THESES.

FOOD ANALYSIS.

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THESIS.

A COMPARISON OF THE RELATIVE VALUES OF CERTAIN WHEATS FOR FLOUR & BREAD-MAKING.

-By-

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1900.
A COMPARISON OF THE RELATIVE VALUES OF CERTAIN
WHEATS FOR FLOUR & BREAD-MAKING.

At the present time considerable work has been done
at different experiment stations in determining varieties of
wheat. In this work simply the yield per acre has been con-
sidered without any reference to the milling quality of the
grain. This has been especially of late, the complaint of
the millers. They claim that the Canadian flour standard is
being lowered in the Old Country on account of the farmers
growing certain varieties of wheat simply for the yield, with-
out taking into consideration that quality of the grain. To
a certain extent we find this to be the case. It does not
always pay farmers, as a body, to grow certain varieties of
wheat because, by so doing, they may reap a peck or more grain
per acre. If good milling qualities went hand in hand with a
large yield this might be done, but such is not the case. In
the investigations carried on for this work, as will be seen
further on, two of the most popular winter wheats now grown
in Ontario, produce a low grade of flour, and bread of an in-
ferior quality.

This work was done with the object of comparing
some six different varieties of wheat as to quality, or as to
their relative value as flour for bread making. The results
are worked out from duplicates, and where they did not agree,
the work was separated until concordant results were obtained.
While these results are correct for the samples of grain used, they cannot be relied upon as absolutely correct for all samples of these varieties. There are several factors which play a very important part in the composition of wheats. One of these is variation in climate. Richardson of the Chemical Division of the U.S. Department of Agriculture, shows this clearly in his Bulletin No. 9 from that station. He had six samples of wheat, two of which were from Oregon, two from Dakota, and two from Colorado. The two samples from Oregon were a light yellow in color, plump and starchy, and contained a very small percentage of albuminoids. Those from Dakota were small, hard, and dark colored, and were rich in albuminoids. Between these two extremes came the intermediate sample from Colorado, which were raised from seed similar to that from which the Oregon and Dakota wheats were raised.

From this we see that climatic conditions are powerful factors in determining the composition of wheats. Aside from climate, the nature and cultivation of the soil upon which the wheat is grown, and the selection of seed from year to year, have their influence upon the character of the grain. By careful selection of seed and proper methods of farming, a wheat may be improved, but this must be kept up continuously to get good results. For example, Hallett of England, after many years of work produced wheat of noted quality, but this grain when grown a few years by ordinary farmers, under unfavorable conditions, reverted to a very common grain.
Thus we may see there are many factors which tend to alter the composition of any variety of wheat from year to year. The samples used for this work were not grown under the same conditions as no two varieties came from the same farm, and the Manitoba wheat, of course, came from the West. For this reason we may not be doing some of the varieties justice, as they may have been grown under very uncongenial environment.

However, six leading varieties of wheat were chosen, and six bushels of as uniform grain as could be obtained was purchased. These were taken to a roller mill and ground into flour. In order to get pure samples of flour the mill was run half an hour with each variety before any was saved out. The very lowest grade of flour was removed with the by-products, leaving the flour much as the farmer gets it in exchange for wheat at the mill.

If we refer to the second column of our table found on the next page, we find quite an important factor in determining the market value of a variety of wheat. A flour may give a large yield of bread and yet be inferior from the miller's standpoint, as the wheat may yield a comparatively small percentage of flour. Barring the Manitoba Hard, of which we did not get the yield of flour, we find that Dawson's Golden Chaff gave more flour per given weight than any of the other flour varieties, with the Early Genesee Giant standing second. The Early Red Clawson here, as in many other columns, stands at the bottom of the list.
An examination of the compositions of flours, shows us that they are made up of water, proteids, carbohydrates, and ash. Nearly 75% of the flour is composed of carbohydrates, which, when the flour is made from fully matured unsprouted wheat, consist almost entirely of starch.

The next and most important constituent is that of the proteids. The two main substances composing the proteids are those which together form the gluten of flour. Gluten is an elastic substance which remains when the flour is carefully washed in water in such a way as to remove all the starch, ash, and fat which occur in it. It is the gluten which gives to wheat flour its peculiar value for bread making. The carbonic acid gas which is generated by the growth of the yeast accumulates in numerous cavities which it forms in the dough. These are formed because of the presence of the tenacious elastic gluten. The walls of these cavities remain in the bread making a light porous loaf.

In determining the gluten contents two methods were used; the washing method, which is the one almost altogether used heretofore; and the chemical method, in which the total nitrogen and non-gluten nitrogen are determined, the latter subtracted from the total nitrogen, and the result multiplied by 5.7 to obtain the percentage of gluten.

In the washing method, 10 grams of the sample of flour is weighed out and made into a stiff dough by the addition of water. This is allowed to stand for one hour and is then washed in water until the starch is removed. The wash-
ing is done with the fingers over a hair sieve, or with the aid of a spatula in a beaker, so that any particles of gluten that may become separated, may be removed and added to the mass. The starch is all removed when the gluten causes no turbidity to clear water or more accurately when it gives no blue coloration when a drop of tincture of iodine is added. As soon as this period is reached the washing should be stopped at once, as the gliadin, one of the two constituents of the gluten, is soluble in water after the starch and the mineral matter have been removed.

When the gluten has been washed free of starch, it is brought to a uniform dryness by working it in the fingers, which are frequently dried, until the free portions of water are removed. The gluten is then weighed so that when it has been dried at 100°C, we are able to obtain the difference between the wet and dry substance.

The quality of the gluten is also noted, as to its color, adhesiveness, and especially as to its elasticity or strength. A stiff elastic gluten indicates a strong flour, while a weak gluten is short in the grain and will not stretch out like from stronger flours. The varieties with the stiffer, tougher, gluten will rise high in the loaf, and make a larger bulk of bread than the same amount of flour containing a weaker gluten. For this reason bakers use larger quantities of flour from Manitoba wheat which contains a high percentage of strong gluten.

Among the six samples of flour, some of the glu-
tens were sticky and others soft and nonelastic. It was quite noticeable that the varieties from which we got the best bread were those containing firm, elastic gluten. The gluten itself is made up of two proteid substances, gliadin and glutenin, and it is the relative amounts of these which determine the quality of the gluten. The gliadin which constitutes from 60 to 70% of the gluten, contains the binding material and enables the dough to retain the gas, and thus become light and spongy when made into bread. Flour deficient in gliadin is lacking in power of expansion; while flour with an excess of this material is soft and sticky. The glutenin is the material to which the gliadin adheres, and because of its character prevents the dough from becoming soft and sticky. In the hard spring wheat flours the gluten is thought to consist of gliadin and glutenin in the proportion of about 65 to 35, while in the softer wheats the ratio is 70 to 30.

After the wet gluten has been weighed it is dried in a water bath at 100° C until all the moisture has been driven off. It is then weighed and the percentage of dry gluten calculated.

In the chemical method the percent of nitrogen was determined by the Kjeldahl method. Then the non-gluten nitrogen was determined by the following method, which is recommended by C. L. Teller of Arkansas Experiment Station.

About 5 grams of flour is weighed out into a 250 cc measuring flask. Then about, 15 cc of a 1% salt solution
is added to make up 250 cc. The contents of the flask are
shaken at intervals of 10 minutes for one hour, allowed to
stand for two hours, and then filtered through a dry filter
and if not clear is refiltered into a dry flask through the
same filter. The nitrogen is then determined from 50 or 100
cc. of the filtrate. From the percent of nitrogen 0.27% is
subtracted as the amount of gliadin soluble in 1% salt solu-
tion. The remaining percent of nitrogen is that correspond-
ing to the non-gluten nitrogen in the sample of flour.

The non-gluten nitrogen is subtracted from the total
nitrogen and the result multiplied by 5.7 to find the per-
cent of gluten present. The factor, 5.7, is used in determin-
ing the amount of gluten, as this was the result of the aver-
age amount of nitrogen found in the proteids of the wheat ker-
nel by Dr. Osborne, of the Connecticut Experiment Station.
This has been found to give a much more accurate result with
flour, than the factor 6.25 which has been in general use
heretofore. The gluten determined chemically gave somewhat
lower results than by the washing method. This is what we
would expect, as it has been found that often the gluten ob-
tained by this method is only about 80% pure, the remainder
being made up of fat, mineral matter, and traces of starch.
This shows the defect of the washing method. While the re-
sults may be used for comparison their accuracy cannot be de-
pended upon. However, we find the two methods place the fl-
ours in the same order as regards percent of gluten, viz:
1. Manitoba Hard; 2. Goose; 3. Early Caneeee Giant; 4. Dai-
Our next column in the table brings in a factor that cannot be overlooked in the comparison of flours. The color of a flour has considerable to do with its commercial value. The people demand white bread, and the miller is compelled to supply it, even at the expense of the proteids, because usually the whiter grades of flours are richer in carbohydrates and deficient in nitrogenous substances, although those present are much more digestible. The color of the different flours was brought out distinctly by putting a small quantity of flour on a thin board, and pressing it out with a spatula, and then dipping this quickly into water and allowing it to dry. By this plan the slightest difference in color is noticeable. We had no scale of colors as is often used for this purpose, but the order which they should occupy was decided by two experienced millers. The Manitoba was easily placed ahead with the Early Red Clawson second. The Clawson, while probably the whitest of any of the flours, was of such a dead, almost greyish color, that it was little better than the Michigan Amber which stands third. The Early Genesee Giant stands next in color, followed by the Dawsons Golden Chaff which is quite dark. At the bottom of the list comes the Goose, with which the principal fault is its color. It contains a comparatively large amount of gluten, yields well, and makes good sweet bread, but it is
very dark and, for this reason, could not command a high price on the market.

The strength of a flour is found by testing the constituency of the dough, after adding a definite amount of water. We weighed out 1/2 ounce of flour, added 2 ounces of water, and made the different samples into dough. These were well worked up and the comparative strength of each was easily arrived at by an experienced miller. With the Manitoba flour the dough was dry and firm, and would have taken more water, but at the same time the gluten it contained was very tenacious and would stretch out to quite a length. The Early Red Clawson flour on the other hand, was sufficiently moist and somewhat sticky. The dough was short in the grain, had very little elasticity, and was quite inferior in every respect. In the comparison of strength the flours were placed in exactly the same order as in the determination of gluten, showing that the strength is dependent upon gluten content.

Not content with leaving the matter here, we carried on two baking tests to see if the flours which were scored the highest would give the best results when made into bread. The baking was carried on under the supervision of an expert baker, and in a manner as similar to that used in a bakery shop as was possible under the circumstances. Ten pounds of flour from each variety was weighed out and worked into dough by the addition of liquor composed of warm water, potatoes and ferment. The dough from each variety was weighed, allowed to stand for six hours in a warm compartment, and then re-
kneaded. It then stood for two hours more, was moulded into leaves, and when it had risen was ready for the oven.

When the bread came out of the oven it was weighed and the loss due to baking was obtained. We find the loss worked out to percentage in column 12 of the table. In all cases the flours which took up the most moisture lost the most in weight with baking. In every case, however, with the exception of the goose wheat flour, the loss was not proportionate to the amount of moisture absorbed. The flour from the goose wheat, while it required more liquor at the first than the Manitoba wheat, lost more than enough in weight during the baking to give the Manitoba the largest percentage yield. This greater loss might be due to a greater loss of solid matter, such as carbon and nitrogen, in the Goose, than in the Manitoba flour during the baking. This was not determined but it was hardly probable such a large difference as 3% would occur from this source.

At the end of eight hours the bread was weighed a second time, and the percentage loss due to drying during that time determined. It was found that while the bread from the two spring wheats lost practically nothing in weight, the four winter wheats lost approximately one percent. This is certainly a point against the four winter wheats used in the experiment, as it shows the tendency of the bread made from these varieties to give off moisture, and to become hard and dry after baking.
In making up the dough into bread one loaf of each sample was made so as to contain one and one half pounds of flour. After the bread had been baked and weighed, the ends of these loaves were removed, leaving a smooth cut surface. These were then photographed.

In the photograph we notice that the loaf from the Manitoba flour is somewhat larger than that from the Goose wheat flour, and then there is a sudden drop in size from the Goose wheat bread, to that of the Michigan Amber. We cannot observe much difference in the size of the four fall wheat loaves, but we might notice the nicely shaped loaf from the Dawsons Golden Chaff flour, and the heavy sodden appearance of Nos. 5 and 6, which are from the Early Genesee Giant and Early Red Clawson respectively.

Unfortunately the texture of the bread is not plainly shown in the photograph, but considerable difference was noticeable. The bread from the two spring wheats was very light and porous, being somewhat too open in the grain. In quality the Goose wheat bread would rival the Manitoba, if it were not for its dark color. We noticed this defect when comparing the color of flours, and it is still more clearly shown in the bread. The bread from the Dawsons Golden Chaff was also dark in color, but otherwise was one of the best, if not the best bread from the fall wheat flours. The bread from the Early Genesee Giant and Early Red Clawson was the lowest in the list as regards quality. While the bread from the Clawson was whiter than that of the other flours, it was sodd-
en and very soon became hard and dry. The Genesee Giant was very similar to the Clawson, with the exception that it was a trifle darker in color, but made a slightly better shaped loaf.

Conclusions:

1. The Manitoba Hard stands at the top of the list in every case, having the highest percentage of firm elastic gluten, standing first in color and strength of flour, and giving the best quality and largest yield of bread.

2. The Goose wheat would stand second, but for its very objectionable color, which, while not interfering with its nutritive value, injures it greatly as a commercial wheat.

3. The Michigan Amber, while containing a comparatively small amount of gluten, yields bread of good quality.

4. Barring color, the Dawsons Golden Chaff gives better results than any of the other winter wheats tried.

5. Early Genesee Giant, while containing a higher percentage of gluten than any of the other winter wheats in the experiment, does not give as good results as might be expected. This must be due to a poor quality of gluten. The two constituents of the gluten, gliadin and glutenin, cannot be in the proper proportions, and as the gluten is soft and adhesive we would infer there was an excess of gliadin.

6. On the whole, the Early Red Clawson is the poorest wheat in the experiment. It yields a low percentage of flour, contains a small amount of weak gluten, and produces a very inferior quality of bread.