allowing the dough to rise to a smaller volume than that regularly required. This change did not make any appreciable difference in the quality of the bread. Tests were also made by omitting altogether the second kneading and putting the dough, when first mixed, immediately into the baking tin. This, as was anticipated, produced bread of inferior quality. Another modification was made by the introduction of another kneading, after the usual second kneading, the dough not being required to rise quite so high during the second period as during the first. This prolonged fermentation did not make very much difference in the quality of the bread. Variations in the amount of yeast used were also tried. The quantity employed for each loaf varying from ·6 grammes to 1·8 grammes of moist yeast. These changes did not seriously alter the figures obtained for the baking strength of the flour. Some of these tests with different quantities of yeast were conducted at a fermenting temperature of 29 to 30 degrees centigrade (84 to 86 degrees Fahrenheit) in place of the usual heat.

None of the variations introduced into the method of bread-making caused any improvement in the quality of the product, and none of them seemed to seriously alter the relative rank of the different flours. It may, therefore, be safely concluded that the figures for baking strength given in the tables are an expression of absolute fact, which, though no doubt subject to slight modification according to the methods of treatment of the dough, would, nevertheless, hold essentially true for most or perhaps all of the systems of making bread which are in common use.

TEA BISCUITS.

It seemed worth while before closing the investigations into the quality of the samples of flour to make a few tests with them to ascertain their suitability for the production of tea biscuits. The term tea biscuit, it may be explained, is commonly used in Canada to signify small cakes made from wheat flour, usually unsweetened, but generally containing a certain quantity of butter or lard. In order to make the biscuits rise some kind of baking powder is used or else some form of sour milk with baking soda. It is almost needless to add that these cakes are not cooked twice as their name would seem to signify.

Baking Powder.—For use in these tests baking powder was prepared according to the following **formula**:—

Sodium bicarbonate	24·35	grammes
Potassium bitartrate	55·65	"
Corn starch	20·00	"
	100·00	"

These three ingredients were thoroughly dried before being weighed and were subsequently intimately mixed. After some preliminary tests had been made and the general practice in regard to the use of baking powders had been considered, the amount of this powder decided upon as the best was 1·8 grammes to 50 grammes of flour. The method of procedure was as follows: 50 grammes of flour were taken and to 45 grammes of this ·6 grammes salt and 1·8 grammes baking powder were added. After thoroughly mixing, 4 grammes of butter and 4 grammes of lard were added and thoroughly worked in. Finally the necessary amount of water was added, being stirred in very quickly, and the dough, which was quite sticky, was immediately removed to a plate covered with the remaining 5 grammes of flour. It was then rolled out to about three-quarters of an inch in thickness, cut into the desired shapes and at once put into the oven, where it remained at a temperature of about 240 degrees centigrade (464 degrees Fahrenheit) for about fifteen minutes. The quantity of water necessary was found to be usually about 10 per cent more than that required for the production of bread. In the process of baking, the tea biscuits usually rose to between two and two and a half times the height of the dough when put in the oven.

It is unnecessary to give the details of these experiments. All the flours tested produced biscuits of about the same volume and though they differed somewhat in character and considerably in colour, the differences were not so striking as those observed in the bread. It appears that almost any flour will make tea biscuits of fair quality. The experiments show that the flours tested had sufficient strength of gluten to attain the necessary volume when the gluten had not been subjected to the prolonged influence of the yeast fermentation, and when the quantity of gas evolved was not very large. For it must be borne in mind that even a well-made tea biscuit has a small volume compared with that of a very light loaf of bread produced from the same quantity of flour. In spite of the similarity in conduct of the various flours, under the conditions just mentioned, it is clear that one is not justified in concluding either that the gluten of all flours is practically identical or that the volume of a light loaf of bread is determined primarily by the quantity of gas evolved. The making of ordinary tea biscuits cannot be considered a test of the ability of gluten to withstand fermentation or of its power to retain a large quantity of gas produced inside the dough.

CONCLUSION.

In closing, it may not be out of place to state that the whole of the work reported upon in Part I. of this bulletin has been done by the writer himself without any assistance whatsoever. It is hoped that in this way the errors due to that uncertainty commonly known as the 'personal equation,' have been reduced to a minimum, though of course they cannot have been entirely avoided.

PART II.

THE RELATIONSHIP OF COMPOSITION TO BREAD-MAKING VALUE.

By Frank T. Shutt, M.A., F.I.C.,

Chemist, Dominion Experimental Farms.

In submitting to chemical analysis the flours discussed in Part I., it was hoped that the data so obtained might throw some further light on the relationship of the composition of a flour to its bread-making value. This problem is by no means a new one; it has been attacked by chemists in both hemispheres, more especially during the past twenty years, but up to the present time its satisfactory and complete solution has eluded the skill of the analyst. To bakers and those engaged in the flour trade it is unnecessary to say anything by way of emphasis regarding the practical value that chemical data would have, provided such data could be correlated with 'strength' or bread-making qualities. For, incomplete as our present laboratory methods are, they furnish results of considerable value in the general or broad classification of flours, if failing to distinguish between examples of approximately the same strength. In the testing of flours small quantities of which only are available (as in the early stages of much experimental work in the cross-breeding and selection of wheats) the importance of a perfected chemical scheme that would give data translatable at once into terms of 'strength', would be still greater.

It has been generally acknowledged for a number of years past that the quantity and nature of the nitrogenous compounds constitute the chief determinative factors in the examination of flours as to their relative values for bread-making. These compounds are known chemically under the collectiv[illegible]ms protein, proteids or albuminoids, and their percentage is ascertained by [illegible]g the percentage of nitrogen analytically obtained by the factor 5·7. By mec[illegible]eparation, namely, by kneading the dough under a stream of water, thus wash[illegible]ay the starch, the well-known substance 'gluten,' which consists of the water-insoluble proteids, is obtained. It has been almost universally held that flours possessing a high percentage of protein, say, 11 per cent or over, with a gluten that is elastic, resilient and capable of retaining a large amount of water, will produce more bread, and that of a better quality, than flours containing a low protein-content (less than 11 per cent) or the gluten of which is flaccid, non-resilient and sticky.

THE NATURE OF GLUTEN.

Gluten has been shown to consist essentially [illegible] substances—gliadin and glutenin—and it has been asserted that the quality of the flour for bread-making is determined by the proportion which the gliadin bears to the glutenin, or, again, by the total gliadin present. From this standpoint certain standards or limits have been suggested by which flours could be classified. Thus, Snyder, of the Minnesota Experiment Station, in 1904, said that in flour of good quality from 55 to 65 per cent of the protein should be in the form of gliadin. And in the year following (1905) the same author wrote: 'as our work on this point extends over a number of years it appears that it is more a question of total gliadin than the ratio of gliadin to glutenin,' but so far as the writer is aware the amount of this constituent so desired has not been stated.

In bulletin No. 50 'Grades of Wheat' (Experimental Farms Series) published in June, 1905, we pointed out that our work to that date had shown that these standards were not strictly applicable, at any rate to the flours under investigation in the Farm Laboratories. Further research during the seasons of 1906 and 1907 makes it appear as extremely doubtful if the 'gliadin number' (percentage of albuminoids in the form of gliadin) constitutes a factor that can be correlated with bread-making values as obtained by baking trials.

COMPONENTS OF FLOUR INLUENCING STRENGTH.

Quite recently an entirely new view has been advanced by Mr. T. B. Wood, of the University of Cambridge, in a paper entitled: 'The Chemistry of Strength of Wheat Flour,' and published in the Journal of Agricultural Science, Vol. II., Part 2, April, 1907. Accepting the definition of Humphries and Biffin (*) that strength is 'the capacity of making large and well-piled loaves,' and leaving out of consideration, as a distinct quality, the power of absorbing and retaining water, Mr. Wood presents data from which he concludes that the size of the loaf and the shape of the loaf are determined each by its own separate and distinct factor.

The size of the loaf is determined, according to this author, by 'the amount of sugar contained in the flour together with that formed in the dough by diastatic action.' The argument is that the size of the loaf is regulated by the expansion of the dough and that this expansion is in direct relation to the amount of carbon dioxide produced during fermentation. The carbon dioxide is the direct result of the splitting up of the sugars in the flour by the yeast, hence the amount of sugar originally present plus that formed by diastatic action in the 'rising' of the dough previous to baking, determines the size of the loaf.

As regards the shape of the loaf, Mr. Wood suggests that the physical properties of the gluten constitute the determinative factor. These properties, he points out, are not consequent upon any chemical differences in composition of its nitrogenous constituents, nor are they due to the ratio or total amount of its gliadin, but rather, he suggests, to the presence in varying proportions of certain small quantities of mineral salts—it being well known that the association of such substances may materially affect the physical properties of proteids. In this connection, Mr. Wood concludes: 'In the few cases examined it was found that strength was associated with a high ratio of proteid to salts and weakness with a low ratio. It is suggested that the variation of this ratio may be the explanation of the different physical behaviour of the gluten of strong and weak flours, and that this is the factor which determines that component of strength which governs the shape of the loaf and its powers of retaining gas.' Unfortunately, the quantity of flour at our command in this investigation was not sufficient to allow us to make the necessary determinations, and consequently we have no data to present on this matter.

In all this we are given certain new starting points of considerable interest and much promise, but the case needs considerable elaboration and further confirmatory evidence before it can be accepted as satisfactorily and completely explaining 'strength' as we to-day understand that quality in flour. If 'the capacity of a flour to give off gas when fermented with yeast, especially in the later stages of dough fermentation,' determines largely the size of the loaf, then it seems to the writer that to obtain data from which to judge of a flour in this particular it will be necessary to produce the gas—the volume of which is to be measured—under conditions precisely similar to those obtaining in the bread making process. Therein lies a difficulty of considerable magnitude. The process adopted by Mr. Wood in his gas determinations can scarcely be said to be strictly comparable to that to which dough is subjected in bread-making.

* Journal of Agricultural Science, Vol. II., Part I.

That the shape of the loaf is dependent upon certain physical properties of the gluten seems very probable. Hitherto it has been thought that the proportion in which its two constituents, gliadin and glutenin, existed, had a direct bearing on the consistency, elasticity, &c., of the gluten, but, as already pointed out, the evidence as it accumulates is conflicting—and we must admit that there are so many exceptions without apparent explanation that this theory can only be considered as tentative. The present research throws the greatest doubt upon the 'gliadin number' as a factor of diagnostic value. The same is true respecting the hypothesis that strength is determined by the amount of gliadin present rather than by the ratio of this constituent to glutenin. Mr. Wood offers in this article another explanation for the strength of flour—the ratio of the soluble salts to total nitrogen. It opens up a question well worthy of investigation. At the present time, however, the data are too few to furnish a sufficient basis for diagnostic purposes.

THE CHARACTER OF ANALYTICAL DATA AS COMPARED WITH THAT OF BAKING RESULTS.

In concluding this prefatory statement of the views as at present held respecting the relation of the chemical composition of the flour to the quality known as 'strength,' something must be said as to the nature of the two classes of data which it is sought to correlate. On the one hand we have the analytical results; on the other, the figures or values derived from the baking tests. While it is not claimed that the former are absolute (for there is always a slight error of experiment, no matter how skilful the chemist) they can for all practical purposes be looked upon as representing facts. Thus, the percentage of nitrogen or of ash found in a flour will not appreciably vary with the analyst; the personal factor is practically eliminated. But such cannot be said to be equally true in baking trials, personal opinion being largely used, as in judging shape, texture, &c. And, again, the values from the baking operations must necessarily be influenced by variations in manipulation and temperature, in the vitality of the yeast, and by a number of other factors. These factors the baker cannot, no matter how careful and skilful he is, keep constant from day to day, or even from hour to hour—and the same consideration shows how improbable it is that any two baking experts will assign the same value to a flour. This is not said with any intention of disparaging the baking values—they are possibly more reliable as a guide in valuing flours than the chemical data—but to make it clear that very serious difficulties present themselves in this matter of harmonizing results.

Much careful work remains to be done before this problem is solved, but undoubtedly the close co-operation of the chemist and the baking expert—practically a new feature in the investigation—will eventually furnish a more satisfactory basis for the valuation of flour than exists to-day.

DISCUSSION OF FLOURS—SERIES I., 1905-6.

The first series of flours to be discussed comprises twelve samples from wheats milled during the winter of 1905-6, the analysis being made in the early months of 1906. It contains eleven samples of spring wheat, largely cross-bred varieties originated on the Central Experimental Farm, and one of winter wheat, No. 92, Turkey Red. Their milling qualities and baking values, together with certain information respecting their origin, are to be found in Part I. of this bulletin among the number examined by the Cerealist, December, 1905-March, 1906.

The analytical determinations made were: moisture, albuminoids or protein, gliadin, wet and dry gluten, directly reducing sugars and sugars after inversion, *i.e.*, non-reducing sugars:—

Analysis of Flours—Series I., 1905-1906.

No.	Variety of Wheat, Locality and Year of Growth.	Moisture.	Protein or Albuminoids. N x 5·7	Gliadin.	Percentage of Albuminoids in the form of Gliadin.	Sugars. Directly reducing calculated as Maltose.	Sugars. Non-reducing calculated as Cane Sugar.	Sugars. Total.
81	Aurora, C.E.F., 1905	7·77	10·60	4·56	43·02	·10	·74	·84
83	Red Fife H., C.E.F., 1905	7·81	13·33	6·49	48·68	Trace.	·87	·87
85	Soft Red Fife, Man., 1905	7·80	9·17	3·93	42·85	·18	1·02	1·20
86	Hard Red Fife, Man., 1905	7·79	11·79	5·64	47·82	...	...	...
87	Assiniboia, Man., 1905	7·80	9·40	4·21	44·78	·03	·98	1·01
88	Huron (selected) C.E.F., 1905	7·61	13·22	6·61	50·00	·09	·84	·93
90	Gatineau, C.E.F., 1905	7·70	15·50	8·03	51·80	Trace.	·78	·78
91	9 J 3, C.E.F., 1905	7·89	14·39	7·18	49·89	...	...	...
92	Turkey Red from Kansas	7·47	16·12	7·29	45·18	·09	·76	·85
95	Advance, C.E.F., 1905	7·68	14·42	6·72	46·60	Trace.	·84	·84
98	Laurel, C.E.F., 1905	7·75	11·51	6·04	52·47	...	...	...
99	Colorado No. 30 from Colorado	7·61	13·96	6·38	45·70	Trace.	1·14	1·14

No.	Variety of Wheat, Locality and Year of Growth.	Gluten. Wet.	Gluten. Dry.	Gluten. Ratio of dry to wet.	Gluten. Physical Characters.	Baking value. — Cerealist's Figures.
81	Aurora, C.E.F., 1905	36·79	12·01	3·06	Good quality; resilient	91
83	Red Fife H., C.E.F., 1905	43·07	14·09	3·06	" "	99
85	Soft Red Fife, Man., 1905	28·67	10·62	2·70	" "	89
86	Hard Red Fife, Man., 1905	41·45	14·89	2·79	" "	100
87	Assiniboia, Man., 1905	32·26	10·97	2·94	Yellowish; lacking somewhat in cohesiveness	91
88	Huron (selected) C.E.F., 1905	44·14	15·13	2·91	Lacking somewhat in resiliency	87
90	Gatineau, C.E.F., 1905	54·22	17·89	3·03	Good, but slightly sticky	95
91	9 J 3, C.E.F., 1905	58·57	18·70	3·13	Flabby, soft, very sticky, non-resilient	78
92	Turkey Red from Kansas	57·63	18·04	3·19	Good quality; resilient	101
95	Advance, C.E.F., 1905	49·37	17·36	2·84	" "	91
98	Laurel, C.E.F., 1905	42·55	16·17	2·63	" "	76
99	Colorado No. 30 from Colorado	45·62	18·67	2·44	Good, but rather granular and lacking somewhat in elasticity	94

Moisture.—The percentage of moisture was obtained by drying the flour in a steam bath, that is, at the temperature of boiling water, for eight hours. The results are somewhat significant. First, as showing a remarkable uniformity in the moisture content of the flours, all ranging between the percentages 7·47 and 7·89; and, secondly, in making plain that all the flours were extremely dry. We have on former occasions remarked on the fact that flours analysed during the winter season, say, from December to March, are characterized by a low moisture-content, due no doubt to the dryness of the atmosphere at that season, and the present results confirm this contention. The moisture-content must affect the absorptive capacity of a flour and its bread-yield, and hence the importance in all investigations to ascertain bread-making values, where comparative results are required, of making the tests at the same period or season of the year and of having moisture determinations made on the flours at the time of the trial as confirmatory that the flours have been alike influenced by atmospheric conditions. In this connection it may be stated that flours produced and analysed in the winter will if exposed, as in bags, till July or August, frequently show an increase of between 4 and 5 per cent in their moisture content.

Protein or Albuminoids.—The percentage of nitrogen as obtained by the Kjeldahl process is multiplied by the factor 5·7 and the result recorded as protein or albuminoids.

Reference to the table of data reveals that considerable differences exist between the members of this series in this important constituent, and hence in their nutritive values. The latter part of this statement is, of course, open to question since the nutritiousness of a bread must be in a sense dependent on its disgestibility, but as this is an unknown factor as regards the present investigation and one which could be to a marked degree modified by the skill of the bread-maker, we must conclude, and the conclusion cannot be far from the truth, that in a series of flours all making palatable bread the percentage of protein marks their relative nutritive value.

Further, it seems more than probable that the percentage of protein is of greater significance than merely indicating nutritive value, a matter upon which, curiously enough, both baker and consumer place little importance. It appears to be a factor of considerable diagnostic value in determining the 'strength' or bread-making qualities. Thus, Mr. A. D. Hall, Director of the Rothamsted Experimental Station, who has been making a special study of quality in wheat for some years past, wrote in 1904*: Although the main question of the cause of 'strength' is still unsolved, it is clear that for the purposes of a selecting test among a number of new varieties, grown side by side, it will be sufficient to determine the total nitrogen. The total nitrogen, as we have seen, fails to measure 'strength' in any absolute sense, but when wheats are grown under the same conditions, the order of their nitrogen content will be the order of their strength, or very nearly so.'

This agrees very well, speaking generally, with the results obtained in these laboratories, in previous investigations. When discussing the correlation of the analytical data with those from the baking tests of the present inquiry this matter will again be referred to, and it will then be seen that in the total nitrogen—or what is the same thing, the protein—(since this is obtained by multiplying the total nitrogen by the constant 5·7) we have a measure of 'strength' of considerable value.

It will not be necessary to enter upon any discriminating discussion of these flours from the standpoint of their protein content, since the object of this work is to ascertain what correlation of the data might exist rather than to classify the wheats. It may however be remarked that in No. 92 we have an excellent example of a winter wheat with a high protein content. This sample of Turkey Red as grown in Kansas, is at least significant in showing that such wheats do exist, in spite of the commonly held view to the contrary.

Gliadin.—The water insoluble protein of wheat flour, more commonly known as gluten, has been shown to consist essentially of two albuminoids or proteids, alike as regards their nitrogen-content, but differing in their physical characteristics. They have been named gliadin and glutenin. Gliadin is a glue-like, sticky body and serves to bind and hold together the non-adhesive, non-plastic glutenin (as well as the starch) when the flour is moistened and kneaded and allows the resultant dough to 'rise' under the fermentative action of yeast.

In the prefatory note we spoke of the importance that has been placed by some chemists on the ratio that these constituents bear the one to the other and indicated that our previous work (Bulletin 50, Experimental Farm Series) did not support the position that Snyder had taken, viz., that a good flour should contain from 55 to 65 per cent of its protein in the form of gliadin. The results of the present research again show that such limits cannot be regarded, even approximately, as those within which

* The question of quality in wheat, A. D. Hall, Journal of the Board of Agriculture (Eng.), Vol. XI., No. 6.

good flours must fall. On the whole, our data would seem to be decidedly lower than those recorded by Snyder. It is only exceptional examples that have given us a 'gliadin number' above 50, and the flours yielding 55 have been very rare. These high numbers, it may be pointed out, have by no means been invariably accompanied by high baking values.

The method for the determination of gliadin is based on the fact that this constituent of gluten may be dissolved out by treating the flour with 70 per cent alcohol, which leaves the glutenin unattacked.* We have found that it is important, to obtain strictly comparable results, that the solvent should be prepared with great accuracy. Comparatively slight differences in the strength of the alcohol used, materially affect the percentage of gliadin (?) nitrogen obtained, as the following data obtained in the Farm laboratories, well show:—

*Flour: 'Five Roses,' Lake of the Woods Milling Co.***

Strength of Alcohol by Weight. Per cent.	Gliadin.	Proportion of Protein in the form of Gliadin.
60	5·36	54·0
62·5	5·30	53·4
65·	5·24	52·9
70·	4·71	47·4
75·	3·41	34·3

Wet and Dry Gluten.—Pure gluten consists, as already remarked, of gliadin and glutenin, and its percentage should correspond more or less closely with that of the albuminoids—the amount of the water soluble proteids in wheat flour being very small. As determined in flour investigations, however, by washing out the starch and subsequent drying in the steam bath, approximations to this datum only are possible. For on the one hand there may be losses through excessive or careless washing or through slight increase in the temperature of the wash water, and on the other hand, there may be gains by retention of fat, fibre and ash constituents, as well as from incomplete drying. According to our method of determination (see page 19, Bulletin 50, Experimental Farm Series), the percentage of dry gluten invariably exceeds, though not in any regular manner or by fixed amounts, the percentage of albuminoids. Estimations made by a process more or less mechanical, as this must be regarded, scarcely admit of that accuracy that characterizes chemical work, and hence are not strictly comparable with analytical data.

The significance of the 'wet' gluten number lies, it is thought, in indicating the relative amount of water taken up in bread-making and, possibly, in that retained on baking. If this be true, we should expect to find a relation between this estimation and the bread yield—a point that will be considered when examining the correlation of the data from the baking trials with those from the analytical work.

The character or quality of the wet gluten is an important factor. In flours of high bread-making values, it is resilient, elastic, firm and cohesive; in poor flours it may be flabby, non-resilient, soft and sticky.

Sugars.—The publication of Mr. Wood's work, already referred to, led us to make determinations of the sugars, reducing and non-reducing, present in these flours, though unfortunately from lack of material in several of the samples, the data from the series

* To five grammes of flour in an Erlenmeyer flask 250 cubic centimetres of 70 per cent (by weight) alcohol are added and the whole agitated at intervals for several hours. After 24 hours the solution of gliadin is separated by filtration and an aliquot portion acidified with sulphuric acid and its alcohol evaporated. The gliadin nitrogen is then determined by the Kjeldahl process.

** This well known brand is largely if not entirely made from North-western wheat and ranks with the best Canadian flours for bread making are incomplete in this respect. It will be remembered that the amount of the sugars, either present as such or produced by diastatic action in the process of bread-making, was considered by Mr. Wood as a factor in determining the size of the loaf.

Our process was, briefly, as follows:—

To 20 grammes of the flour placed in an Erlenmeyer flask 200 cubic centimetres of a 70 per cent (by weight) solution of alcohol are added and the whole well shaken every five minutes for one hour. The mixture is then allowed to stand for 12 hours, at the end of which period the supernatant liquid is thrown on a dry filter and the sugars determined in accurately measured aliquot portions of the filtrate by means of Fehling's solution, gravimetrically.

We have on record very little definite knowledge as to the amount and nature of the sugar or sugars that are present in flours, and it would not seem profitable, here, to enter upon any discussion of the various views presented on this subject of sugar content. Such a discussion would not throw any light upon the problem under consideration, viz., the relation (if any exists) betwen the sugars in sound flours and the size of the loaf produced therefrom. There seems, however, but little doubt of two conclusions: that the amount of such sugars is never large (usually less than 1 per cent) and that of this the proportion in the form of sugars that would very readily break up with gas production, is extremely small—in many instances not more than traces.

Our method of analysis (*) did not permit of the estimation of sugars formed by diastatic action in the dough and therefore the results presented are not strictly comparable with those of Mr. Wood, who measured the carbonic acid evolved while the dough was in fermentation. They are not brought forward to confirm or refute his conclusions. They are valuable, however, in showing the amounts of the sugars present and as such, the writer thinks, should give some evidence of the relative loaf-size, if the hypothesis be a sound one. The following are the data, the order being that of the volume, and it is obvious that they do not indicate any relation between sugar-content and size of loaf**:—

Flour.	Volume of Loaf.	Sugars Per cent.
No. 86	560	....
" 92	550	·85
" 83	538	·87
" 95	526	·84
" 81	516	·84
" 90	514	·78
" 85	504	1·20
" 87	504	1·01
" 88	490	·93
" 99	473	1·14
" 91	454	....
" 98	428	....

It is to be admitted that the quantity of flour used in this estimation was small and the number of analyses was not large, nevertheless there seems no reason to doubt the accuracy of the data. The determinations were made with the utmost care and always in duplicate, closely concordant results being obtained.

The writer does not wish to be thought as bringing forward any data that might be considered as contradicting the view that the volume of gas produced in the fer-

* That the solvent used would dissolve out all the sugars present in the flours is, I think shown by the following experiment: One gramme of maltose, grape sugar and cane sugar each was placed in an Erlenmeyer flask in contact with 100 cubic centimetres of 70 per cent alcohol and left standing over night. At the end of that time examination showed that the sugars were entirely dissolved.

** Sufficient flour was not obtainable in samples Nos. 86, 91 and 98 for the determination of the sugars.

mentation is a measure of the size of the resultant loaf—we can offer no data on that point, but it does seem more than probable that the very small amount of sugar in sound flours cannot be regarded as having any marked influence in that direction. If Mr. Wood's contention is correct it seems to the writer that it is the relative activity of the diastatic action set up by the yeast, on possibly many compounds of the flour, that is the determinative factor, and not chiefly the amount of sugars existant in the flours.

CORRELATION OF THE DATA.

The most interesting features of the work will be brought out by considering first, how far the chemical data may agree among themselves and secondly what relationship may exist between these data and the values obtained in the baking tests.

Arranging the flours in the order of their protein content and comparing the results with the data for the gliadin and dry gluten, similarly arranged from the highest percentage downwards, it will be found (1) that four of the first five flours in each column are the same; (2) that as regards protein and dry gluten the first five flours are the same in both columns; (3) that not only are the last three flours in each of the three columns the same, but that the order is the same in all.

This general agreement between these three classes of data will be apparent by an examination of the following table, in which these determinations have been placed side by side in the arrangement described:—

RELATIONSHIP OF PROTEIN TO GLIADIN AND DRY GLUTEN.

Protein.	%	Gliadin.	%	Dry Gluten.	%
No. 92	16·13	No. 90	8·03	No. 91	18·70
" 90	15·50	" 92	7·29	" 99	18·67
" 95	14·42	" 91	7·18	" 92	18·05
" 91	14·39	" 95	6·72	" 90	17·89
" 99	13·96	" 88	6·61	" 95	17·36
" 83	13·33	" 83	6·49	" 98	16·17
" 88	13·22	" 99	6·38	" 88	15·13
" 86	11·79	" 98	6·04	" 86	14·89
" 98	11·51	" 86	5·64	" 83	14·09
" 81	10·60	" 81	4·56	" 81	12·01
" 87	9·40	" 87	4·21	" 87	10·97
" 85	9·17	" 85	3·93	" 85	10·62

There seems to be little doubt, therefore, but that there is a relationship, more or less close, between these determinations, that the percentage of gliadin and of dry gluten will increase and decrease with that of the protein, though apparently not regularly and without any constant difference.

The 'gliadin number' (proportion of protein in the form of gliadin) is very erratic, compared with the percentage of protein. It is true that certain of the flours with the highest protein also have a high 'gliadin number' and that the last three flours in the above list have, similarly, the lowest 'gliadin number,' but evidence is lacking of any agreement between these determinations in the larger number of instances. We may, therefore, conclude from the data under discussion that no definite ratio has been discovered between these estimations.

The wet gluten follows the dry gluten, though not regularly. As a rule the more of the latter the higher will be the former, but the ratio is not constant. Undoubtedly the property of holding moisture is one possessed in varying degrees by different glutens, but the reason for this we have yet to find.

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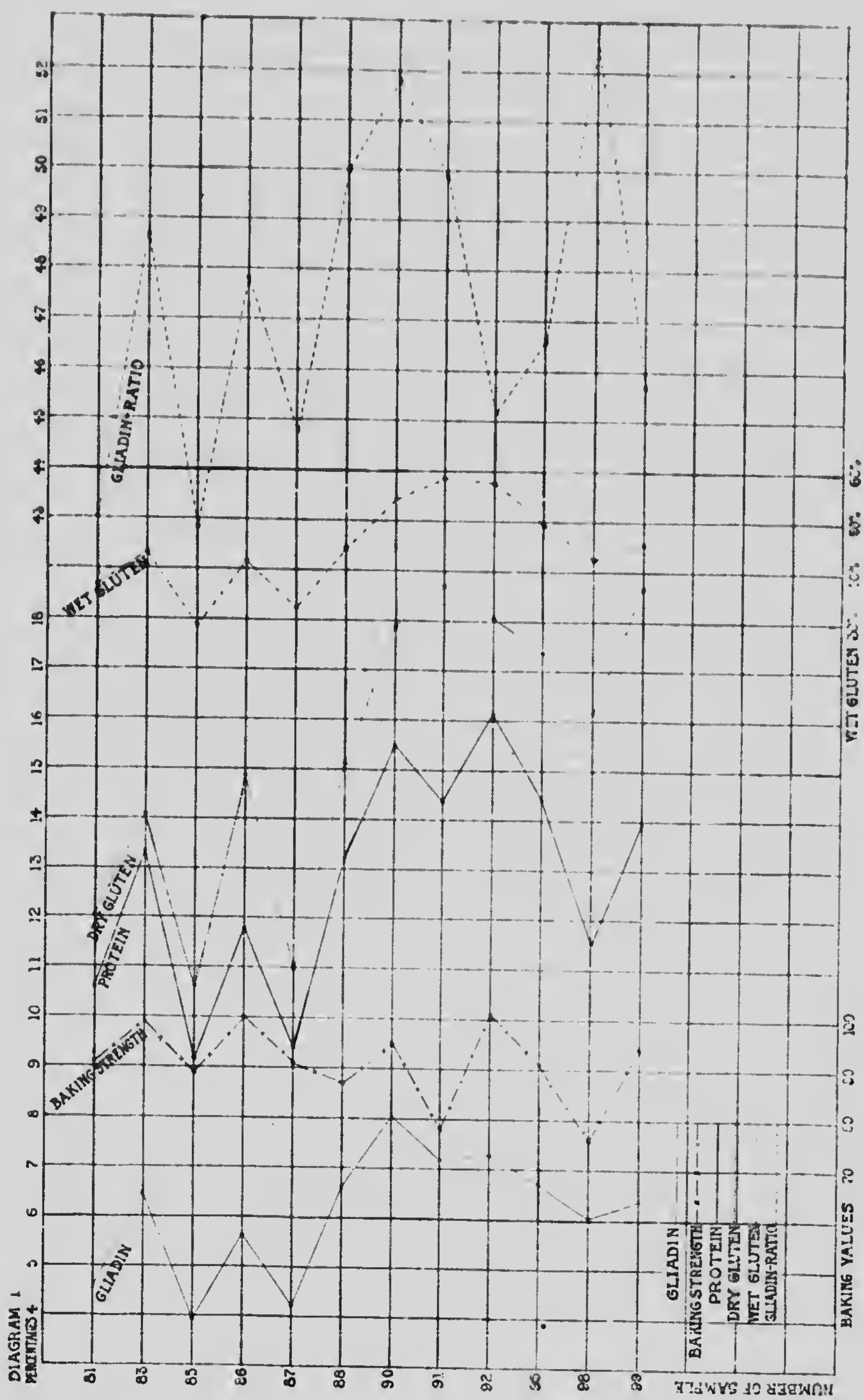


Comparison of the data for the wet and dry gluten with those for volume and bread yield (see Part I.) makes it apparent that there is no constant ratio between any of these determinations. It is further evident from the results presented that the bread yield does not necessarily increase with an increase of wet or dry gluten.

In order to show at a glance the relationship that may exist between these determinations and their relationship to 'Baking Strength,' Diagram I. has been prepared. Upon it has been plotted the various estimations and the 'gladin number,' the figures for the 'Baking Strength,' taken from Part I. being also given. The points indicating the percentages have been joined to assist the eye in making the correlation.

In the first place, the general agreement between the protein, gliadin, wet and dry gluten will be observed. The plottings may with advantage be discussed and the exceptions noted as follows:—

The curves showing the percentages of protein and gliadin give evidence of a fair measure of parallelism; if the percentage of gliadin in No. 92 had been higher it would have allowed the whole series to present a more pronounced agreement, but nevertheless the trend is the same throughout.

Comparing the protein with the wet and dry gluten, it will be seen that, with the exception of the data from one sample, all three curves follow one another closely, though, as already remarked, there is not a constant ratio between these data. The exception is No. 91, and it is significant that it was this flour only of the whole series that gave a decidedly flabby, soft, sticky, non-resilient gluten. This relationship or rather agreement between the protein and gluten has also been noticed by Thatcher, who in a recent article on the 'Baking Qualities of Flour,'* says, 'another interesting fact is that the precentage of protein, as determined by a chemical process, and that of gluten, as separated mechanically, is in very close agreement, except in the case of those samples where the total nitrogenous matter is low.'

Perhaps of still greater interest will it be to make such correlation as exists between the baking strength as determined by the Cerealist, and the chemical data.

At first sight, a general agreement between the 'Baking Strength' and the percentages of the nitrogenous compounds is to be noticed. However, on closer inspection it will be plain that while the trend of these curves throughout the series remains the same (with one exception), the parallelism is far from perfect for the series. The first five flours, Nos. 81, 83, 85, 86 and 87, have furnished data both as to Baking Strength and percentages of protein, gliadin and wet and dry gluten that show a distinct though not absolute correlation, and omitting the figures for the gluten determinations of No. 91, the last six flours on the chart also show a more or less close parallelism.

Discussion of Flours.—Series II., 1906-7.

This series comprises thirty flours from wheats milled in December, 1906. Of these wheats, twenty-five were spring varieties, three winter (Nos. 102, 103, 151), and two Durum. The results of the milling and baking tests of this series are given in the second group of tables in Part I.

The analytical work was begun about the middle of January, 1907, and completed towards the end of April following. In addition to the determinations made on the first series (see page 39) the precentages of total ash and ash in gluten were obtained.

* Journal Am. Chem. Soc., vol. xxix., No. 6, pp. 910-921.

ANALYSIS of Flours—Series II., 1903-1907.

Number.	Variety of Wheat, Locality and Year of Growth.	Weight of 100 Kernels.	Moisture.	Ash.	Protein or Albuminoids (N x 5·7)	Gliadin.	Percentage of Albuminoids in the form of Gliadin.	Baking value. (See Part I.)
102	Dawson's Golden Chaff, C.E.F., 1906	3·951	8·40	·45	7·75	3·82	49·2	76
103	Turkey Red, No. 380, " "	3·951	8·27	·55	9·75	4·45	45·6	[illegible]
106	Stanley, A " "	3·249	8·34	·60	8·89	3·99	44·9	87
107	Stanley, C " "	2·777	8·26	·70	12·23	6·16	50·4	89
108	Ladoga, " "	2·474	7·75	·70	11·69	5·47	46·8	75
109	Red Fife H " "	2·461	7·39	·62	13·45	6·33	47·1	102
112	Ebert " "	3·064	7·75	·71	11·86	5·02	42·3	65
113	Spence Yellow " "	2·889	7·93	·71	13·85	6·33	45·7	76
114	Gatineau " "	3·182	8·68	·80	13·68	7·07	51·7	96
117	White Russian " "	3·125	7·42	·60	11·97	5·64	47·1	82
118	Preston A " "	3·054	8·01	·74	9·41	3·76	38·3	84
120	Percy A " "	2·667	7·20	·79	10·66	4·05	38·0	83
122	Kubanka " "	3·487	7·35	1·06	13·51	5·59	41·3	99
123	Goose " "	3·331	8·07	1·25	14·71	6·84	46·5	81
125	Colorado " "	3·519	7·35	·59	11·17	5·07	45·4	77
126	Pringle's Champlain " "	2·804	8·43	·64	11·74	5·59	47·6	93
131	Huron (selected) " "	2·701	8·02	·67	11·00	5·42	49·3	82
132	Red Preston " "	2·778	7·35	·73	11·91	4·73	39·7	83
134	Herisson Bearded " "	2·530	7·34	·53	10·03	4·90	48·8	84
135	Hayne's Blue Stém " "	2·932	7·80	·67	12·31	5·64	45·8	100
136	Red Fern " "	2·559	7·88	·68	12·14	5·36	44·1	96
138	Bobs " "	3·087	7·23	·63	11·23	5·30	47·2	98
139	Chelsea " "	2·772	7·05	·75	11·69	5·42	46·3	99
141	Grant " "	2·881	7·45	·74	12·31	5·81	47·2	57
145	Laurel " "	2·892	8·05	·56	11·46	5·47	47·7	76
146	Red Fife Indian Head, 1906	2·673	8·34	·52	15·85	7·41	46·7	95
147	Pringle's Champlain " "	2·787	8·33	·47	13·34	5·02	37·6	80
149	Red Fife C.E.F., 1902	3·133	8·21	·67	11·06	5·30	47·9	107
150	White Fife C " 1906	2·879	8·16	·66	14·08	6·84	48·6	100
151	Turkey Red, Lethbridge, Alta., 1906	3·269	7·85	·52	12·43	5·87	47·2	87

Analysis of Flours—Series II., 1906-1907.

Number.	Variety of Wheat, Locality and Year of Growth.	Sugars. Directly-reducing calculated as Maltose.	Sugars. Non-reducing calculated as Cane Sugar.	Sugars. Total.	Gluten. Wet.	Gluten. Dry.	Gluten. Ratio of Dry to Wet.	Gluten. Ash.	Physical Characters. *Resiliency.*	Physical Characters. *Elasticity.*	Physical Characters. *Colour.*
102	Dawson's Golden Chaff, C.E.F., 1906	·11	·96	1·07	26·61	9·55	2·78	·074	Poor	Poor.	Slightly yellow.
103	Turkey Red, No. 580 "	·14	·82	·96	34·22	11·15	3·07	·097	Good.	Good.	Good.
106	Stanley A "	15	·88	1·03	27·50	9·52	2·89	·077	Fair.	"	"
107	Stanley C "	·13	·87	1·00	44·42	14·86	2·99	·179	Poor.	Fair.	Slightly yellow.
108	Ladoga "	·09	·98	1·07	41·37	13·26	3·12	·151	Fair.	Good.	Slightly yellow and sticky.
109	Red Fife II "	Trace.	·83	·83	45·70	16·07	2·84	·102	Good.	Good.	Good.
112	Ebert "	Trace.	·96	·96	38·45	13.57	2·83	·100	Fair.	Poor.	Fair.
113	Spence Yellow "	·11	1·11	1·22	46·18	16·51	2·80	·127	Good.	Good.	Good.
114	Gatineau "	......	......	......	47·10	16·28	2·89	·121	"	"	"
117	White Russian "	Trace.	·75	·75	39·33	13·81	2·85	·055	"	"	"
118	Preston A "	·02	1·10	1·12	30·75	10·76	2·86	·111	Fair.	"	"
120	Percy A "	·05	1·17	1·22	34·45	12·54	2·74	·126	"	"	"
122	Kubanka "	·12	1·28	1·40	46·70	16·54	2·82	·292	Good.	"	"
123	Goose "	·14	1·60	1·74	45·47	15·86	2·86	·323	"	"	"
125	Colorado "	·11	·68	·79	36·50	12·31	2·96	·076	Poor.	Poor.	"
126	Pringle's Champlain "	·16	·46	·62	37·85	13·56	2·79	·114	Good.	Good.	"
131	Huron (selected) "	·11	·82	·93	37·18	13·03	2·85	·123	"	Fair.	"
132	Red Preston "	·05	1·05	1·10	38·35	13·37	2·86	·135	"	"	"
134	Herisson Bearded "	Trace.	·64	·64	35·11	12·35	2·84	·097	Poor.	Poor.	"
135	Haynes Blue Stein "	Trace.	·79	·79	40·99	14·06	2·91	·096	Good.	Good.	"
136	Red Fern "	Trace.	69	·69	42·58	13·71	3·10	·131	"	"	"
138	Bobs "	·08	·83	91	40·06	13·58	2·95	·093	"	"	"
139	Chelsea "	·08	1·05	1·13	37·44	13·63	2·74	·135	"	"	"
141	Grant "	......	......	......	39·44	14·67	2·66	·113	"	"	"
145	Laurel "	·02	·95	·97	42·40	16·90	2·50	·100	Fair.	Fair.	"
146	Red Fife, Indian Head, 1906	Trace.	·96	·96	55·82	19·61	2·85	·110	Good.	Good.	"
147	Pringle's Champlain, Indian Head, 1906	Trace.	·62	·62	47·72	17·23	2·76	·091	"	"	"
149	Red Fife, C.E.F., 1902	·06	·92	·98	37·33	13·93	2·68	·101	"	"	"
150	White Fife C, C.E.F., 1906	Trace.	·68	·68	49·30	16·81	2·93	·123	"	"	"
151	Turkey Red, Lethbridge, Alta., 1906	·09	1·00	1·09	46·15	15·00	3·07	·120	"	"	"

Moisture.—These flours do not present quite the same uniformity nor are they quite so low as regards moisture content as those of Series I, most probably due to slight and more or less irregular absorption of moisture from the atmosphere, the determination being made in April, when the air is not so constantly or consistently dry as in mid-winter.

Protein or Albuminoids.—The percentages of protein range from 7·75 to 15·85, limits which again give evidence of extremely large differences in nutritive value. We have also in these figures a contradiction to the widely accepted view that spring wheats are necessarily rich in protein.

The Durum or Macaroni wheats—Kubanka and Goose (Nos. 122 and 123)—are characterized, as might have been expected, by a high protein content. It is a type invariably rich in gluten, though not yielding a flour, according to the general impression, that is suitable for bread-making.

Samples Nos 103 and 151 are both Turkey Red—the former grown at Ottawa, the latter at Lethbridge, Alta. No. 103 contains 9·75 per cent protein, No. 151, 12·43 per cent protein. It must not be assumed that this difference (2·68 per cent) results entirely from differences in environmental conditions during growth: No. 103 is a selected, pure strain, whereas No. 151 is from a commercial sample and most probably not pure. No. 151 is a further instance (see also No. 92, Series I) of a winter wheat with a high protein content.

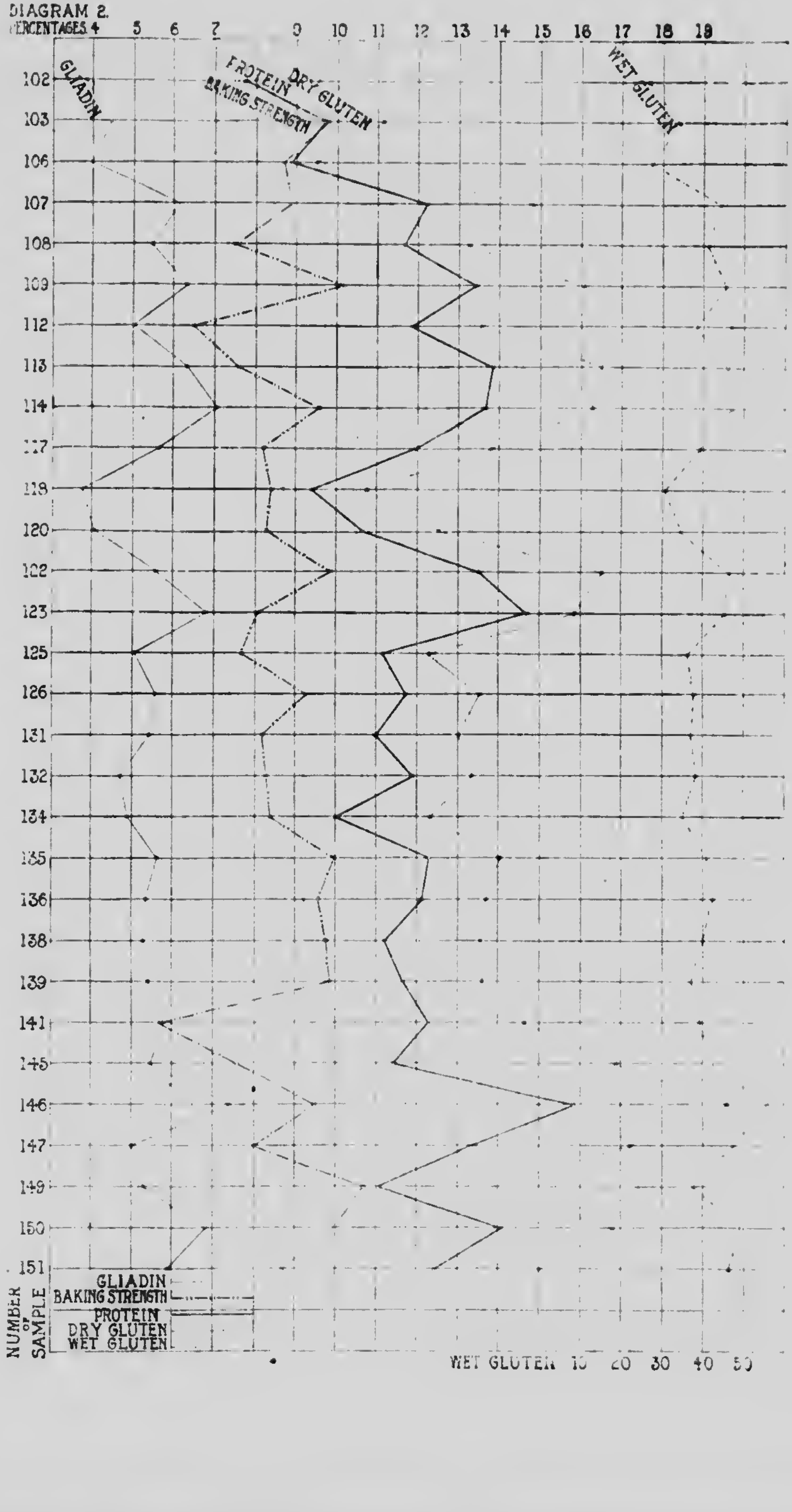
Gliadin-number.—As already pointed out, the 'gliadin-number' of the flours in Series I. was decidedly low: that is, from the standpoint of the limits suggested by Snyder. The same is true of the series under discussion—the highest ratio is 51·7, and in by far the larger number of instances it is below 50·0.

Wet and Dry Gluten.—Since, as we have shown, these data vary, for the most part with the protein, it is not surprising to find in this series very considerable differences. The quality of gluten cannot be measured as accurately as the amount; it must be admitted that as regards physical condition approximations only can be obtained. But granting this, any relation that might exist between quantity and quality should be evident to some degree from these data—and no such correspondence has been found. Undoubtedly the best bread-making flours are, as a rule, those richest in protein, but it is also true that there are flours of excellent quality possessed of but a medium gluten content. Occasionally, also, we find a high gluten content associated with inferior quality. The acceptance of these conclusions makes it clear that the quantity of gluten (or protein) must be regarded as but one factor, though in all probability the one of most importance, in the judging of flours.

The percentage of the ash constituent in the gluten was determined. Excepting the results for the two Durum wheats (Nos. 122,123) this estimation varies from ·055 per cent to ·179 per cent. For the most part these figures are much higher than those which would be obtained from the gluten of good commercial flours, a result due undoubtedly to the presence of a larger proportion of the bran elements incidental to the method of milling. Apparently there is no significance to be attached to this—there are no indications of any relation between these results and the other data. It is of interest, however, to note that in the case of the Durum wheats—Kubanka and Goose—this gluten ash is much higher than in any other of the series—possibly due to a larger proportion of bran present in the flour.

Sugars.—Of directly-reducing sugars (e.g., maltose) the amount present is very small—from traces to ·15 per cent; of non-reducing sugars (e.g., cane sugar) the percentage is larger, but still seldom exceeds 1 per cent. The Durum varieties, Kubanka and Goose, contain slightly more than any of the others of the series, with 1·28 per cent and 1·60 per cent cane sugar respectively. If these two wheats are excepted, the total sugars present fall within the limits, ·62 per cent and 1·22 per cent.

DIAGRAM 2.


PERCENTAGES 4 5 6 7 9 10 11 12 13 14 15 16 17 18 19
GLIADIN
PROTEIN
BAKING STRENGTH
DRY GLUTEN
WET GLUTEN
102
103
106
107
108
109
112
113
114
117
118
120
122
123
125
126
131
132
134
135
136
138
139
141
145
146
147
149
150
151
GLIADIN
BAKING STRENGTH
PROTEIN
DRY GLUTEN
WET GLUTEN
NUMBER OF SAMPLE
WET GLUTEN 10 20 30 40 50

As with Series I., no relation can be discovered between the sugar content and the volume of loaf.

Ash.—The total ash of the flours of Series II. was determined. The figures, generally, are decidedly higher than those from the best commercial brands, but this fact has apparently no further significance than that the milling process did not perfectly eliminate the bran. Kubanka and Goose, the two Durum varieties in the list, stand highest in this constituent, with 1·06 per cent and 1·25 per cent, respectively.

CORRELATION OF THE DATA.

Following the plan adopted in the discussion of the data of Series I., we have arranged in the following table the results for the protein, gliadin and dry gluten, the order being from the highest to the lowest percentage in each column. A general agreement is again to be observed. Thus, of the first ten samples in the column giving the percentages of protein, seven are to be found among the first ten in the gliadin column, and nine among the first ten in the gluten column. Again, of the ten lowest in protein, seven are among the ten lowest in gliadin and eight among the ten lowest in gluten. If, therefore, we fail to find a definite ratio between these determinations, the evidence of a well marked relationship is very clear and strong—and particularly is this the case between the protein and dry gluten.

RELATION OF PROTEIN, GLIADIN AND DRY GLUTEN.

Protein.		Gliadin.		Dry Gluten.	
No. 146	15·85	No. 146	7·41	No. 146	19·61
" 123	14·71	" 114	7·14	" 147	17.23
" 150	14·08	" 123	6·84	" 145	16·90
" 113	13·85	" 150	6 84	" 150	16·81
" 114	13·68	" 109	6·33	" 122	16·54
" 122	13·51	" 113	6·33	" 113	16·51
" 109	13 45	" 107	6·16	" 114	16·28
" 147	13·34	" 151	5·87	" 109	16·07
" 151	12·43	" 141	5·81	" 123	15·86
" 135	12·31	" 117	5·64	" 151	15·00
" 141	12·31	" 135	5·64	" 107	14·86
" 107	12·23	" 126	5·59	" 141	14·67
" 136	12·14	" 122	5·59	" 135	14·06
" 117	11·97	" 108	5·47	" 149	13·93
" 132	11·91	" 145	5·47	" 117	13·81
" 112	11·86	" 131	5·42	" 136	13·71
" 126	11·74	" 139	5·42	" 139	13 63
" 108	11·69	" 136	5·36	" 138	13·58
" 139	11·69	" 138	5·30	" 112	13·57
" 145	11·46	" 149	5·30	" 126	13·56
" 138	11·23	" 125	5·07	" 132	13·37
" 125	11·17	" 112	5·02	" 108	13·26
" 149	11·06	" 147	5·02	" 131	13·03
" 131	11·00	" 134	4·90	" 120	12·54
" 120	10·66	" 132	4·73	" 134	12·35
" 134	10·03	" 103	4·45	" 125	12·31
" 103	9·75	" 120	4·05	" 103	11 15
" 118	9·41	" 106	3·99	" 118	10·76
" 106	8·89	" 102	3·88	" 102	9 55
" 102	7·75	" 118	3·76	" 106	9·52

The 'gliadin number' apparently bears no relationship to the protein; nor does it show any agreement with the 'Baking Strength.'

Neither the ratio of ash to protein, nor of ash in gluten to protein, has, apparently any relationship to the 'Baking Strength.'

On Diagram II. plottings are given of the following values: 'Baking Strength,' Protein, Gliadin and Wet and Dry Gluten. Omitting for the moment consideration of the 'Baking Strength,' the general agreement already referred to between the other data will be at once apparent. Thus between the protein and the gliadin it is only in four instances out of thirty that the trend is not in the same direction. A very fair agreement is also observed between the protein and the wet and dry gluten determinations: the trend is divergent in two cases only in comparing protein and wet gluten.

In Series I. the trend of the curves denoting 'Baking Strength' was with one exception in the same direction as that of the protein (see Diagram I). This agreement is not so marked in Series II.; in ten instances (one-third of the number of samples examined) there is no possible correlation. No explanation or reason for this can at the moment be offered; the data have been carefully studied but they reveal nothing that throws any light upon these (apparently) exceptional cases. It is, of course, open to question if there exists a distinct relation between protein and 'Baking Strength,' though it must be admitted the balance of proof certainly goes far to support that contention. On the other hand, it might be urged that still further modifications in the baking process might alter the present values assigned to baking strength and bring them into greater consonance with the protein content.

It has already been pointed out that between the protein and gliadin of this series a very fair measure of parallelism exists; it follows, therefore, from what has just been said that there is no better correlation to be discovered between the 'Baking Strength' and gliadin than that between 'Baking Strength' and protein.

Diagram III. bears the plottings of the Protein, 'Gliadin-number' and Total Sugars. Again, no relation is to be found between the 'gliadin number' and protein content, nor is there any apparent relation between the 'gliadin-number' and the Baking Strength, if the curves of the former be compared with those of the latter as given on Diagram II.

The sugar results are extremely erratic, as in Series I., and do not show any agreement, save in a few exceptional instances, with any of the other data. They appear to be quite independent, not only of the nitrogenous compounds in the flour—which perhaps is not to be wondered at—but also of the various factors that go to make up baking strength.

Before summing up the results given in this part of the bulletin and drawing such conclusions as may be possible, it will be well to point out that there has been no attempt on the part of the writer to classify the flours examined from the chemical data. The intention, as stated at the outset, was merely to ascertain what relationship might exist between composition as revealed by analysis and the Baking Strength as determined by the practical trials of the Cerealist. Incidentally, we have obtained confirmatory evidence of the relation between certain of the nitrogen compounds, as well as information on one or two other points of interest in connection with this question of quality in wheat.

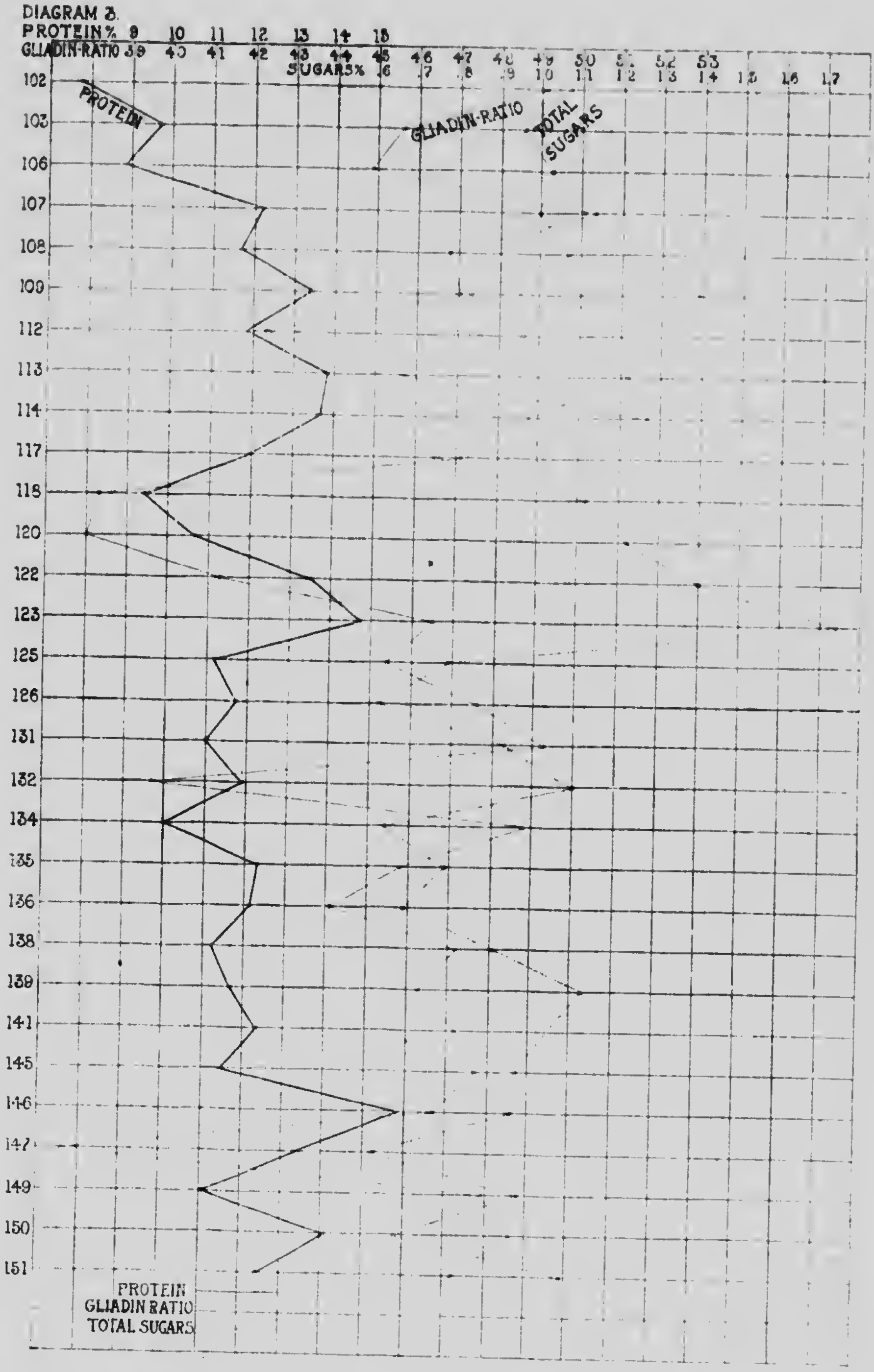


DIAGRAM 3.
PROTEIN %
GLIADIN-RATIO
SUGARS %
PROTEIN
GLIADIN-RATIO
TOTAL SUGARS
PROTEIN
GLIADIN RATIO
TOTAL SUGARS

Summary.

In bringing to a close this brief discussion of the data, it seems to the writer that we may safely conclude that the evidence presented shows:—

1. That between the protein, gliadin and wet and dry gluten there is a distinct relationship, but that there is no evidence of a definite or absolute ratio. It is apparently approximate in character. The only instance in Series I. in which an agreement did not obtain, that is, in which the same trend was not apparent between these data, was in the case of a flour possessing a gluten of markedly inferior quality. In Series II., though the agreement is not so close as in Series I., there is nevertheless good evidence of a close relationship between these determinations.

2. That the 'gliadin number,' though holding with the other nitrogenous data in certain parts of the series, is evidently a datum not to be considered as definitely related to the nitrogen compounds or to the 'Baking Strength.'

3. That while it may not be possible to prognosticate from the nitrogen determinations (protein, gliadin, and gluten) the particular order in which the members of any series of flours will fall when submitted to a baking test, these estimations constitute factors of prime importance in judging of the value of a flour for bread-making purposes, and especially is this true when taken into consideration with the physical character of the gluten. The results from both series of flours clearly indicate a distinct relationship between these chemical data and 'Baking Strength'—a figure made up chiefly of the values for volume, shape and weight of loaf. It does not appear, however, that any definite ratio can be established between these two classes of data.

4. That if the size of the loaf produced is controlled by the volume of gas evolved in the bread-making process, then this volume is dependent on the degree of the enzymic action (which may affect the proteids as well as the carbo-hydrates) rather than on the amount of sugar present in the flours.

5. That no relationship has been discovered between the ratio of total ash to protein and 'Baking Strength,' nor between the ratio of ash in gluten to protein and 'Baking Strength.'

For assistance in the analytical work and in the preparation of the data, the writer would gratefully acknowledge his indebtedness to Mr. A. T. Charron, Mr. H. W. Charlton and Mr. A. G. Spencer, of the Chemical staff.