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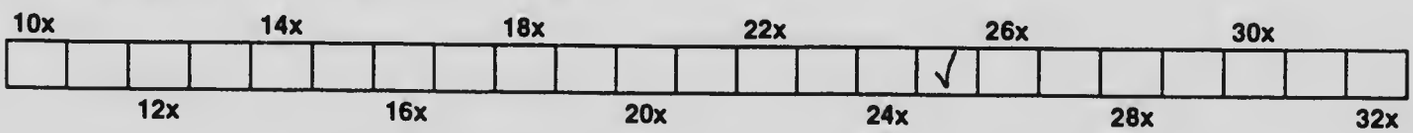

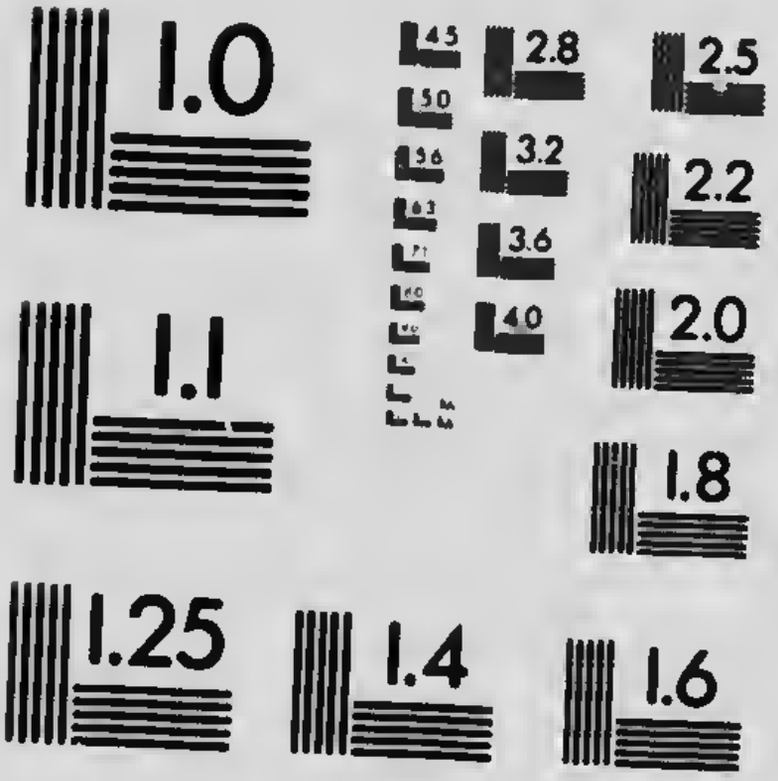

DEPARTMENT OF AGRICULTURE

CENTRAL EXPERIMENTAL FARM
OTTAWA, CANADA

THE MILLING AND CHEMICAL VALUE

OF THE

GRADES OF WHEAT

IN THE

MANITOBA INSPECTION DIVISION

CROP OF 1904

PART I

BY

CHAS. E. SAUNDERS, Ph. D.,
Experimentalist

PART II

BY

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

BULLETIN No. 50

JUNE, 1905

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

To the Honourable the Minister of Agriculture,

Sir,—I have the honour to submit for your approval, 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.

The Milling and Baking tests reported on in Part I. have been conducted by Dr. C. E Saunders, Experimentalist, while the results of a chemical study of the grain and flour of these grades carried on by Mr. F. T. Shutt, Chemist of the Experimental Farms, are presented in Part II.

The investigations which are reported upon in this bulletin were undertaken under your instructions, in response to a request received from the Manitoba Grain Growers Association, asking that the Experimental Farm staff should determine as accurately as possible the value of each grade of wheat (in the Manitoba Inspection Division) for milling purposes, and also from the standpoint of chemical composition.

This subject is one of deep interest to the farmers of the Canadian North-west, and every effort has been made to make the investigation thorough and complete. The uniformity of the results obtained by these independent workers gives evidence of the care and accuracy with which the work has been conducted, and will doubtless inspire confidence in the reliability of the conclusions reached. I trust that the facts presented in this bulletin will be helpfu leading to just conclusions in reference to this important inquiry.

I have the honour to be

Your obedient servant,

Wm. SAUNDERS,
Director of Experimental Farms.

Ottawa, June 6, 1905.

PART I.

THE MILLING VALUE OF THE GRADES OF WHEAT

By Chas. E. Saunders, B.A., Ph.D., *Experimentalist.*

Method of selecting the wheat.

In order that definite conclusions may be drawn from tests and analyses of the wheat of different grades it is evident that *the grain must in every case be thoroughly representative of the average of the grade.* Individual lots of grain, each grown in one field, are obviously untrustworthy (and may be quite misleading) when general conclusions are to be drawn; because they may be either above or below the average of the grade (though not, of course, below the legal standard), and may possess peculiarities due to the soil or climate of the district in which they were grown or due to the variety of wheat sown.

Through the courtesy of Mr. David Horn, the Chief Inspector of Grain, we were able to obtain for this investigation from the Winnipeg inspection office a sufficient quantity of wheat of each grade made up by the mixing of small quantities taken from a number of different car-loads from various sections of the country. These samples of wheat were screened, under Mr. Horn's direction, to bring them to the condition in which the grain leaves Fort William.

These composite lots may therefore be depended upon to represent accurately the *average* of the different grades as shipped out of Fort William. This average is, of course, above the legal standard, which defines only the minimum of quality required for each grade.

The grades received were No. 1 Hard, Nos. 1, 2 and 3 Northern, No. 4 Extra, No. 4, No. 5, Feed and No. 2 Feed. A sample of frozen wheat, No. 5 Frosted, was also obtained in addition to the regular grades mentioned.

Cleaning the wheat.

The grain as received from Mr. Horn was subjected to further cleaning before being milled. This cleaning was designed to remove oats, barley, weed seeds, &c., and also to take off to a certain extent the hairs from the tips of the wheat kernels.

The loss of weight caused by this cleaning, and the weight per bushel of the cleaned samples are given in the following table:—

	Loss in Weight on cleaning.	Weight per bushel cleaned.
No. 1 Hard	0·2 per cent	64 Lbs.
No. 1 Northern	0·6 "	63½ "
No. 2 "	0·8 "	62½ "
No. 3 "	1·0 "	60½ "
No. 4 Extra	1·4 "	58½ "
No. 4	1·2 "	58½ "
No. 5	1·8 "	57 "
Feed	1·8 "	56 "
No. 2 Feed	2·0 "	53½ "
No. 5 Frosted	0·8 "	59 "

50—2½

It will be noticed in the above table that the loss on cleaning increases, and the weight per bushel decreases in passing from the higher to the lower grades. No. 1, however, occupies a somewhat anomalous position.

METHOD OF MILLING.

The different kinds of wheat were ground in an experimental (roller process) flour mill, adapted for the use of small quantities of grain. A fixed system of milling, such as the large mills employ, was not used. Such systems are adapted specially to the higher grades of wheat and cannot therefore be expected to give accurate results when low grades are being ground. In this respect, therefore, an experimental flour mill has a distinct advantage over a larger, fixed system; because the treatment of each kind of wheat can readily be altered to suit its special requirements. But wherever comparisons are being made between different lots of wheat of good quality and similar in character, a fixed system is to be preferred.

Before milling, the wheat was moistened with about three per cent of water and was allowed to stand for about one hour. The time and the amount of water added varied somewhat according to the nature of the wheat.

Four breaks were generally found sufficient when the higher grades were being milled. The first break was made very light, and the first break flour (usually less than one per cent) was always put into the low grade flour. The flour from the other breaks was put into the 'straight' grade, except in the case of No. 2 Feed which gave break flour so dark in colour that it could only be put into the low grade.

The number of reductions varied somewhat with the character of the wheat which was being ground.

After each operation, the mills and sieves were thoroughly brushed out, in order to make the results as accurate as possible, quantitatively. This cleaning entirely prevented the mixing of flour from one lot of wheat with that from any other, (which always occurs in large mills), but it made the colour of the flour less brilliant than it would otherwise have been.

The loss in milling was usually about three per cent.

FLOUR, SHORTS AND BRAN.

Since the terms *flour, shorts* and *bran* are scarcely capable of rigid definition, it seems necessary to explain as accurately as possible the meanings attached to them in this investigation. It is a perfectly simple matter to make seventy per cent or more of *flour* from even the very lowest grades of wheat, provided the definition of the term *flour* is made sufficiently broad. A little additional grinding will also always transfer a considerable quantity of bran into the shorts, bringing the latter to a relatively large bulk. Therefore, the different proportions of the products obtained by various investigators are not necessarily contradictory, even though they may seem to be so at first sight. In the present investigation an effort has been made to use the terms *flour, shorts* and *bran* in exactly the same sense in every case.

Flour.—This material all passed through No. 10 bolting silk and was classified according to colour into three grades, first, second and low. The first and second grades were then mixed and are referred to as *straight* flour. Care was taken to include in the straight flour all the material which seemed, by its colour, to be fit for the making of bread of fair quality. The low grade flour could of course be used for bread making, but so far as the writer is aware, such material as this is not so used in Canada, but is employed in the feeding of animals. Bread made from it is certainly most uninviting.

Shorts.—This product passed through No. 20 silk gauze and was retained on No. 10 bolting silk.

Bran.—The material finally retained on No. 20 silk gauze was designated as bran.

The proportion of shorts to bran did not vary very much in the last seven grades, the shorts being a little less in amount than the bran. In the last two grades the shorts and bran were about equal. As these differences have very little significance, and as the relative proportions of the two products can so readily be altered by slight changes in the method of milling, it seems unnecessary to report upon them separately. The totals only are therefore given.

The following table gives the yield of flour, shorts and bran, obtained from the different grades of wheat. These milling tests were done in duplicate and the figures given are the average of the two.

YIELD OF FLOUR, SHORTS AND BRAN.

(The figures are percentages of the total products obtained).

—	Straight Flour	Low grade Flour.	Total Flour.	Shorts and Bran.
No. 1 Hard	[illegible]	6½	71	29
No. 1 Northern	62	7½	69½	30½
No. 2 Northern	61	8	69	31
No. 3 Northern	59½	8	67½	32½
No. 4 Extra	56	10	66	34
No. 4	52	14	66	34
No. 5	45½	14½	60	40
Feed	38	21	59	41
No. 2 Feed	22	27	49	51
No. 5, Frosted	45	16	61	39

It will be seen that the amounts of straight flour and of total flour decrease as we pass from the higher to the lower grades; while the amounts of low grade flour and of shorts and bran increase. These changes are fairly regular, though the differences between any two grades become much greater as the lowest grade is approached.

As already stated, the straight flour contains, in each instance, all the flour that seemed (from its colour) to be suitable for bread-making.

The large proportion of low grade flour produced from the poorer samples of wheat shows clearly their inferior character.

BREAK FLOUR AND PURIFIED MIDDLINGS.

It may be of interest, from a miller's point of view, to state the proportions of break flour and of purified middlings obtained from the different grades. The figures for the break flour represent the average of three determinations. The purified middlings were determined once.

Patent flour was not made, but the quantity of purified middlings produced will give a fair idea of the amount of patent flour which might be obtained from each grade.

The middlings were made in the usual way and were then purified by sifting and by the use of a current of air to remove bran particles. The purified middlings passed through No. 50 silk gauze and were retained on No. 9 bolting silk. The break flour passed through No. 10 silk.

The figures given below are percentages of the wheat ground.

	Break Flour	Purified Middlings.
No. 1 Hard	8	47
No. 1 Northern	8	45
No. 2 Northern	9	43
No. 3 Northern	9	41
No. 4 Extra	8	38
No. 4	9	36
No. 5	7	32
Feed	6	26
No. 2 Feed	5	16
No. 5 Frosted	6	39

The break flour from the lower grades was darker in colour than that from the higher grades; and the purified middlings from the lower grades did not possess the same rich, yellowish colour as those from higher grades.

COLOUR OF THE FLOUR.

The straight flours made from the different grades were all much alike in colour, in the dry state; but the flour from the lower grades was less creamy and of a rather grayish tint.

After moistening and drying, differences of considerable importance could be observed. The flour from the first six grades was all of about the same colour, No. 5 and No. 5 Frosted were slightly darker, while Feed and No. 2 Feed were of a decided brownish-gray tint.

BAKING TESTS.

Many baking tests were conducted with the straight flours from the different grades of wheat. These tests were made rather severe so as to bring out clearly any differences which there might be in the strength of the various flours. Slightly different methods of fermentation of the dough were tried, but in each case the whole of the flour was made up into dough at the commencement of the operation. This was kneaded down twice, in addition to the very thorough kneading which it received at the beginning. The same quantities of flour, salt, yeast and sugar were always used, and water was added until all the samples of dough were as nearly as possible of uniform consistency. The fermenting cupboard was kept at about 33° C. (= 91° F.), and the bread was baked at about 205° C. (= 401° F). When cool, the weights and volumes of the loaves were ascertained.

WATER ABSORBED IN BREAD-MAKING.

The amount of water absorbed and retained by any flour when made into bread is a very important consideration in determining its value to the baker. The following table gives the averages of a number of different bakings of the straight flour from each grade of wheat. As the loaves made were quite small and were thoroughly baked, the amount of water retained was not so large as it would be in ordinary bread making. The results are, however, strictly comparable throughout:

	Weight of bread made from 100 parts of flour.	Number of Bakings.
No. 1 Hard.....	137½	9
No. 1 Northern....	137	5
No. 2 Northern.....	135	6
No. 3 Northern.....	136	4
No. 4 Extra.....	134	5
No. 4.....	136½	4
No. 5.....	136	6
Feed....	137	4
No. 2 Feed (not sufficient flour for repeated tests).		
No. 5 Frosted.....	138	6

Most of these differences in water absorption are too small to be of much importance; but the rather high position occupied by the flour from No. 5 Frosted wheat is interesting.

VOLUME OF THE LOAVES FROM DIFFERENT FLOURS.

The cubic volumes of the loaves produced in the different bakings were carefully determined in all cases. The results obtained, however, showed very few variations of interest. There was no difficulty in making excellent bread (as light as was desired) from almost every one of the samples of flour, though they did not all give their best results under exactly the same conditions. In general terms it may be said that flour from the lower grades acted better with rather long fermentation, while flour from the higher grades required somewhat shorter periods.

Some of the lower grades (No. 4 Extra, No. 4, No. 5 and No. 5 Frosted) gave dough which felt rather unusual and seemed to possess less elasticity than that made from the higher grades; but, when properly treated, very good bread was produced from it.

The flour from Feed wheat gave bread of somewhat less volume than the others, while with No. 2 Feed it was very difficult to make light bread at all.

COLOUR OF THE BREAD.

The colour of the bread made from the different flours varied only slightly from No. 1 Hard down to No. 5 and No. 5 Frosted, though the bread from these lower grades was certainly not quite equal in colour to that made from No. 1 Hard wheat. Below No. 5 there was a very distinct darkening. The colour of the bread made from Feed wheat was quite dark and unattractive, while that from No. 2. Feed was distinctly worse. The flavour of the bread in these two instances was also poor.

Conclusions from Baking Tests.

We may conclude from the baking tests that the straight flours made in this investigation were all suitable for bread making except those from Feed and No. 2 Feed wheat. These latter may be entirely condemned. The writer has never seen any such flour used for bread making, and it is not probable that it could be sold at any price for that purpose in Canada.

It may therefore be safely concluded that Feed and No. 2 Feed wheat have no milling value whatever, and that their actual worth is to be determined by their usefulness as food for chickens or other animals, either as whole grain or in the ground condition. Chemical analysis will therefore give a much better idea of the value of these two grades than any milling and baking tests.

VALUES OF MILL PRODUCTS.

Having eliminated the lowest two grades an attempt will now be made to ascertain the relative values of the mill products obtained from the remaining grades of wheat. In order to do this it is necessary to re-state the amounts of the different products obtained in terms of *uncleaned* wheat, the material which the miller purchases.

In preparing this table a deduction has been made for the loss in cleaning the wheat (particulars of which have already been given), and a further allowance of three per cent for loss in milling.

Small fractions are disregarded as in the previous table:

YIELD OF FLOUR, SHORTS AND BRAN FROM 100 LBS. OF UNCLEANED WHEAT

	Straight Flour.	Low Grade Flour.	Shorts and Bran.
	Lbs.	Lbs.	Lbs.
No. 1 Hard	62½	6	28
No. 1 Northern	60	7	29½
No. 2 Northern	59	7½	30
No. 3 Northern	57	7½	31
No. 4 Extra	53½	9½	32½
No. 4	50	13	32½
No. 5	43½	13½	38
No. 5 Frosted	43½	15½	37½

After a careful study of the prices of flour, shorts and bran in Winnipeg during the past winter, the following values were selected as approximately correct for the products made in these milling tests:—

Straight flour	$2.50	per 100 lbs.
Low grade flour	1.10	"
Shorts and bran (mixed)	0.70	"

Even though these prices may not be strictly accurate, they will serve very well for the calculation of the relative values of the mill products obtained from a bushel of wheat of each different grade.

The following table shows the

VALUE OF THE MILL PRODUCTS OBTAINED FROM A BUSHEL OF WHEAT.

Grade.	Straight Flour.	Low Grade Flour.	Shorts and Bran.	Total.
	$ cts.	$ cts.	$ cts.	$ cts.
No. 1 Hard	0 94	0 04	0 12	1 10
No. 1 Northern	0 90	0 04½	0 12½	1 07
No. 2 "	0 88½	0 05	0 12½	1 06
No. 3 "	0 85½	0 05	0 13	1 03½
No. 4 Extra	0 80½	0 06½	0 13½	1 00½
No. 4	0 75	0 08½	0 13½	0 97
No. 5	0 65½	0 09	0 16	0 90½
No. 5 Frosted	0 65½	0 10	0 16	0 91½

In calculating the above figures no allowance has been made for the fact that the straight flour from the lower grades of wheat was of somewhat less value than

that from the higher grades. There may also be some slight errors in assuming that the other mill products are of the same value whatever grade of wheat they have been made from. In studying this table it should not be forgotten that the value of the mill products does not necessarily indicate the value of the wheat to the miller. The cost of running a mill is approximately the same whether each bushel of wheat is yielding products to the value of $1.10 or only to the value of 90 cents. In the latter case the cost of production is relatively greater, and may even be so much greater as to render the poorer wheat quite unprofitable for milling purposes, except at a greatly reduced price. We have also to consider the fact that the demand for low grade flour and other inferior products may be less keen than that for bread-making flour. So that a miller may prefer to pay a relatively higher price for a superior grade of wheat in order to have a large daily output of high grade flour from his mill. Further, the prevailing systems of milling, arranged as they are for good plump wheat, would require some modifications in order to produce the best possible results with inferior wheat, and millers are naturally averse to making such changes. In view of these considerations it cannot be doubted that the value of the lower grades of wheat for milling purposes is distinctly less than the figures given in the above table would seem to indicate.

In regard to the value of the highest grades of wheat, the following quotation from "The Miller" (London, England, Feb. 6th, 1905) is of interest:—

'The English miller does not want No. 1 Hard for making a purely No. 1 Hard wheat flour, but to mix with other sorts in order to make a standard flour of his own, and so long as the No. 1 Canadian wheat is of the very highest milling value it will command a premium over and above its real single milling value.'

No doubt these remarks would also apply to No. 1 Northern and possibly to No. 2 Northern, as well.

It is clear, therefore, that we must always expect the market price of the highest grades to be *higher* and the market price of the lowest grades to be *lower* than the value of the mill products obtained from each would suggest.

AVERAGE PRICES OF THE GRADES IN WINNIPEG.

(Winter of 1904-5.)

Taking the average of several quotations covering the whole of last winter, the following were found to be the average prices per bushel (of 60 lbs.) of the different grades of wheat in Winnipeg:—

No. 1 Northern	96 cents.
No. 2 Northern	93 "
No. 3 Northern	86 "
No. 4 Extra	77 "
No. 4	74 "
No. 5	63 "
Feed	55½ "
No. 2 Feed	52½ "

The quantity of No. 1 Hard offered for sale was so small that it was almost ignored as a factor in the market. In answer to an inquiry, Mr. Paul Horn kindly furnished the information that the usual price of No. 1 Hard, during the past winter was one cent per bushel above that of No. 1 Northern.

By comparing this list with the previous table it will be seen that the average price of a bushel of wheat is much closer to the total value of the mill products obtainable from it in the case of the higher than in the case of the lower grades. This would indicate that farmers are being insufficiently paid for wheat of the lower grades if the value of the mill products were the only point to be considered in fixing the

price of the wheat. But we have pointed out several important considerations which modify the case. In addition to those already mentioned it should not be forgotten that a scarcity or an abundance of wheat of any particular grade would tend as a rule to raise or lower its price in relation to the other grades. Further, any grades for which there is a special demand will usually command relatively higher prices than the next grades immediately below them. This seems to be illustrated in the above list of prices. The large drop (9 cents) between No. 3 Northern and No. 4 Extra is perhaps due to the fact that many millers refuse to buy wheat of any lower grade than No. 3 Northern; and, again, the still larger gap (11 cents) between No. 4 and No. 5 may indicate that No. 4 is the lowest grade used by any mills.

It is evident that what may be called the *single* milling value of the different grades can never fix the prices that will be paid for the wheat. The highest grades will probably always command enhanced prices, while the value of the lowest grades will be determined by their utility for feeding purposes and not for milling. For some of the intermediate grades, it seems possible that millers could afford to pay relatively higher prices than those which have lately prevailed, if greater attention were given to the grinding of such wheat and special efforts made to find the most advantageous markets for the products.

PART II.

A CHEMICAL STUDY OF THE GRAIN AND FLOUR OF THE GRADES OF WHEAT.

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

Chemist, Dominion Experimental Farms.

The chief object in view in making a chemical examination of the various grades of wheats described in Part I and their resultant flours, was to ascertain what relationship might exist between the composition of a wheat and the quantity and quality of the flour that could be obtained therefrom, when wheats differing in degree rather than in kind were under examination*. It has long been well known that in comparing wheats differing as regards origin or conditions of growth, chemical analysis is of the greatest value in indicating the quality or strength—and to some extent—the quantity of the flours that might be obtained from them. It was, therefore, thought that data from such a series of analyses as have been carried out in this investigation might prove of considerable interest, and possibly of great service when placed side by side with the results from practical milling and baking tests.

It was, further, hoped that from the more detailed analyses of the flours a closer relationship than now exists might be established between the gluten data and the bread-making value of a flour.

The analyses of the wheats were made on the cleaned samples representing the various grades, and referred to on page 5 of this bulletin. The preparation of the samples consisted in grinding the wheat until the whole was reduced to fine powder. For this purpose the two mills commonly employed in the laboratory in grinding fodders and feeding stuffs were employed. The determinations made included moisture, protein, fat, carbo-hydrates, fibre, and ash. The weight of 100 kernels was also taken.

The flours analysed were those obtained in the milling test and designated as 'straight.' (See page 7, Part I). In addition to the estimation of the constituents mentioned in the foregoing paragraph, the proportion of gliadin (one of the constituents of gluten) was determined, a mechanical separation of the gluten made and the relative acidity of the flours ascertained.

COMPOSITION OF THE WHEATS.

Moisture.—All the samples had been kept for some weeks previous to grinding under the same atmospheric conditions. It is not surprising, therefore, to find that the differences in moisture-content are comparatively small and do not call for any extensive comment. It may be pointed out, however, that all the wheats are characterized by a low percentage of moisture—a feature of spring wheats and a matter of consider-

*The wheats inspected and graded at Winnipeg are all of the same hard, spring wheat type (very largely Red Fife) and grown in Manitoba or the North-west Territories. It is evident, therefore, that the differences between these grades are not those which might result from the mixing of wheats of various types (e.g. Spring and Fall) or of wheats grown under widely different conditions of soil and climate.

able importance to the bread-maker, since, other things being equal, the drier the flour the greater the weight of bread that can be made from it.*

There is also another interesting deduction that can be made in this connection, though it is probably not one of great importance. The weight of the kernel in this series is in direct ratio to the plumpness of the grain. By comparing the moisture percentages with the data representing the weight of the kernel it will be observed that the heavier, or, in other words, the plumper, samples contain the larger percentages of moisture. Though the relation throughout the series is not regular, the results generally show that the lighter, and possibly more or less shrivelled, grain is the drier.

Crude Protein.—This is obtained by multiplying the total nitrogen contained in the wheat by the factor 6·25. It is the most important constituent and in wheat consists almost, but not entirely, of gluten—the ingredient which determines the relative 'strength' of the flour and its value for bread-making purposes. Since, however, a part of the protein exists in the bran and in the aleurone layer enclosing the endosperm and which may be separated with the bran, it does not invariably follow that the richer the grain in protein, the stronger the flour, although this is most probably true when comparing wheats of equal plumpness and with equal thickness of bran when milled alike.

The differences in protein-content to be observed between the grades of wheat from No. 1 Hard to No. 5 are very small and the writer doubts if he would be justified in making any deduction of an emphatic nature as to the relative superiority of any one of these grades over another as regards the strength of the flour which they would yield. There is certainly no indication in these crude protein results of a steady decline in strength from the first to the last of the series.

It is a significant fact, however, that the crude protein is perceptibly higher in No. 2 Feed and in No. 5 Frosted than in the grades preceding them, and the writer thinks that this may be accounted for in No. 2 Feed by the smallness of the grain, and hence the larger proportion of bran (which is highly nitrogenous) to endosperm, and in No. 5 Frosted by the shrivelled character of the grain.**

Hence, for grinding as cattle feed these two latter grades are in all probability the most valuable of the series, and following these we should place No. 5 and Feed.

Selected samples of Red Fife, as grown in Manitoba and the North-west Territories, have usually been found richer in protein than these wheats. Thus, in 1893, the writer obtained 14·62 per cent protein as the average for 9 samples grown in Manitoba and 14·53 per cent for a similar number from the North-west Territories. Undoubtedly the character of the season affects the character of the grain, especially as regards protein (gluten), and we may expect from year to year changes of more or less import, both in quantity and quality of this important constituent, but it is evident that the general and mixed character of grade samples should be borne in mind when comparing their analysis with pure, selected grain, or erroneous conclusions may be drawn.

Fat.—Here, also, the results are so uniform—the differences being such as might almost be accounted for in the unavoidable error of experiment—that it would not be safe to discriminate between the wheats, if we except No. 2 Feed and No. 5 Frosted, which, as in protein content, give slightly higher results than the other wheats of the series.

It may be of interest, however, to note that the percentages of fat throughout the whole series are considerably above the average usually quoted for wheats, viz., 1·85. Our former researches, which now include a large number of analyses, have always shown that wheats as grown in the Canadian North-west generally are so characterized and we must consider this as an important and valuable feature from the nutritive standpoint.

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* These wheats were ground in February. The air in a heated building at Ottawa during the midwinter months is, as a rule, very dry, and this no doubt has had its influence u the moisture-content of the wheat.

** It has been shown by recent researches in the Experimental Farm laboratories that frosted and rusted grain are in a measure immature, and as a rule characterized by a higher protein-content than similar wheat that has become plump through maturing.

Carbo-hydrates.—These consist, in the case of wheat, mainly of starch, and are found by substracting the sum of the other constituents from 100.

ANALYSES OF WHEATS.

Designation of Samples.	Weight of 100 Kernels.	Moisture.	Crude Protein (N. × 6·25).	Fat.	Carbo-hydrates.	Fibre.	Ash.
	Grammes.	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
No. 1 Hard	2·902	10·98	12·56	2·17	70·37	2·45	1·47
No. 1 Northern	2·918	10·63	12·81	2·09	70·62	2·36	1·49
No. 2 "	2·681	10·37	12·69	2·14	70·88	2·39	1·53
No. 3 "	2·465	9·51	12·56	2·25	71·09	2·84	1·75
No. 4 Extra	2·204	8·66	12·43	2·41	72·06	2·73	1·71
No. 4	2·244	9·63	12·25	2·20	71·53	2·71	1·68
No. 5	2·206	8.73	12·81	2·27	71·68	2·71	1·80
Feed	2·160	8·91	12·87	2·35	71·22	2·84	1·77
No. 2 Feed	2·104	9·99	13·06	2·66	69·20	3·25	1·84
No. 5 Frosted	2·337	9·13	13·62	2·42	70·62	2·68	1·53

Fibre and Ash.—It will be noticed that the percentages of these constituents increase, though not regularly, as the weight of the kernel decreases—that is, from the higher to the lower grades. The explanation for this lies in the larger percentage of bran in the smaller (and lighter) grain, and in the fact that the bran coats are the part of the kernel richest in fibre and ash elements. No. 2 Feed illustrates this fact very well; its kernel is the lightest and it contains the highest percentages of fibre and ash.

Weight of the kernel.—The weight of the kernel as ascertained from, say 500 or 1,000 average grains, furnishes important data when comparing among themselves different samples of wheat of the same type. Previous investigation has shown that when such grain is examined there is a very close relationship between this weight and the weight per bushel of the cleaned wheat—the heavier the kernel, as a rule, the larger the weight per bushel and, as may be pointed out, the greater the amount of first grade flour that may be obtained. The present series offers an excellent illustration of this relationship, for with one or two minor exceptions the order of the grades as regards weight of the kernel is that of the weight per bushel and of the amount of 'straight' flour.

WEIGHT OF KERNEL, WEIGHT PER BUSHEL AND YIELD OF FLOUR.

Designation of Samples.	Weight of 100 Kernels.	Weight per Bushel.	Yield of Straight Flour.
	Grammes.	Lbs.	Lbs.
No. 1 Hard	2·902	64	64½
No. 1 Northern	2·918	63½	62
No. 2 "	2·681	62½	61
No. 3 "	2·466	60½	59½
No. 4	2·441	58½	52
No. 5 Frosted	2·337	59	45
No. 4 Extra	2·204	58½	56
No. 5	2·205	57	45
Feed	2·161	56	38
No. 2 Feed	2·105	53½	22

The wheat which offers the chief exception in this consideration is No. 5 Frosted, in which, it is to be observed, that although the ratio between the weight of kernel and weight per bushel is maintained, the yield of 'straight' flour is less than from several wheats of heavier character. The yield of *straight* flour is determined on a colour basis and has in this instance been reduced by the discolouring action of the frost. Examination of the *total* yield of flour for this sample shows that the amount of flour obtainable is directly proportional to the weight of kernel and weight per bushel—and hence, from this standpoint, this wheat falls into line with the rest of the series.

It may be remarked that if these wheats were judged simply by the weight of kernel even the higher grades would be found below rather than above the average as ascertained in our laboratories for first class Red Fife.

COMPOSITION OF THE FLOURS.

The flours submitted to chemical examination in this investigation were obtained in the experimental roller mill and are those designated in Part I of this bulletin as *straight* flours, a definition of which is given on page 6. In addition to the determination of the moisture, protein, fat, fibre, and ash, as in the case of the wheats, the direct estimation of the gluten was made, the proportion of protein in the form of gliadin ascertained and the relative acidity taken.

Moisture.—The percentages of moisture in these flours are considerably less than those in the usual brands of flour upon the market. This is accounted for chiefly by the fact that after milling and before analysis these flours were exposed for some weeks (in small quantities, in bags) when the atmosphere was comparatively speaking, dry. (See note on page 14). This was done for the purpose of equalizing the moisture-content throughout the series and undoubtedly had the effect of drying the flours. The low moisture-content should indicate, other things being equal, high absorptive capacity and a concomitant large bread yield—and this was found to be the case. As the differences, however, between the flours in the percentages of moisture they contain are very small, it would be undesirable to draw any conclusions as to the relative values of the flours in this respect.

Protein or Albuminoids.—As stated in the accompanying table of analyses, the percentage of protein is found by multiplying the percentage of nitrogen in the flour by the factor 5·7. This number has been adopted of recent years as giving more accurately than 6·25 the composition of gluten, of which the protein of flour practically consists.

A study of these data at once shows that it would be practically impossible on this score to discriminate between these flours, the differences in protein-content being so small. It is interesting to note, however, that in this regard No. 1 Hard does not surpass the other grades, indeed it does not stand at the head of the list. As is well known, and as stated in the consideration of the wheats, the protein (gluten) is the most important constituent in determining the bread-making power of a flour. It has been generally held that flours of good quality should contain between 11 and 12 per cent (N x 5·7), but it has been shown by recent analyses in the Farm Laboratories that good bread-making flours may contain considerably less than this amount.

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. It is stated by Osborne and Voorhees, Snyder, Fleurent

and other chemists who have made a special study of gluten and its compounds, that the bread-making value of a flour depends not only upon the amount of gluten present, but also upon the proportion of gliadin to glutenin. Professor Snyder (Minnesota Experiment Station) says: 'Either an excessive or scant amount of gliadin may cause a flour to have poor bread-making qualities.' As regards tentative standards this writer further says that: 'Flour of good quality should contain about 11 per cent protein (N x 5·7) and that from 55 to 65 per cent should be in the form of gliadin.' (Journal

ANALYSES OF FLOURS.

Designation of Samples.	Moisture.	Protein or Albuminoids. (N × 5·7)	Fat.	Carbohydrates.	Fibre.	Ash.
	p. c.	p. c.	p. c.	p. c.	p. c.	p. c.
No. 1 Hard	8·53	10·77	1·16	78·83	·13	·58
No. 1 Northern	8·83	11·00	1·58	77·57	·44	·58
No. 2 "	8·75	10·77	1·43	78·02	·44	·59
No. 3 "	8·42	11·30	1·57	77·41	·50	·80
No. 4 Extra	8·38	11·17	1·62	77·78	·41	·64
No. 4	8·60	11·00	1·60	78·06	·07	·67
No. 5	8·51	10·89	1·43	78·28	·19	·67
Feed	8·14	11·12	1·95	77·52	·51	·76
No. 2 Feed	8·59	11·34	1·43	77·42	·23	·99
No. 5 Frosted	9·15	11·23	1·49	77·24	·16	·73

Designation of Samples.	Gliadin. (N × 5·7)	Percentage of Protein in the form of Gliadin.	Gluten.			Acidity.
			Wet.	Dry.	Ratio of Dry to Wet.	
	p. c.	p. c.	p. c.	p. c.		p. c.
No. 1 Hard	4·85	45·0	37·56	13·00	2·88	·15
No. 1 Northern	4·90	44·5	33·01	13·48	2·89	·15
No. 2 "	4·85	45·0	35·31	12·64	2·79	·15
No. 3 "	4·73	41·8	36·44	12·81	2·89	·16
No. 4 Extra	4·85	43·4	36·02	12·68	2·84	·15
No. 4	4·85	44·1	36·90	12·61	2·89	·16
No. 5	4·79	43·9	35·86	12·31	2·91	·17
Feed	4·67	41·9	36·40	12·61	2·88	·24
No 2 Feed	4·33	38·1	31·89	11·35	2·80	·41
No. 5 Frosted	4·90	43·6	38·16	13·30	2·87	·22

of American Chemical Society, March, 1904). It would, however, appear from more recent work that there is ample reason to believe that in many good flours the proportion of gliadin is considerably less than here stated. Thus, from bulletin No. 90, Minn. Exp. Stn., issued January, 1905, by Prof. Snyder, in which the analyses of flours are given from 10 standard grades of wheat of 1904 (Minnesota inspection) I obtain, partly by calculation, the following results:

PROTEIN AND GLIADIN IN MINNESOTA FLOURS.

Number.	Designation of Samples.	Protein.	Gliadin, (N. × 5·7).	Percentage of Protein in the form of Gliadin.
		p. c.	p. c.	p. c.
1	No. 1 Northern, inspected in	10·34	5·58	53·9
2	No. 1 " " out	10·60	4·79	45·1
3	No. 2 "	8·57	4·79	55·8
4	No. 3 "	11·10	5·13	46·2
5	No. 4 "	11·08	4·56	41·1
6	Rejected.	11·20	5·01	44·7
7	No grade	11·39	5·24	46·7
8	No. 2 Northern	11·38	4·73	41·5
9	No. 3 "	10·81	4·84	44·7
10	No. 4 "	11·50	5·06	44·0

It will be observed that in only two cases do the percentages of protein in the form of gliadin approach the standard and that in one flour only is the lower limit reached. Eight of the ten samples give percentages practically between 41 and 46.

In answer to a letter of enquiry regarding the gliadin ratio of flours, Professor Snyder writes me, under date of May 29, 1905, as follows: 'As our work on this point extends over a number of years it appears that it is more a question of total gliadin rather than the ratio of gliadin to glutenin. I find that from year to year the gliadin-glutenin ratio varies quite widely, but the total gliadin is a more constant factor and rises and falls with the total gluten, but not regularly. In making nitrogen determinations of the gliadins from wheats grown during different years, I find there is not that constancy that could be desired, suggesting quite considerable changes in the composition of gliadin during different years.'

It should be stated that the method we have followed in the determination of gliadin is essentially that used by Professor Snyder, so that as regards results obtained our data and his should be strictly comparable.*

The percentages of gliadin in the series of flours under investigation are, with the exception of No. 2 Feed, exceedingly close, showing that in respect to this important constituent the flours are extremely uniform. The proportions of protein in the form of gliadin are also (with the exception of No. 2 Feed) close, the differences not being such as to allow any marked inferences being drawn as to the relative values from this standpoint, though it may be pointed out that in this respect No. 3 Northern and Feed appear to be somewhat inferior to the other grades.

It is highly significant that the flour of No. 2 Feed falls considerably below any of the others of this series in the gliadin content, as it also does in wet and dry gluten. Though containing the largest percentage of protein in the series, it would probably be valueless for bread-making, apart from the fact that it is disqualified by colour.

To ascertain how far our data as regards percentage and proportion of gliadin might compare with those obtained from standard brands of flour upon the market, milled largely if not exclusively from North-western wheat, we have analysed 'Five Roses' (Lake of the Woods Milling Co.) and 'Strong Bakers' (The Dowd Milling Co.) and append results.

These results show that the flours of the present series are fairly uniform with those upon the Canadian market at the present time in respect not only as regards protein but also as to gliadin-content and the proportion of this constituent in the protein.

* To five grams of flour in an Erlenmeyer flask, 250 c.c. of 70 per cent (by weight) alcohol were 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.

PROTEIN AND GLIADIN IN 'FIVE ROSES' AND 'STRONG BAKERS' FLOURS.

Designation of Samples.	Protein (N×5·7.)	Gliadin (N×5·7.)	Percentage of Protein in the form of Gliadin.
Five Roses	10·32	4·56	44·2
Strong Bakers	9·92	4·62	46·6

Wet and Dry Gluten.—With respect to these determinations, it may be said that they indicate, approximately, at any rate from the practical standpoint, the relative values of the flours for bread-making purposes, though the character as well as the amount of the gluten is a most important factor in this consideration.

It is generally admitted that the bread yield is dependent largely upon the so-called 'strength' of the flour—that is, the power to absorb and retain water—(a quality that is directly related to the gluten-content). The 'capacity for producing a well risen loaf' which will retain its moisture and elasticity under a crisp crust is rather due to the nature or physical character of the gluten.

The estimation of the gluten is a mechanical rather than a chemical process, and hence the data obtained are in a measure dependent upon the method adopted. We may, therefore, give in outline the process used:

Ten grammes of flour are placed in a porcelain dish, moistened with a sufficient quantity of water and carefully kneaded into a ball. Care is exercised that each particle of the flour has become thoroughly moistened and that none adheres to the sides of the dish. The ball of dough is then allowed to stand for one hour at the end of which time it is transferred to the palm of the hand and there carefully kneaded while a small stream of water is allowed to play on it. The starch is thereby completely eliminated and the operation considered finished when no more turbidity is noticed in the wash water. The ball of gluten having been freed from starch is placed in the porcelain dish, covered with distilled water and allowed to stand for one hour. It is then pressed between the palms of the hands in order to exclude as much water as possible and immediately weighed in a flat bottom platinum dish. The weight obtained multiplied by ten is recorded as wet gluten.

The dish is immediately placed in a water-oven and dried at a temperature approximating 98° C. for forty hours and re-weighed. From this weight the percentage of dry gluten is easily calculated.

Authors usually recommend drying for a period of twenty hours only. It was found, however, that an additional period of twenty hours produced a decrease in weight, thus indicating that the ball of gluten was not completely dry. Periods of desiccation longer than forty hours did not result in any appreciable decrease.

With the exception of No. 2 Feed, the data present great uniformity, including a very close agreement among the flours of the series in bread-making capacity. Mr. A. T. Charron, Assistant Chemist, who made these estimations reports that, with the exception of the gluten from No. 2 Feed, all were firm, elastic and resilient and evidently of excellent quality. The gluten from No. 2 Feed was not soft, flabby and sticky as is usually the case with poor flours, but rather of a pulverulent character, showing lack of cohesion and acting as if there were a deficiency of gliadin. It is of peculiar interest to note, therefore, that it is this sample and this sample only which shows an exceptionally low proportion of protein in the form of gliadin.

Acidity.—The first seven grades have given practically the same figures. These are quite normal for flours from sound wheats, showing that no heating or fermentation of the grain or flour had occurred. In the case of No. 2 Feed there is a well marked rise and it is also of interest to note slightly increased percentages in Feed and No. 5 Frosted

CONCLUSIONS.

In concluding the discussion on this part of the investigation, we may endeavour to briefly answer the questions: How far does the composition of the wheats as revealed by chemistry agree with the official grading? Can we predict from such wheat analyses the quantity or quality of flour to be obtained therefrom?

We find a great similarity in composition between these wheats, especially among the higher members of the series, as regards all the more important constituents, i.e., those which affect the bread-making quality, and we should presurmise, therefore, that the grading has been based upon the relative yield of first quality flour (of which colour is an important factor) rather than upon the essential differences in what might be termed the relative strengths of the wheats.

As regards quantity of flour, we have shown that in such a series the weight of the kernel and the weight per bushel, and to a minor degree, the fibre, indicate the relative flour yield. Our results in these determinations are in excellent accord, supporting the supposition that the grading of the wheats has been made primarily from the standpoint of yield of first quality flour.

The percentage of protein in the wheat undoubtedly is a measure of the strength of the resultant flour, but if we except No. 2 Feed and No. 5 Frosted we scarcely think it would be justifiable to use differences in protein content such as we have met with between these wheats (frequently less than ·25 per cent), as a basis for the arrangement of the wheats in their order of merit. And the same holds true for the data regarding gluten and gliadin. It is highly significant, therefore, that the resultant flours were found so uniform in quality for bread-making.

Grateful acknowledgment must be made to Mr. A. T. Charron and Mr. H. W. Charlton, Assistant Chemists, for much valuable assistance in carrying out the analytical work of this investigation.