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ED. H. WEBSTER, *Director.*

FARM BULLETIN.

Department of Chemistry.

J. T. WILLARD, *Chemist in Charge.*

Milling Tests of Wheat and Baking Tests of Flour.

BY

J. T. WILLARD, *Chemist.*
C. O. SWANSON, *Assistant Chemist.*

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Department of Chemistry.

J. T. WILLARD..........Chemist in Charge.
C. O. SWANSON.........First Assistant in Chemical Investigations.
J. W. CALVIN...........Assistant in Animal Nutrition.
R. C. WILEY............Assistant in Feed and Fertilizer Control.
C. E. MILLAR...........Assistant in Soil Analysis.

Work of the Department of Chemistry.

A large part of the work **of** the Department of Chemistry in the Experiment Station is in cooperation with other departments, by contributing the chemist's point of view in planning experiments, and in making the chemical analyses incident to investigations. Among these investigations are: Feeding experiments, conducted by the Department of Dairy **Hus**-bandry; experiments touching soil fertility, in charge **of** the Department of Agronomy; experiments in the study and improvement of wheat and alfalfa, by the Departments **of** Agronomy and of Botany, and experiments bearing upon the methods **of** handling and storing wheat, conducted by the Department **of** Milling Industry.

Among the lines **of work** more completely in charge of the Department of Chemistry are certain experiments touching the composition, digestibility and nutritive value **of feeds;** milling tests **of** wheat, and baking tests **of flour;** the collection and analysis **of** samples of soils, typical of the various regions **of** the state; the inspection and analysis of fertilizers sold in the state and the inspection and analysis **of** feeding stuffs sold in the state.

Bulletins are issued from time to time as required, **or** as the results **of** investigations warrant. These may be obtained without charge **by** addressing the Director of the Experiment Station, Manhattan, Kan.

Milling and Baking Tests.

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Milling Tests of Wheat and Baking Tests of Flour.

J. T. Willard, *Chemist.*
C. O. Swanson, *Assistant Chemist.*

Introduction.

The testing of varieties of wheat is a line of experimental work that was followed at the Kansas State Agricultural College for years before the establishment of the Experiment Station. After that the work was greatly enlarged, and by the establishing of branch stations and cooperative work with the United States department of agriculture the scope of observation was widened still more.

While these trials led to valuable results, it was felt that milling and baking tests should be made on the varieties found suitable agriculturally, in order to discover differences in the usefulness of them, if such existed. To this end an experimental reduction mill was purchased in 1905, and at a later date an outfit for making baking tests.

Previous to this time work in the chemical department of the College had thrown considerable doubt on the then current statements concerning the determining influence of the percentage of gliadin and of the gliadin-protein ratio on the baking qualities of flour. It was therefore planned to include in the investigations a study of the chemical composition of the wheats, and the flour produced from them, with a view to learning more if possible concerning the chemical factors affecting bread quality.

Mr. W. E. Mathewson, assistant professor of chemistry in the College, and assistant chemist in the Station for a few months, interested himself in the chemical side of this question, especially with reference to gliadin, and his resignation to accept a position in the bureau of chemistry of the department of agriculture was a distinct loss to this investigation in the purely scientific lines.

The experimental reduction mill used was obtained from the

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Allis-Chalmers Company, Milwaukee, Wis. Its motive power is a five-horsepower electric motor, which also runs the scourer and the middlings purifier. Some modifications in the mill were made to enable the product to be more completely removed in the interest of quantitative accuracy. The disks for setting the rolls were also improved by graduating their peripheries. Pointers attached to the frame enabled the miller to measure accurately the extent to which the disk was turned, and to restore it to any given position.

The earlier work with the mill showed that, although flour could be made with it, the quality, especially as to color, was much impaired by dust and fine particles of bran. As the quantitative comparisons of the milling value of different wheats required operation under as good conditions as the small scale of the process would permit, and a fair testing of the flours produced required that they be free from impurities of unknown influence on the results, it was deemed necessary to introduce a middlings purifier.

The middlings purifier as devised and built is a combination of ideas gleaned from various sources. In operation the middlings fall repeatedly in a thin, even sheet and are subjected to moving air of progressively less and less velocity. The carrying power of the air current thus becomes less and less and the middlings thus settle in the several parts of the purifier considerably assorted according to size, while the fine dust and bran particles are carried farther. The action of the purifier has been found very satisfactory. A cut illustrating it, and some further description of its use, are found farther on in this bulletin.

In the further interest of obtaining a high quality of flour a simple scourer was devised and constructed with which the wheat was treated previous to grinding.

Equipped with the scourer and middlings purifier, and by the exercise of unremitting care and attention, the little mill has yielded us flour of very good quality, and we believe that the baking tests made upon it may be regarded as unaffected by any defects in the milling. The greatest defect is, of course, the presence of but one set of corrugated rolls. With several sets differing in their fineness, setting, etc., it would be possible to do better work and especially to do it with far greater rapidity and ease.

The samples of wheat awaiting grinding and the residues

held in reserve, were kept in galvanized iron half-bushels provided with loosely-fitting covers. This excluded mice but fumigation with hydrocyanic acid was found advisable to reduce insect pests. The products of milling were kept in screwcap Mason fruit-jars.

The baking outfit purchased was obtained of John Koelner, but great modifications were made in its use. The oven is electrically heated and susceptible of considerable range as to temperature. The apparatus is further described at appropriate points in this bulletin.

In connection with the inspection work provided for by the Kansas feeding-stuffs law we have had some opportunity to collect information concerning the processes preliminary to milling, by which wheat is prepared for grinding in some of the Kansas mills, and it has been deemed of interest to include a statement of these in this bulletin before proceeding with the account of our experimental work proper.

CLEANING WHEAT: A SUMMARY OF PROCESSES USED IN SOME KANSAS MILLS.

Wheat as received by the miller from the elevators and farmers contains many substances which must be removed before it can be made into good flour. Among these substances are bits of straw, chaff, various kinds of weed seeds, kernels of other cereals such as oats, rye and corn; also sand and soil, mud balls, bits of droppings from farm animals, and other substances whose nature depends on how the wheat has been handled. Substances such as fine sand and soil get into the crease of the berry and require vigorous treatment before they can be removed, especially if the wheat has been exposed to damp weather conditions. In that case the "mud" is dried on the wheat berry. Besides, certain parts of the outside of the wheat berry must be removed, such parts as the thin outer bran coats and the fine hairs at the end of the berry.

ELEVATOR TREATMENT.

In general, wheat receives its first treatment in the elevator. Here it is put through a receiving separator. The machine removes the coarsest materials, such as the coarse sand, chaff, straw, mud balls, shrunken wheat, kernels of other cereals and dust. This machine is a very large fanning mill capable of

handling a thousand bushels of wheat an hour, more or less, according to the size of the elevator and the mill.

The receiving separator removes three classes of products, (1) those removed by a strong current of air; (2) those separated by screens; and (3) those which tail over the screens. The first is made up of the chaff, small shreds of straw and dust similar to the fine dust from the threshing machine. The second is made up of shrunken and broken kernels of wheat, weed seeds, heavier pieces of the wheat straw, kernels of other cereals, particles of soil and grains of sand. The third is made up of all the particles too heavy to be removed by the current of air and too large to pass through the screens. In this will be found grains of corn, pieces of corn cobs, pieces of wood, mud balls, larger pieces of straw, portions of wheat heads and poultry droppings.

TREATMENT IN THE MILL.

In some mills the wheat is sent directly into the mill from the receiving separator, in others it is first put through a large scouring machine. This is for the purpose of loosening the chaff and dirt which clings to the wheat. This machine removes chaff, bits of straw, fine particles of bran and germ, small broken pieces of wheat kernels, weed seeds, broken pieces of other cereals and dust.

When the wheat enters the mill proper it is put through the milling separator. This is the first treatment given in the mill, whether the wheat enters the mill directly from the receiving separator or is put through the intermediate scouring process in the warehouse. The milling separator removes three kinds of products, and the operation of this machine and the nature of the products are somewhat similar to those of the receiving separator. (1) The tailings, similar to the tailings from the receiving separator, but the amount is very small in comparison; (2) the screenings. While the nature of these screenings is similar to those from the receiving separator, their quality is much better. The larger per cent is made up of shrunken and broken wheat kernels. There is comparatively little sand and soil present. The rest consists mostly of bits of straw, weed seeds and shrunken kernels of other cereals, mostly oats; (3) the dust from the milling separator consists mostly of very fine bran. Some is as fine as flour, from this it grades off into larger sizes. A little chaff is also present.

In some mills there are two and sometimes more milling separators. But the materials removed from the wheat are in the main like those described above, except that if there are several separators the quality of these materials becomes better in the second than in the first, and better in the third than in the second, and so on. That is, the wheat becomes more free from foreign matter and shrunken kernels all the time, and as the worst impurities are removed by the first machines, there is less for the other machines to do.

From the milling separator, or separators, the wheat passes to the scourer. The principle on which this machine works is mechanical agitation sufficiently violent to loosen all impurities not previously removed. Besides loosening the impurities foreign to the wheat berry this machine knocks off the fine hairs at the end of the berry and removes a portion of the outer tissue of the wheat kernel. Chaff which so presistently clings to the wheat berry that it has resisted the action of the other machines is freed from the berry by the scourer. A few germs are also set free. We have in the main two classes of materials removed by the scouring machine. The first is scourings, consisting of chaff, small pieces of broken kernels, germs and pieces of bran. The second is scouring dust, which is mostly fine bran and small particles of chaff.

From the scouring machine, the wheat goes to the tempering bin. This has two objects. First, to toughen the bran so that in grinding a large flaky bran with as little bran dust as possible is produced. Second, to loosen any dirt which clings so persistently to the outside of the berry that it has resisted all the previous treatment. The wheat receives from one to two per cent of water, depending on its hardness. This water is thoroughly mixed with the wheat, usually by means of a screw conveyor. The wheat stays in the tempering bin from four to seven hours. From here it goes to the second scourer or brush machine. The brush machine gives the wheat a gentler treatment. The purpose of either machine is to put the final touches on the cleaning process, and two classes of materials are removed, scourings and dust. These two are very similar to the scourings and dust obtained from the first scourer only they are of a better quality. These scourings contain a large number of germs. The dust consists of very fine bran.

From the first scourer, and also from the second, we have
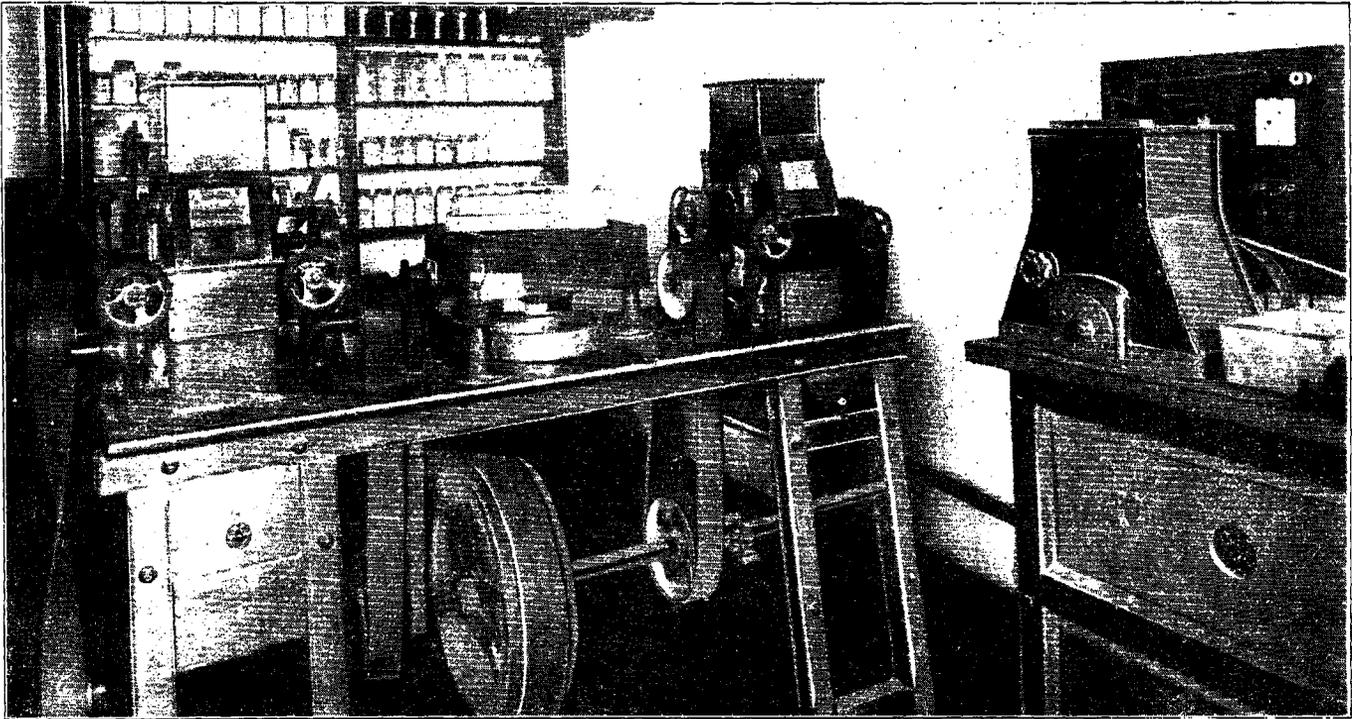
PLATE 1.   The experimental mill and one end of the middlings purifier.

tailings; those from the first consist mostly of shrunken and broken pieces of wheat kernels besides some chaff. The tailings from the second scourer consist mostly of broken kernels. These are as clean as the wheat which goes to the rolls. These tailings or screenings are sometimes sent to the lower breaks.

The processes of cleaning wheat will necessarily vary to 'suit local conditions, but the above represents the average used by the mills of Kansas. In some places and countries, the wheat is covered with more or less mud, fine clay which adheres very firmly to the wheat berry, and mixed with the wheat are found mud balls and more or less gravel. To remove these, washing devices are resorted to. This would be wet cleaning. When the wheat is washed in water it must be dried before it can be milled. Great care must be exercised by the miller so that the wheat does not become too wet, or that in drying it is not overheated, as either would injure the flour produced.

THE EXPERIMENTAL MILLING OF WHEAT.

Wheat used in these milling tests is clean, as that term is ordinarily understood. That is, it is as free from impurities as the ordinary fanning mill can make it. But the wheat which appears clean usually has considerable dirt in the crease. This dirt as well as the fine hairs at the end of the berry must be removed if white flour free from specks is to be obtained. One of the ever-present difficulties in the production of white flour is the continuous production of bran powder. This can be seen if a few kernels of cleaned wheat are left for some time on a piece of white glazed paper. Wheat that is thoroughly cleaned by all known processes will still continue to give off this bran powder. The presence of these specks can be avoided only by use of the very best machinery suited to the different grades of stock produced in the milling process. The scourer used in these tests removes the crease dirt, a considerable portion of the outer bran coat, and the fine hairs at the end of the berry. The fine bran powder produced in making the breaks gets into the break flour and the middlings. To remove the bran powder from the break flour is not practicable, but from the middlings most of it is removed by the purifier.

SCOURING.

The principle of the process of scouring as used in these tests is mechanical agitation sufficiently violent to shake out the crease dirt and knock off the fine hairs.   The mechanical construction of the scourer employed in our laboratory is simple.   Plates 2 and 3 show some of its details.   Six paddles made of heavy sheet iron are fastened to an iron pulley.   This wheel including the paddles is 18 inches in diameter and re-
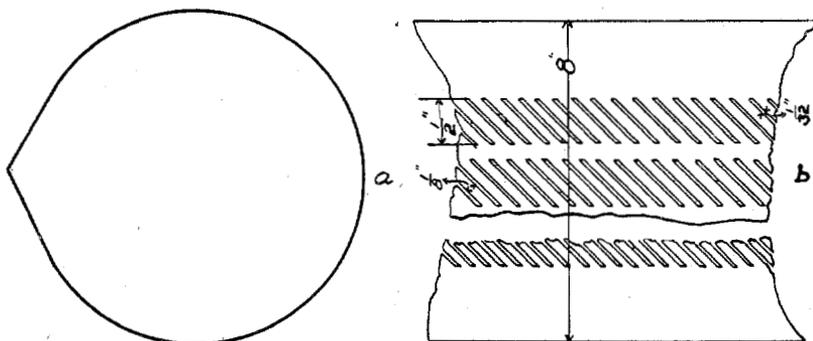
PLATE 2.   (*a*) Form of section through scourer.   (*b*) Section of perforated iron surrounding part of the scourer.
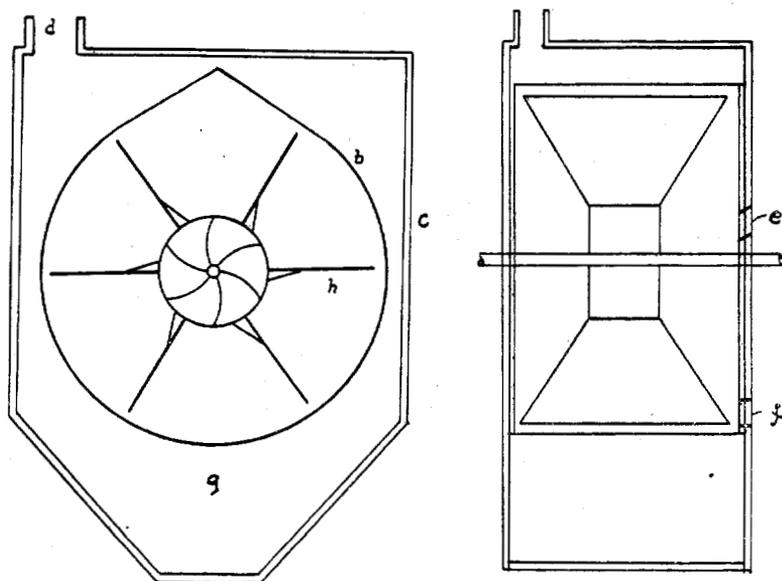
PLATE 3.   (*c*) Box frame inclosing essential parts of scourer.   (*d*) Outlet to exhaust fan.   (*e*) Opening for introduction of wheat.   (*f*) Opening for the removal of wheat.   (*g*) Space around scouring chamber.   (*h*) Revolving paddle wheel.   (*i*) Opening to remove heavy particles removed in scouring.

volves at a rate of 400 revolutions per minute. The wheel is enclosed by a perforated iron *(b)* bent around two heavy circular boards *(a)* 18½ inches in diameter. These are not complete circles but shaped like *(a)*. The whole is then enclosed in a tight box *(c)*, which is connected at *(d)* with the exhaust fan. The paddles come within one-fourth inch of the sides of the perforated iron. The enclosing sides are lined with sheet iron. The wheat is put in at *(e)* near the eye of the wheel. This small opening is covered with a removable piece of perforated iron to prevent the wheat from being thrown out.

The process of scouring is carried out as follows: The machine is started empty, then the wheat by means of a funnel scoop is poured in at the opening made for the purpose. The paddles take the wheat from the lower part, carry it around the half circle, where near the top, on account of the inclosed space, the wheat is thrown against the perforated iron, from whence it rebounds and falls to the bottom. This process is repeated at the rate of about 400 times a minute. The wheat also receives more or less rubbing against the perforated iron as well as against itself. This violent agitation loosens all the dirt, shakes it out from the crease, and brushes off the small hairs at the end of the berry. The inclosed space *(g)* is connected with the exhaust fan at *(d)* and the air enters the scourer at *(e)*. The suction of the exhaust, together with the motion of the paddles, creates a strong current which carries the loosened dust and dirt from the wheat through the perforated iron *(b)* into the inclosed space *(g)*, thence to *(d)* and the exhaust fan. Heavier particles can be removed from opening at *(i)*. The exhaust fan is the same one as is used in connection with the purifier described later. When the wheat is scoured it is removed through the opening at *(f)*. This machine is made with a capacity of scouring 2000 grams at one time. The length of the time of treatment depends on the character of the wheat, being usually from one to four minutes. The wheat is weighed before and after scouring. The loss in scouring varies from 20 to 60 grams on 2000, or one to three per cent.

TEMPERING.

After scouring, the wheat is tempered. The average amount of water used for 2000 grams of hard wheat is 50 cc. The amount depends on the hardness and the moisture content. For durum wheat 75 cc. or 100 cc. may be necessary. The
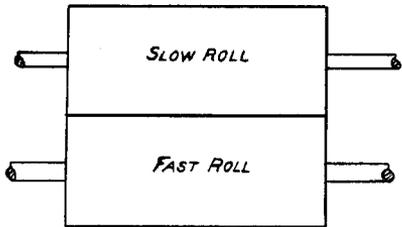
SHARP TO DULL
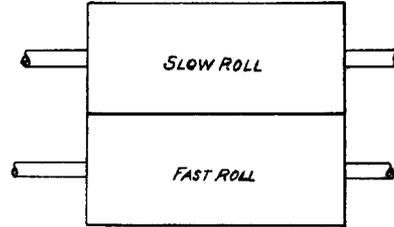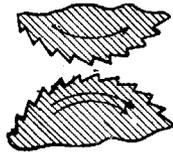
DULL TO SHARP
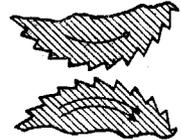
PLATE 4.   Corrugated rolls.   Sharp to dull and dull to sharp.
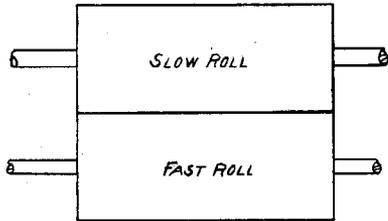
SHARP TO SHARP
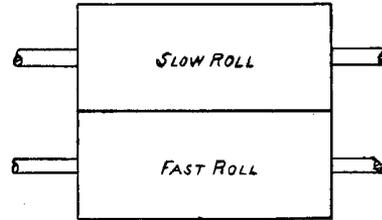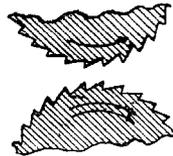
DULL TO DULL
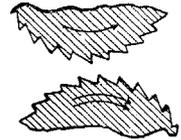
PLATE 5.   Corrugated rolls.   Sharp to sharp and dull to dull.

moisture as determined in the dry grain may be the same in two wheats, one hard and the other soft, yet the amount of water needed for tempering the hard wheat is at least three times that used for the soft. Some millers use no water whatever for soft wheats. The wheat is put in a shallow three-gallon earthenware jar and the probable amount of water poured over it. Experience and judgment only can determine how much water to put on. After adding the water the wheat is stirred very thoroughly so that the moisture is evenly distributed. The jar is well covered and left for four hours before the wheat is milled. If this does not fit in with the working hours, the wheat may be partially tempered the evening before, when three-fifths of the probable amount of water needed is used, and the rest is added at least half an hour before grinding. This time is sufficient, providing that the water last added is not too large in amount. If this is the case a longer time is necessary. The practice of putting on the water in two successive portions is better for the inexperienced than using the one application as the correct amount of water needed can be gauged more accurately. It is not good practice to use all the water the evening before as proportionally too much water penetrates the interior of the berry and the bran partially dries again. In using the water in two portions the bran gets a relatively larger amount of moisture. This is a desirable condition as one of the main objects of tempering is to toughen the bran.

GRINDING.

The mill used in our laboratory has two stands of rolls, one smooth and the other corrugated. The corrugated rolls have eighteen corrugations to the inch. All the rolls are six inches in diameter and six long (6 x 6). The corrugated rolls grind dull to sharp. The meaning of these terms can be seen by the accompanying illustration. In the illustration the teeth are very much exaggerated. In reality the shape of the corrugations is nearly the same on both sides and it requires close inspection to determine which way the rolls are set to grind. The fast roll of the corrugated pair runs a little more than twice as fast as the other. This has the effect of splitting the berry and then shaving the bran. The slow corrugated roll makes less than 200 revolutions per minute while the fast one makes over 400. Before starting the mill the rolls must

be parallel. This adjustment is partly secured by means of
large screws on the sides of the rolls. These adjust the rolls
so that they are in the same plane. Whether or not the rolls
are in the same plane is determined by means of an iron plate,
one face of which is exactly plane. This is called a face plate.
The first adjustment is proper when this plate touches a line
in each roll at the same time. The face plate will then rest
firmly on the rolls. This adjustment once made need not be
attended to again unless the screws should become loosened.
After the rolls are in the same plane they must be set so that
they are parallel. This is done by means of circular and grad-
uated dish. By means of the lever the rolls are thrown apart.
A thin strip of cardboard is held between the rolls one at a
time. The rolls are thrown together with the lever. The
disks are now turned until the rolls touch the cardboard equally
at both, ends. When the rolls are parallel they are then set
the proper distance apart to suit the stock fed into them. This
setting has to be done every time the stock is changed. In
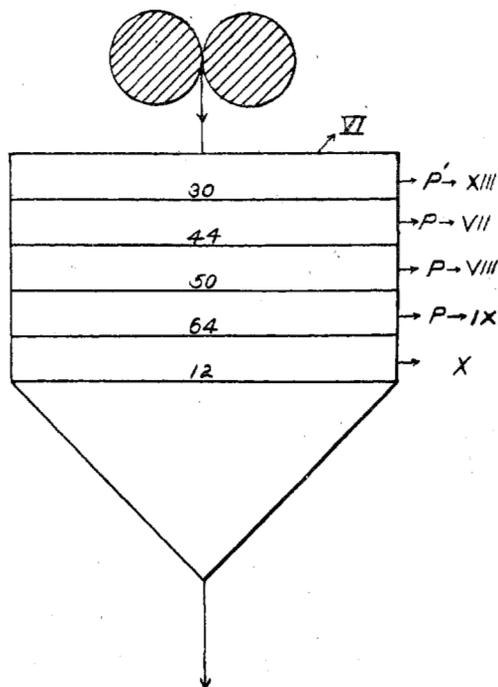
PLATE 6. Diagram illustrating a step in the process
of grinding, sifting and passing to further processes.
See text for explanation.
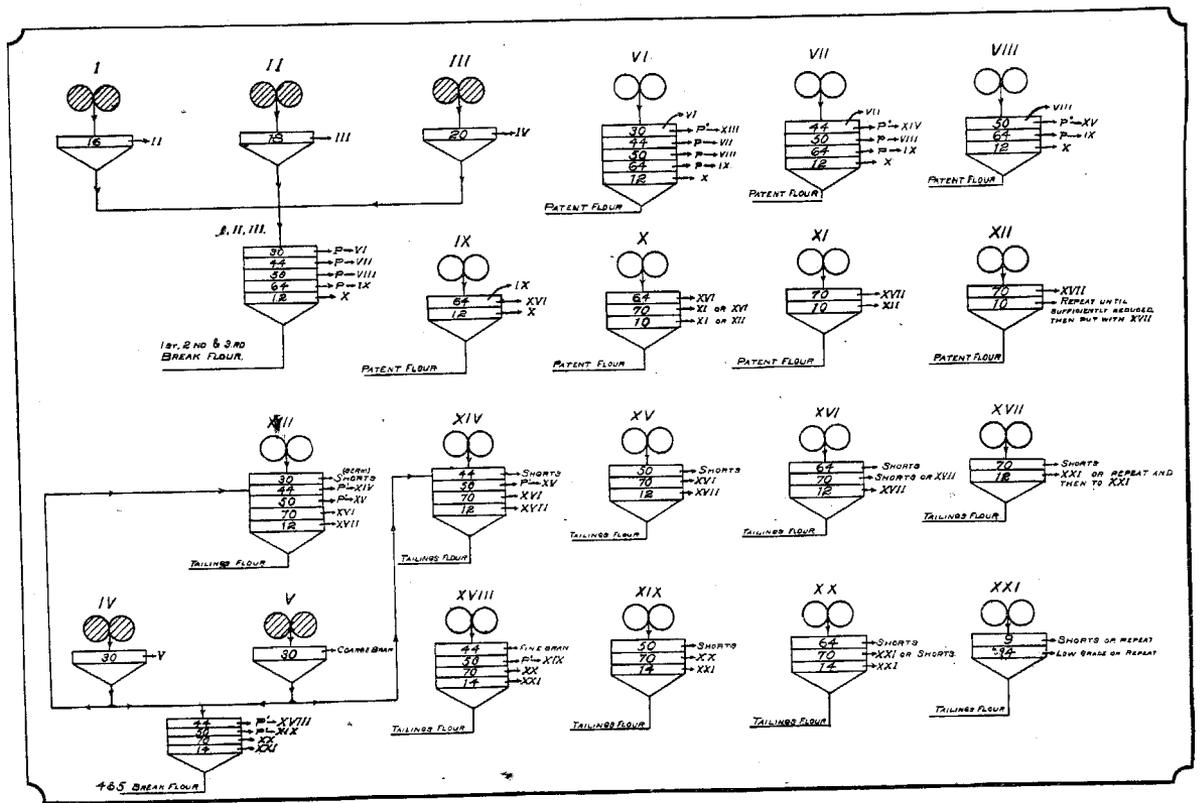
PLATE 7. Flow sheet showing the course of milling products in the process of separation.

setting the rolls the adjustment is made accurate only when the setting disks are turned in the same direction.

Plate 6 represents one step of a milling process diagrammatically, and the flow sheet shown in plate 7 shows the succession of such processes that the material passes through.

The circles with cross lines represent the corrugated rolls. When these circles have no parallel cross lines the smooth rolls are represented. The Roman numerals above the rolls indicate the break number or the reduction number. The rectangle below the rolls represents the sieves which perform the duties of scalping, grading and dressing. The stock from the break rolls is scalped and graded and the stock from the smooth or reduction rolls is dressed and graded. In this mill the same sieves are used for the different operations. The stock from the break rolls is graded at the same time that it is scalped. The above figure represents five sieves placed one above the other. They have a gyratory motion and work similarly to the plansifter. The numbers in Arabic numerals refer to the number of wire cloth or the number of silk bolting cloth used in the sieve. Each sieve has an area of 13 x 13 inches. The number of sieves used is thirteen. Numbers 16, 18 and 20 are made of wire cloth. Numbers 30, 44, 50, 64, 68 and 70 are the bran and shorts sieves. Numbers 9, 10, 12 and 14 are the flour sieves. The fineness increases with the higher numbers, but one must understand that the flour sieves are in a different series from the others. Symbols to the right of the rectangle show where the stock goes after being scalped or bolted on the sieve. Thus $\rightarrow$ P means that the stock goes to the purifier, and $\rightarrow$ XIII means that it goes to the break or reduction number indicated by the Roman numerals. The combination of the two $\rightarrow$ P $\rightarrow$ XI means that the stock first goes to the purifier and after being purified goes to the reduction indicated by the Roman numerals. A mark like this $\rightarrow$ P' $\rightarrow$ XII means that the stock may be sent directly to the rolls without going through the purifier if the amount milled is very small. In this case the amount of stock is too small to be successfully handled by the purifier. The mark $X \atop 30$

means that the stock has not been sufficiently reduced by the last reduction and is sent back to the rolls set a little closer. When the rolls have to be reset for every reduction it is not always possible to set them to grind to the desired fineness,

especially with the coarser middlings. When the milling is continuous the rolls can be adjusted properly and thus need of repetition is avoided. With the coarser middlings there is more danger of grinding too close than not close enough. If too close grinding is practiced it cannot be remedied. But if the grinding is not close enough the rolls are set a little closer and the stock is fed to them again. This last statement may apply to any part of the reduction process.

The system of milling is long or short according to the number of breaks and reductions used. With the longer system a more complete separation is effected. In the short system more flour goes into the bran and shorts. In the plan outlined below five breaks and fifteen reductions are indicated. As the work has all to be done on two sets of rolls and on different wheats, the number of reductions and also the breaks varies somewhat. If the same kind of wheat were ground from day to day and the hygroscopic condition of the air were constant, we could fix a flow sheet from which but little variation would be necessary. But in grinding different kinds of wheat, some hard, some soft, some with relatively high moisture content and some low in moisture, some days damp and some days dry, it is necessary that the flow sheet be varied. In the large mill, where the process is continuous and the number of rolls corresponds to the number of breaks and reductions, the flow sheet is constant and the rolls are changed in their setting to suit varying conditions.

The Breaks.

First break: The cleaned, scoured and properly tempered wheat is put in the hopper. The feeding in both sets of rolls is accomplished by means of a small corrugated roll placed above the other rolls. The rate of feed is regulated by a feed gate controlled by a cam so placed that the rate of feed can be very accurately controlled. The rolls are set so that the wheat berry is split open. Roughly, every berry is broken into four parts, very irregular of course; some kernels are split open, and from some large numbers of different sized, irregular fragments are produced. The material from this break is sifted over No. 16 wire cloth. That which passes through is combined with similar material from the second and third breaks, and all are scalped and graded together as indicated in the flow sheet. Very little flour is made in the first break.
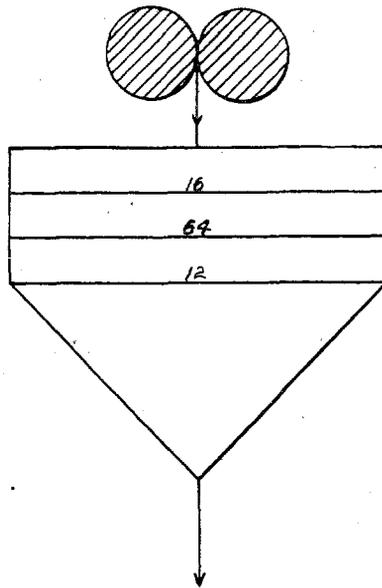
PLATE 8. Diagram illustrating possible
separation of break flour.

If it were desired to secure the flour from the first break, the three sieves 16, 64 and 12 could be used as indicated in plate 8. This would give us two grades of middlings as well as the break flour. If sieves 12, 64, 50, 30 and 16 were used we would separate the middlings from the first break into four grades. The separation of the break flour and the grading of the middlings from the second and third breaks can be effected in the same manner.   The material which does not pass through sieve No. 16 is sent to the second break.

Second break: The rolls are now set closer, from one-half to two-thirds of a turn of the disk.   The berry now being split open the object is to break out the inside of it.   The purpose of the first three breaks is to loosen the germ, make the maximum amount of middlings by separation of the endosperm from the bran, and to produce the minimum amount of break flour.   The product of this break is sifted over No. 18 wire cloth.   The material which passes contains a much larger proportion of endosperm than that of the first break, and a lesser proportion of branny particles after scalping.   The material left over No. 18 wire sieve, *i. e.,* that which does not go through, is sent to the third break.   The branny character of the material begins to be evident.

Third break: The rolls are set closer again by one-half to two-thirds of a turn of the disk.   In starting the mill the position of the disks when the rolls run as close as possible is determined.   Then for the first break they are turned out four-thirds.   This is the position for ordinary hard winter wheat.   For some large wheats nine-sixths or five-thirds may be necessary and for smaller grains seven-sixths may be correct.   When the rolls have been set for the first break, determine how far the disks are turned.   From this subtract one-sixth.   Divide the remainder into two parts.   For the second break turn as much as one of these parts and for the third break bring the rolls to one-sixth of a turn of the disk from the point where the rolls touch.   In the third break the object is to shave off all the endosperm possible without making too much bran dust.   Considerable flour is made in the third break and the middlings are finer than in the first and second breaks.   The branny particles are also finer than in the first two breaks.   The material from the third break is sifted by wire cloth No. 20 and what remains over this goes to break IV.   This material is quite branny.   Endosperm is found only in portions of the bran.

Fourth break: The rolls are now set so that one-eighteenth of a turn of the disk would bring them together.   Very little flour is produced.   The flour is very fine and yellowish in appearance.   More bran dust and fine bran is produced than in the previous breaks.   The material from break IV is sifted over No. 30 wire cloth and what remains over this is sent to break V or the last break.

Fifth break: The rolls are now set as close as they will grind.   The material that goes to break V is barely distinguishable from bran; it has a few larger particles of endosperm and feels a little sharper.   When it has passed through the fifth break the feel of it will be quite soft.   When it is remembered that bran is one four-hundredth of an inch thick, it is seen that the adjustment necessary to complete the grinding on the corrugated rolls is quite delicate.   The setting for the fourth and fifth breaks must differ with thick- and thin-skinned wheats.   What has been said applies to varieties of hard Kansas wheats.   The chop from the fourth and fifth breaks is sifted over 44, 50, 70 and 12 cloth sieves as indicated in the flow sheet.   The flour is very fine, yellowish, specky and

very nitrogenous. What is left over the No. 30 cloth in the fifth break constitutes the coarse bran.

Purification of Middlings.

The middlings from over Nos. 30, 44, 50 and 64 sieves are put successively through the purifier, a section of which is shown in plate 9, or $\underline{\text{I, II, III}}$ is first purified, then $\dfrac{\text{I, II III,}}{30}$ $\dfrac{\text{I, II III,}}{44}$ $\dfrac{\text{I, II III,}}{50}$ $\dfrac{\text{I, II, III}}{64}$ are combined with $\dfrac{\text{VI,}}{44}$ $\dfrac{\text{VI}}{50}$ and $\dfrac{\text{VII;}}{50}$ $\dfrac{\text{VI, VII}}{64 \quad 64}$ and $\dfrac{\text{VII}}{64}$ respectively. By an inspection of the flow sheet, it will be seen that these middlings are of the same grade as $\dfrac{\text{I, II, III,}}{44}$ $\dfrac{\text{VI, VII}}{50}$ and $\dfrac{\text{VI, VII, VIII,}}{64}$ and can therefore be treated together, both in the purifier and the subsequent milling processes. However, the finer middlings produced from the coarser sizings are purer than those obtained direct from the break material. The hopper and feed-roll of the purifier are identical with those of the mill. The essential feature is to secure an even, regular feed which can be varied to suit the different grades of middlings. The purifier works on the principle of an aspirator. The middlings as delivered from the feed-roll fall at point *a*. From here they slide into a series of chutes. The air enters at points *b*, narrow slits one-half inch by five and one-half inches. At points *c* the air can go down *e* or up at *d*. As the opening upward is larger most of the air will be deflected this way and pass through the sheet of down-flowing middlings. The position of *e* also helps to deflect the air upward. The heavier middlings will continue down another chute, while the light particles will be carried over into chamber *B,* whence they will fall into the pan below. It is seen that the air passes through the middlings four successive times, the last time all the air passes through the middlings. The heaviest and best middlings fall into *A*. Only these are used in the production of patent flour. As the air passes into *E, C* and *D* it expands more and more. In this way the purifier acts as a dust collector. *E, F, G* and *H* are obstructions to catch the dust. *E* and *G* are movable so that the openings between *x y* and *m n* can be regulated. The air suction is produced by means of an exhaust fan placed at the end of the
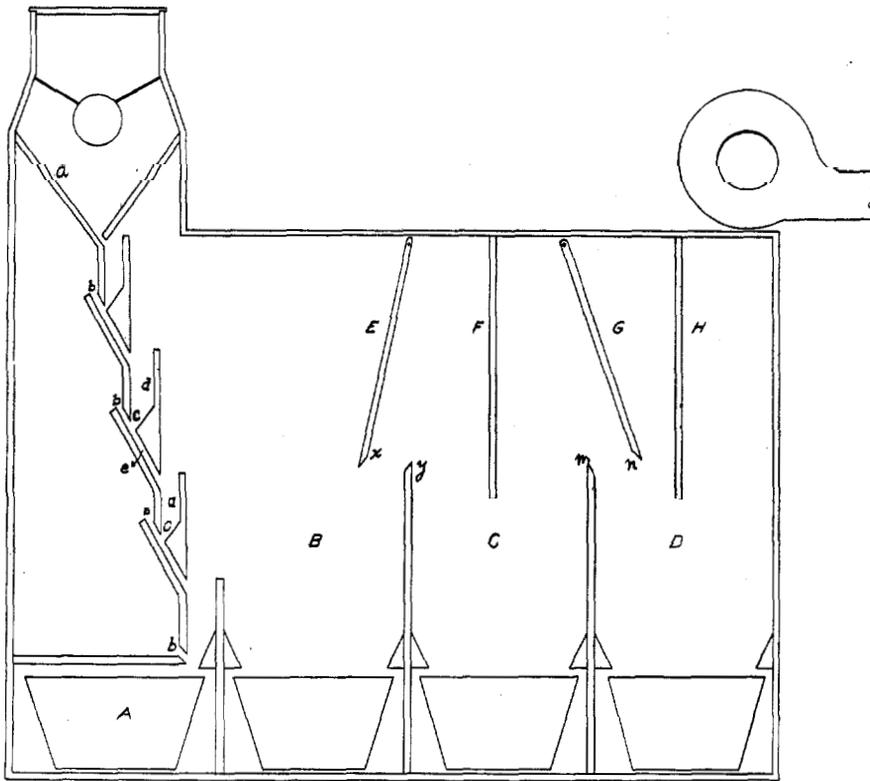
PLATE 9. Vertical section through middlings purifier.

machine, and to the fan is attached a dust collector not shown in figure.

In these tests very little dirt passed over into the dust collector. The material collected in *D* was mostly fine flour dust; in *C* it was flour dust and very fine particles of bran. In *B* the material is fairly good, but is used only in the production of low-grade flour and tailings flour. Material from *B* is added to XVIII, and material from *C* and *D* is added to XIX of the flow sheet.

The purpose of the purifier is to remove the fine bran particles from the middlings, otherwise they would be ground to bran powder and so find their way into the patent flour. In a large milling system purification is carried on to such an extent that bran powder finds its way only to the poorest grades of flour.

When the fine material from the first three breaks has been

sifted, the different grades are removed from the sieves and placed in properly labeled pans. In these tests four-quart milk pans were found convenient. When the different grades of middlings have been removed from the sieves these are replaced as shown in VI of the flow sheet.

Reduction.

The treatments given by the corrugated rolls are called breaks, those given by the smooth rolls are called reductions. To avoid confusion in numbers these treatments are numbered consecutively on the flow sheet. Thus the reduction designated by VI is the first treatment with the smooth rolls. However, not all middlings are treated at this point, as will be seen by an inspection of the flow sheet. Some of the middlings produced are not treated till the reduction designated by X. As in the breaks, some flour is produced in each reduction, consequently some flour has passed the smooth rolls but once.

The material from the first three breaks which has passed wire sieves Nos. 16, 18 and 20 is combined and sifted over cloths 30, 44, 50, 64 and 12. The fine material from each of these three could be separately sifted and graded and the resulting grades treated by themselves This would be desirable in case a comparison was desired of the break flour with the flour produced from the middlings from each break. Otherwise the separate treatment is unnecessary in the production of flour. The object of this sifting is twofold: First to remove all the fine flour from the middlings, since otherwise a large part would be lost in the process of purification. Second, before successful reduction is possible the middlings must be separated into lots in each of which the particles are of nearly the same size. If coarse and fine middlings are sent to the rolls together the fine middlings will be entirely untouched if the rolls are set to treat the coarse middlings properly, and if the rolls are set close enough to treat the fine middlings the coarse will receive too severe treatment. Coarse middlings can be spoiled beyond recovery by too close grinding.

In setting the rolls for the reductions, we first make sure that the rolls are parallel, using the method mentioned above. Then we determine the position of the setting disks when the rolls are together or touch. The disks are divided into seventy-two parts, so that one division is one seventy-second of their

circumference. Both the smooth and corrugated rolls can be tightened beyond the point where they come together. In the later reductions of middlings the smooth rolls are tightened several degrees beyond the point where they touch. This can be done without harm to the smooth rolls but would ruin the corrugated. For convenience in description, when the disks are so turned that the rolls are farther apart than the point where the rolls touch, we will call the position "out," and when they are tightened closer than the point of contact we will call the position "in."

The smooth rolls have a differential of 7 to 10, that is, the fast roll makes ten revolutions while the slow one makes seven. While these are called smooth rolls, they are not perfectly so, and for a purpose. The dull finish enables the slow-moving roll to hold the particles of middlings a trifle while the fast-running roll crushes it with a rub. It is a question worthy of serious consideration in large milk whether the rolls used on some middlings should not have a very fine corrugation, say 100 to the inch, instead of being smooth as they are now. The action of the smooth rolls is not mashing, but a crushing rub repeated several times. Each time a particle of middlings is reduced it becomes smaller, and some flour is crushed and rubbed off. It is this action which produces the well-known granulation of patent roller flour, especially if milled from a hard wheat. As compared with the flour produced from the best of the middlings, called patent flour, the break flour from the first three breaks is of a fine texture and of a bluish-white tinge and contains a relatively larger number of specks from bran powder. As a rule the break flour is not put in with the best patents. Soft wheats produce a larger per cent of break flour and a smaller per cent of flour made from middlings, as compared with the hard wheats. In milling all wheats it is desirable to produce as little break flour as possible.

As can be seen from the flow sheet, each reduction produces a series of products; some flour, middlings of various grades and tailings, or such materials as are taken off from the same number of sieve from which the middlings just reduced were taken. The finer middlings produced from the coarser middlings are placed with the same grade and size of middlings obtained in the processes of the breaks. From the earlier reductions the tailings still retain a considerable portion of the

endosperm. These tailings are saved for the later reductions. As the reductions proceed the tailings become poorer in endosperm and finally they are placed with the fine bran or shorts.

Reduction Desigaated by VI.

The middlings from $\underline{\text{I, II, III}}$ are coarsest and contain a con-
30
siderable amount of germ and bran snips. These middlings are commonly called sizings. The smooth rolls for $\underline{\text{I, II, III}}$
30
are set 8 to 12 divisions out. The rolls are properly set when the germ is flattened and freed from the endosperm and branny particles. Care must be taken not to crush the germ nor make bran dust. The product from the rolls is carefully examined with a small magnifier. In case of doubt it is better to reduce too little than too much. The whole process of getting rid of the germ consists in flattening it so that it can be sifted out from the roundish middlings, and as this is accomplished the bran snips are also gotten rid of. The crushing action of the rolls is such that the endosperm is acted on sooner than the bran, the bran being tougher, and so can withstand the action of the rolls while the endosperm is made into flour.

When the sizings from $\underline{\text{I, II, III}}$ have been reduced they are
30
sifted, the sieves being in the same position as in the previous sifting, the arrangement shown in VI. This sifting will produce a series of sizings and middlings very similar to the ones obtained in the sifting of the fine materials from the breaks. But as the process continues the middlings produced at each reduction will become more and more free from germ and branny particles. If after sifting $\underline{\text{VI}}$ is not sufficiently re-
30
duced, it is passed through the rolls again set closer. No definite rules can be given for this; judgment based on experience is the sole guide. As intimated, the symbol $\underline{\text{VI}}$ represents
30
the end point of the operation; the Roman numerals indicating the reduction, and the Arabic the material which does not pass the sieve of the number indicated. The reductions VI to XII are all on material from the first three breaks. In these reductions also all the best flour is produced. $\underline{\text{VI,}}$ after
$\textbf{30}$

being sufficiently reduced, may be put through the purifier and
then sent to reduction XIII, or it may be sent directly to this
reduction without being sent through the purifier. While more
flour may be obtained from VI it is of a yellowish color, and the
$\frac{30}{}$
close grinding will also produce more or less bran powder,
which will find its way into the flour. How much of the flour
from VI and the following reductions up to XII shall pass into
$\frac{30}{}$ $\quad\quad\quad\quad$ **10**
the patent flour will depend on the skill of the miller and the
machinery and other milling conditions under his control.

Reduction Designated by VII.

Combine $\frac{VI}{44}$ with $\frac{I, II, III}{44}$ and send them through the
purifier. In doing so shut off part of the suction. As the
middlings we purify become finer we use less and less suction.
For $\frac{I, II \; III}{30}$ a full force is used. Then for $\frac{VI}{44}$ part is shut
off and more is shut off for the middlings from the two suc-
ceeding reductions in turn. After the stock is purified proceed
with the reduction VII having the rolls set 4 to 6 divisions
closer than in VI. After reduction, sift, having the sieves
placed as shown in VII. If $\frac{VII}{44}$ is not sufficiently reduced, it is
passed through the rolls set closer and resifted. When $\frac{VII}{44}$
is sufficiently reduced it is sent through the purifier and then
to reduction XIV, or it may be sent directly to this reduction.
In reductions VI to IX only the top sieve need be changed be-
tween each reduction if the sample ground is not more than
two kilograms of wheat.

Reduction Designated by VIII.

Combine $\frac{I, II, III}{50}$; $\frac{VI}{60}$; $\frac{VII}{50}$, and send through the purifier
using less suction than was used before. For reduction VIII
the rolls are set about four divisions closer than for VII. As
noted before $\frac{VIII}{50}$ can be reground if not sufficiently reduced.
This will rarely happen if the rolls in the previous reductions
have done their part. When $\frac{VIII}{60}$ is finished it is fairly soft.

If sufficient in amount it may be sent through the purifier before being sent to reduction XV, or it is usually sent there direct. In these tests $\frac{VI}{30}$, $\frac{VIII}{44}$ and $\frac{VIII}{50}$ are not purified until reduction XIII is reached. If these stocks are purified, $\frac{VI}{30}$ is purified by itself, $\frac{VII}{44}$ is combined with $\frac{XIII,}{44}$ and $\frac{VIII}{50}$ is combined with $\frac{XIII}{50}$ and $\frac{XIV.}{50}$

Reduction Designated by IX.

Combine $\frac{I,\ II\ III}{64}$ $\frac{VI,}{64}$ $\frac{VII,}{64}$ $\frac{VIII}{64}$ and send through the purifier, using very little suction. For this reduction the rolls are set so that they just touch or a little closer. After sifting examine $\frac{IX}{64}$ and if necessary reduce again. When $\frac{IX}{64}$ has been sufficiently reduced pass it to reduction XVI. As indicated by the flow sheet, sieve No. 12 is now replaced by 10 with 70 above and the middlings accumulated from $\frac{VI,}{12}$ $\frac{VII,}{12}$ $\frac{VIII}{12}$ and $\frac{IX}{12}$ are all placed together with $\frac{I,\ II,\ III,}{12}$ and these are now passed to reduction X.

Reduction Designated by X.

These middlings are quite pure and clean, and if the work has been properly done up to this point, there is a large amount of these middlings. They are so pure that most of them are ready to be converted into flour; only a small amount of white shorts is obtained as a by-product. The rolls are set 3 to 5 divisions "in" for this reduction, and for subsequent reductions in the production of patent flour the rolls are set "in" each time. The treatment of the middlings at this stage of the milling process requires as great care as at any stage. The feed should be even and regular and the rolls not set too close. If set too close $\frac{X}{64}$ will show a large amount of flaky material. Under proper conditions $\frac{X}{64}$ will be small in amount and will show some fluffy stock. This can be sent to reduction XI, or, if too poor for this, to reduction XVI. $\frac{X}{70}$ may be sent

to reduction XVI, or if $\dfrac{X}{70}$ is sent to reduction XI, then $\dfrac{X}{10}$ is sent to XII.

Reductions Designated by XI and XII.

Theoretically $\dfrac{IX}{12}$ should require but one reduction to reduce it to flour and white shorts, but practically this is not possible. But the reductions after IX are essentially the same. Reduction X produces the largest percentage of flour. But while the larger part of the middlings are reduced to flour, a considerable portion passes over No, 10 sieve. Ordinarily the stock caught on 64 and 70 is flaky and fluffy and contains but very little good stock. $\dfrac{X}{10}$ is nearly as good as $\dfrac{IX}{12}$, only darker, owing to the presence of a greater. percentage of branny particles. The purpose of reductions XI and XII is to separate the endosperm from the branny particles and reduce the semolina-like middlings into fine flour. It may take more reductions than here indicated. What is in each case caught on sieve No. 70 is either sent to the shorts or to reduction XVI or XVII. It is a flaky material and appears as if the particle of endosperm and the bran snip, instead of being separated, had been pressed together. Under favorable conditions and with good wheat the amount of such flaky material is small. If at any part of the process the rolls have been set too close there is an undue amount of flaky material. Whether $\dfrac{XII}{10}$ shall need one or two more reductions depends upon the character of the wheat, the milling conditions and the skill of the operator.

Reduction Designated by XIII.

In this reduction we use the material from $\dfrac{VI}{30}$ either directly or first having passed the purifier. If, in the milling process, we proceed directly from reduction XII to XIII, we must set the rolls with reference to reduction VI. Usually setting the rolls 4 to 6 divisions closer than they were in reduction VI will give the best results. After this last reduction of $\dfrac{VI}{30}$ it is sifted as shown in XIII, producing a series of middlings resembling the series from I, II, III somewhat in size, but much poorer in endosperm and correspondingly richer in branny materials. When the material from reduction XIII

has been sifted as shown in the diagram, $\underline{XIII}\atop 30$ is placed with the bran or shorts. Very often it is desirable to place the fine material from break IV which has passed No. 30 cloth on top of No. 44 and resume the sifting. This will unite the material of similar character and result in a larger per cent of higher grade flour. For convenience we may call the flour produced in reductions XIII to XVII first tailings and that produced in reductions XVIII to XXI second tailings, or low grade. Whether $\underline{XIII}\atop \mathbf{30}$ shall belong to the bran or shorts is arbitrary. It contains a large portion of the germ and is high in protein and fat. If placed with the bran it would result in a richer and better bran. As shorts is rich in both protein and fat it does not need material like $\underline{XIII.}\atop 30$

If we find it desirable to take the fine material from break IV which has passed No. 30 cloth and put it on top of cloth No. 44 at XIII, and at the same time we put similar material from break V on the above-mentioned cloth at XIV, the reductions XVIII to XXI are omitted entirely. The result will not be as good as if the reductions are carried out in full, but this abbreviation is entirely permissible if in our baking tests we use only the patent flour, and also desirable when the amounts milled are small. What course shall be pursued depends on the circumstances and the object in view. If we by this combination omit the last reductions, we get a much darker first tailings flour, due to the presence of bran powder from breaks IV and V, especially V. We may also find it desirable to place what passes No. 30 cloth from the IV break on cloth No. 44 at XIII and add similar material from break V to cloth No. 44 at reduction XVIII. What course to pursue depends on the condition of the stock, and this in turn depends on the previous handling. The flow sheet is made so general that we may suit the operations to the stock as it is at the time we work on it.

It should be understood that in the wheat berry itself there is no such thing as tailings and low-grade flour. All flour in the wheat berry is first grade. The reason we have the different grades of flour is that the first milling process starts to mix bran, germ and flour and this mixing is increased with every break. In sifting out the break flour we accomplish the

first separation, but already some of the bran is reduced to
such a fine state of division that it can not be separated from
the flour. In the different breaks we loosen the bran, germ
and the endosperm from each other, but at the same time they
are very thoroughly mixed. By subsequent sifting and purifi-
cation we partially overcome this. In the reductions we reduce
the particles of endosperm to smaller dimensions and at the
same time they are freed from still adhering bran snips and
particles of germ. Because the endosperm is more brittle it
will break up into fine particles sooner than the bran and germ.
If then the floury endosperm is sifted away as soon as pro-
duced, that first sifted out will be very fine and pure and free
from bran powder and particles of germ. It is this first sifted
out endosperm which goes into the patent flour.

From what has been said, it is seen that as the reductions
go on, the bran snips which adhere to the endosperm undergo
a treatment the severity of which increases with the re-
ductions. Consequently in these last reductions more and
more bran powder finds its way into the flour, and even if the
stock is handled so carefully that practically no bran powder
finds its way into the flour, some of the coloring matter of the
bran is imparted to the flour. The close proximity of the bran
to the endosperm and the severe treatment both receive easily
make this possible, whether the coloring matter is a dry solid
body or one that on pressure yields a minute amount of liquid.

Reduction Designated by XIV.

In this reduction we use the material from $\underline{\text{XIII,}}$ either
                                                   44
directly or having undergone purification. The rolls are set
somewhat closer than in XIII. $\underline{\text{XIV}}$ goes to the bran or shorts.
                                    44

Reductions Designated by XV, XVI, XVII.

From what has been said in regard to the previous re-
ductions and the flow sheet, the manner of carrying out these
reductions is easily seen. $\underline{\text{XV, XVI, XVII}}$ are in each case
                                50   64   70
carefully examined, and just when the reduction is complete
can be learned by experience. The material should be quite
soft and free from sharp particles of endosperm. When the
bran snips show no particles of endosperm with sharp outline
the action as a rule is complete.

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Reductions Designated by XVIII to XXI.

If these are carried out, we use in XVIII material from breaks IV and V, or from V only. As was indicated above, what course is pursued depends on the object in view and the condition of the stock. Reductions XVIII to XXI are carried out in a manner similar to reductions XIII to XVII.

General Remarks on the Experimental Milling of Wheat.

The foregoing flow sheet, with the accompanying description, is intended as a guide to the experimental milling of wheat. The number of reductions indicated will be found more than is needed in most milling tests, but this system is sufficiently extended to allow as large a scope in experimentation as possible. In practice, the whole test can be carried out in an hour and a half to two hours. The greatest skill and experience are needed in the latter reductions. Milling up to $\frac{X}{10}$ is easy, and the difficulties in producing good flour are small. Very little or no variation in the flow sheet will be desirable before $\frac{X}{10}$ but beyond this point the character of the wheat so influences the stock yet to be treated that only general directions can be given, and judgment based on experience must guide the subsequent operation. It should be borne in mind that if a series of tests is made on wheats of the same grade, or wheats of the same grade differently treated experimentally, the tests of that series should be made as nearly alike as possible.

THE BAKING TESTS AS MADE ON THE FLOURS.

In making baking tests on different flours it is above all desirable that the tests should be so conducted that the difference in results should be caused by the inherent qualities of the flour, and not to variations due to the method employed. A method which in the hands of a skilled baker gives good bread may not be at all adapted to use in making comparative baking tests. In conducting these tests it may be desirable to use a method which would not be selected were the making of good bread the only object aimed at. A skilled baker will, consciously or unconsciously, adapt his method to suit the different flours he uses, and defects in the flour may to some extent be remedied by the process of baking.

THE STRAIGHT DOUGH TEST.

In these tests straight dough means one that has been subject to a short period of fermentation and baked as soon as the dough has risen a standard amount. This amount is fixed by preliminary trials and is uniform in all these tests. The short period of fermentation varies from one to three bows and is secured by means of fresh compressed yeast used in large amounts. Two hours is the average time. When the proving is done in one hour, the yeast shows unusual vigor; three hours indicates that the yeast is becoming weak. In these tests we used yeast from pound cakes bought from a local bakery. Yeast that is clammy to the knife when cut is not desirable. Yeast of a firm texture and somewhat brittle was found to be most desirable. When the compressed yeast becomes soft it is worthless. Good yeast, properly kept, will retain its full vigor over a week. It is essential, however, that it be kept dry and cool.

In the short period of fermentation the natural color of the flour is retained. By means of a long period of fermentation it is possible to produce an artificial color in the bread. In this way skilled bakers can produce a very white bread. The short period of fermentation also preserves the natural flavor. If two loaves are baked under identical conditions except that one is baked as soon as the dough has attained a desired lightness and the other is knocked down and allowed to rise to the same height and then baked, the two loaves will differ both in flavor and texture. Under favorable conditions this would lengthen the period of fermentation only about one hour, using the method here described. If by using a less amount of yeast the period of fermentation is lengthened to ten or twelve hours the difference would be still greater. In this case there would be a distinct difference in color, the long period of fermentation producing the whiter loaf. Temperature conditions must also be uniform as the yeast plant is very sensitive to temperature changes. In the short period of fermentation it is obviously easier to control the temperature changes than in the long period.

Percentage of Absorption.

By percentage of absorption we denote the amount of water a flour will take up in the production of a dough with the desired stiffness. Flours differ considerably in the amount of

water they will absorb. Strong flours will absorb 55 to 60 per cent of their weight; weaker flours from 45 to 50 per cent. Power to absorb water is due to the inherent nature of the flour and will differ in the different flours, due account being taken of the moisture content of the flour. Two, samples of flour, originally from the same source, will show different percentages of absorption if they have been exposed to unlike hygroscopic conditions so that one contains a larger per cent of water than the other. The one with a less amount of water will give a higher per cent of absorption than the one with the larger amount of water. Flour is very sensitive to hygroscopic conditions. The amount of water and consequently the percentage of absorption will vary with the hygroscopic state of the air. A flour exposed in the sack to the air will differ somewhat in percentage of absorption from one season to another. To find the true percentage of absorption we must determine the hygroscopic water in the flour and add this amount to that found as described below.

Thirty grams of flour are carefully weighed out into a 250 cc. evaporating dish. In the absence of such a dish a strong porcelain teacup will answer. For a strong flour, measure out 17.5 cc. of water from a burette. If a weak flour is being tested 15.5 cc. will probably be enough. In general hard-wheat flours from western wheats are stronger than flour from soft wheats grown in humid sections. In these tests distilled water was always used. This is desirable but not necessary. The water and flour are carefully mixed, first by means of a stiff spatula, then the dough ball is worked in the hands until the flour and water make a smooth, homogeneous dough. If the right amount of water has been used the dough will have the desired stiffness. It can be easily worked in the hands, pulled and molded into any shape desired. If made into a roll, this will have a certain amount of elasticity when drawn out, but will break with a snap when pulled. Dough that pulls approximately similar to taffy has a very weak gluten and is undesirable for bread making. If too much water has been added the dough will be soft and sticky. If too little the dough will be too hard; it does not work easily and is too elastic.

In careful work it is best to determine the limits, *i. e.,* the amount of water which will make it too soft and the amount

which will make it too stiff. In this way the correct amount is better assured. A difference of 0.5 cc. is very distinct in its effect. It is desirable to use as much water as possible since this makes a lighter and more palatable bread. When the correct amount of water for thirty grams has been determined the amount needed for the quantity of flour used in the baking test is calculated by simple proportion. When a certain standard of stiffness has been adopted it is necessary to adhere to this standard throughout the series of baking tests. Two loaves made from the same flour under identical conditions except that one has a stiffer dough than the other due to the use of less water will differ in texture; the one with the less water will have a closer texture than the other. (See photograph of loaves 1, 2, 3. Plate 12.) To obtain a uniform stiffness it is best to select a certain good flour as a standard. This flour should be kept in a carefully covered container. A large wide-mouthed, glass-stoppered bottle will be very serviceable.

Making the Straight Dough.

Three hundred and forty grams of flour, ten grams of compressed (Fleischmann's) yeast, twelve grams of sugar and five grams of salt are weighed out. The amount of water as determined by the absorption test is also measured out. For strong flours this will be about 200 cc.; for weaker from 170 cc. to 190 cc. The flour is placed in a tin pan in a layer one inch thick and placed in the expansion case. This case is constructed of galvanized iron, in the shape of a large drying oven, and is lined with asbestos. It is supported on a stand so that a small gas burner can be placed beneath, by means of which it is heated to any desired temperature. The flame of the burner is controlled by means of a thermo-regulator. The shelves are made of woven wire. This facilitates the free circulation of air. The door is made of glass so that the inside is open to view. In these baking tests the temperature was kept at 35° C. All ingredients and apparatus are also kept as nearly as possible to this temperature.

The dough kneader is clamped to a table. The smaller space at the end of the kneader is filled with water heated a little above 35° C. In practice it was found best to pour in some quite hot water first and then temper this with cold

water.   If the room is considerably cooler than 35° C. it is
very important to have the machine warmed to the right tem-
perature, otherwise the dough will be chilled and the time of
fermentation unduly delayed.   The water measured for the test
is heated to 35° C.   The yeast is diffused in part of this water
and poured with the rest into the dough kneader.   Two-thirds
of the flour together with the sugar and salt are now added and
the short handle of the crank is turned as fast as possible for
ten minutes.   The kneader has two adjustments, one for beat-
ing and one for kneading.   The shaft which turns the spiral
has two grooves, one inner and one outer.   By means of these
the spiral can be set so that its broad end comes very close to
the lower end of the machine without rubbing against it.   It
has this position when the beating is done.   After beating ten
minutes the spiral is set out and the remaining one-third of
the flour is added.   For convenience it is well to have the flour
weighed out in separate pans, since the machine works best
when two-thirds and one-third of the flour is used respectively.
Now the long handle of the crank is turned as fast as possible
for ten minutes, while by means of a large somewhat flexible
spatula all the flour is worked into the dough.   It is not neces-
sary that all of the dough should be removed from the kneader
as it is weighed after panning.   If due care is exercised
the dough will weigh within twelve to twenty grams of the
materials used in its making.

   The dough is now placed in a pan previously greased and
weighed.   As indicated above, the pan should have the tempera-
ture of 35° C.   This can best be secured by keeping it in the
expansion case.   The dough is transferred from the machine
to the pan with the hands greased or lightly dusted with flour.
When pans are used a roll is made in the hands the length of
the pan.   Dusting the hands with flour is preferable to greas-
ing as this is more likely to produce a smooth crust on the loaf.
A baking board is not used as this would cause some loss of
material and is likely to chill the dough.   A record is made
of the time the dough is put in the expansion case.   The dough
is allowed to rise to the height of a tin strip placed across the
pan.   The pans are 2 x 10 inches bottom, $2\frac{1}{2}$ x $10\frac{1}{2}$ inches
top, and $2\frac{1}{2}$ inches deep.   The tin strips have this shape:

$\frac{1}{2}$" $\frac{1}{2}$ "

2¼"
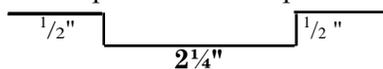
The rising must be watched very carefully. If the dough is allowed to rise too long, the texture, volume and color of the loaf will be influenced very materially. The volume of loaf produced by a given flour has little meaning if the amount of rise is not fixed by a definite standard. Too much rise will produce bread coarse in texture. If raised too little, the bread will be heavy. The rise should be so regulated that a loaf of fine texture is secured. When the dough has risen the standard amount it is weighed. The loss in weight during rising will be closely proportioned to the time of rising. The pan is next placed in the oven, heated to 237° C. (460° F.), and baked exactly twenty-five minutes. The temperature of the oven will fall slightly at first, owing to the moisture given off by the dough, but the temperature will soon rise again. In comparative tests it is best to keep the oven at a certain temperature. The oven has an opening at the top and one at the bottom. By means of these, together with the electrical regulator, any desired temperature can be maintained. If the same temperature is maintained in all the tests, the exact time when the loaf is baked will be known. The loss in baking is about thirty grams. If the loaf is sufficiently baked it will have an even brown crust all over and the sides will spring back when pressed with the finger.

Volume of Loaf.

In measuring the volume of the loaf it is put in an oblong box open at one end. The box is a little longer than the loaf, and the open space is somewhat less than half the usual loaf volume. A shaft with one side made of glass graduated in inches and having a slide at the bottom is completely filled with flaxseed. The graduations are so made that one-eighth of an inch equals one cubic inch volume. The shaft holds ninety-six cubic inches, and the box in which the loaf is measured one hundred and sixty-five. By holding the shaft over the open end of the box and allowing the flaxseed to completely fill the open space around the loaf, its volume can readily be obtained. The volume varied from 77 to 87 cubic inches in these experiments.

In comparative baking tests the volume should be measured at a time set relative to the baking as the loaf shrinks somewhat on cooling. The same is true in regard to weighing.

After the loaf is cool it is cut in two one-third from the end, and the color, flavor and texture are judged.

In making a baking test of an unknown flour, a flour the baking qualities of which are known is selected as a standard and tested at the same time as the unknown flour. Both are baked under identical conditions, and in this way the unknown flour can be judged.

GLUTEN EXPANSION DOUGH TEST.

This is for the purpose of testing the quality of the gluten. The procedure is identically the same as for straight dough up to the point where the dough is ready to be panned. Instead of putting the dough in a pan it is put into the expansion cylinder. This cylinder is made of heavy tin 10.8 cm. in diameter and 32 cm. high. On one side is a glass window 2 cm. wide and extending the whole length of the cylinder. This window is constructed similarly to those used on cream cans. To one side of the glass is placed a strip of aluminum foil graduated in millimeters. When the dough is taken from the dough kneader it is rolled into a round ball and placed in the cylinder. The cylinder is lightly greased and should be at the temperature of 35 ° C. before the dough is put into it. This is accomplished by keeping the cylinder in the expansion case, where it is also kept during the subsequent process.

For the first hour no attention need be paid to the dough. After the first hour the height of the dough is recorded. The readings are taken at the level of the meniscus, or upper curved surface. The taking of the readings is facilitated by means of a heavy aluminum strip 1.3 cm. wide bent at right angles. By placing this against the window the level of the meniscus can be read to millimeters. After the first hour the readings are taken thirty minutes apart for a time, then every fifteen minutes and at last every ten minutes. The dough is allowed to rise till it falls. The last stage must be watched very carefully. When the dough begins to fall the total height is recorded, and it is taken out of the cylinder and kneaded in the machine with fifteen grams of flour, after which it is again placed in the cylinder and the whole process repeated.

TABLE 1. Summary of milling data. McPherson wheats. 1906.

Serial number	Number of wheat	VARIETY OR NAME.	Bushels per acre	Grains per ten grams	Specific gravity	Condition of berry	Percentage of moisture	Tempering water, grams	Per cent total flour	Per cent patent flour	Per cent second-grade flour	Per cent low-grade flour	Per cent bran	Per cent shorts	Per cent dust	Pounds total flour per bushel
1	1395-2	Mediterranean	24.88	368.8	1.3351	Plump.	10.91	15	73.94	50.26	21.17	2.51	20.71	4.86	0.51	44.36
2	1435	Crimean	21.90	345.5	1.3650	Plump.	10.89	50	73.98	49.63	22.87	1.48	18.79	5.90	1.33	44.39
3	1487	Crimean	29.12	381.1	1.3702	Plump.	10.63	50	74.27	50.07	22.36	1.83	18.59	6.00	1.14	44.56
4	1438	Ghirka Winter	24.92	439.7	1.3648	Plump.	10 87	50	75.59	51.13	21.39	3.07	19.33	4.08	1.01	45.35
5	1442	Kharkov	35 08	357.1	1.3385	Plump.	10.88	35	74.55	50.70	20 58	3.26	20.68	3.77	1.00	44.75
6	1589	Torgova	34.17	390.2	1.3351	Plump.	10.98	50	75.60	51.69	21.37	2.54	19.09	4.82	0.49	45.36
7	1558	Turkey	34 79	411.9	1.3472	Plump.	10.56	50	74.76	50.42	21.37	2.97	21.32	2.97	0.94	44.86
8	1559	Crimean	37.93	362.4	1.3299	Plump.	10.99	50	76 03	52.37	21 27	2.39	18.88	4.23	0.85	45.62
9	1564	Pesterboden	21.95	420.7	1.3458	Plump.	11.08	50	75.47	47.44	26 00	2.03	18.35	5.42	0.76	45.28
10	1571	Turkey	23.76	388.1	1.3458	Plump.	10.72	50	77.63	52.72	21.81	3.10	17.84	4.02	0 51	46.58
11	1588	Kharkov	36.21	359.9	1.3471	Plump.	11.22	50	76.84	53.13	22.59	1.13	16.18	6.10	0.87	46.10
12	1739	Budapest	14.41	333.7	1.3698	Plump.	10.49	45	76.70	53.09	21.84	1.77	16.97	5.72	0.61	46.02
13	1756	Missouri	33.85	380.5	1.3583	Plump.	10 87	50	74.73	52.88	20.50	1.40	19.70	4.71	0.85	44.84
14	1757	Japanese Velvet Chaff	28.54	327.7	1.3388	Plump.	10.75	15	74.96	57.96	15.27	1.93	20.31	4 22	0.51	44.98
15	1824	Zimmerman X Turkey	24.63	389.4	1.3452	Plump.	10.75	15	71.33	47.25	21.79	.2 29	23.57	4.33	0.76	42.80
16	1544	Beloglina	32.17	402.4	1 3618	Plump.	12.47	40	74.63	52.97	19.13	2.54	19.99	4.36	1.02	44.79
17	2906	Currell	19.62	421.4	1.3216	Plump.	10.97	15	72 31	46.67	23.31	2.32	20.63	5.52	1.55	43.39
18	2907	Zimmerman	22.71	427.1	1.3486	Plump.	10.93	15	74.55	49.95	21.62	2.98	19.32	4 97	1.15	44.73
19	2908	Malakoff	28.71	399.0	1.3505	Plump.	10.72	50	75.44	52.24	21.79	1.41	19 81	4.44	0.81	45.26
		Average	27.86	385.0	1.3506		10.93		74.91	51.17	21.47	2.26	19.45	4.75	0.88	44.94

TABLE 2.—Summary of milling data. Manhattan wheats, 1906.

Serial number.	Number of wheat.	VARIETY OR NAME.	Bushels per acre.	Grains per ten grains.	Specific gravity.	Condition of berry.	Percentage moisture.	Tempering water, grams.	Per cent total flour.	Per cent patent flour.	Per cent second flour.	Per cent low-grade flour.	Per cent bran.	Per cent shorts.	Per cent dust.	Pounds total flour per bushel.
21	366	Bearded Fife	48.79	335.9	1.3683	Plump.	10.83	50	74.94	50.78	22.74	1.41	17.53	6.47	1.06	44.96
22	367	Fultz	48.91	312.1	1.3626	Plump.	10.07	25	71.77	46.04	22.82	2.91	19.11	8.12	1.00	43.06
23	368	Malakoff	46.42	331.3	1.3537	Plump.	10.41	50	74.50	50.80	21.35	2.35	18.30	6.30	0.80	44.70
24	529	Minnesota	44.43	312.8	1.3264	Plump.	10.46	50	74.12	50.47	22.15	1.49	18.88	6.01	1.00	44.47
25	373	Defiance	48.81	377.6	1.3408	Plump.	10.20	55	74.15	50.60	22.16	1.39	19.32	5.58	0.95	44.49
26	378	Red Winter	48.09	318.7	1.3572	Plump.	10.13	50	73.58	53.12	18.43	2.33	19.67	5.05	1.39	44.33
27	570	Turkey	46.12	305.8	1.3792	Plump.	10.85	50	75.01	52.25	20.84	1.92	19.02	5.01	0.96	45.01
28	573	Kharkov	44.98	327.7	1.3562	Plump.	10.14	50	76.27	51.59	22.97	1.71	16.73	6.10	0.91	45.76
29	574	Crimean	41.58	358.4	1.3635	Plump.	10.65	50	74.71	50.52	22.84	1.85	17.86	6.33	1.10	44.83
30	576	Weissenberg	44.79	300.9	1.3509	Plump.	10.03	40	75.24	52.64	20.79	1.81	16.10	7.15	1.51	45.14
31	577	Currell	48.28	326.0	1.3738	Plump.	10.03	45	71.30	45.55	23.40	2.35	21.60	5.90	1.23	42.78
32	578	Ghirka	32.76	355.2	1.3871	Plump.	10.50	50	74.85	55.50	17.65	1.70	17.90	6 05	1.25	44.91
		Averages	45.33	335.1	1.3664	....	10.28	.....	74.22	50.82	21.47	1.93	18.50	6.17	1.09	44.53

MILLING TESTS. CROP OF **1906.**

The data obtained in milling wheats from the crop of 1906 are shown in tables 1 and 2. The results shown in table 1 are from the wheats grown at the cooperative station at McPherson, and those in table 2 from the wheats grown by the Agronomy Department of the station at Manhattan. Although the wheats from Manhattan are somewhat better in quality than those from McPherson, they were all equal to No. 1 grade. The year 1906 was very good for wheat. Twenty-four of these wheats are classed as hard wheats and seven as soft. No. **20** was a commercial wheat and is not included in the averages.

YIELD PER **ACRE.**

While most of these wheats are good yielders, there is a large variation in this respect. Those grown at McPherson vary from 14.41 bushels in No. **12,** Budapest, to 37.93 bushels in No. 8, Crimean. The yields of the wheats at Manhattan were very much larger. These vary from 32.76 bushels in No. **32,** Ghirka, to 48.91 in No. 22, Fultz. The soft wheats compare well with the hard wheats as yielders. The average for the wheats grown at McPherson is 27.86 bushels and for those grown at Manhattan is 45.33, a difference of 17.47 bushels. That this is due more to the soil and climatic conditions than to the inherent yielding power of the variety is shown by comparing the yield of the same varieties grown at the two places. Nos. 3, 4, 5, 7 and 17 are from the same varieties as 29, 32, 28, 27 and 31 respectively; yet the average of the first five grown at McPherson is 28.70 bushels and that of the corresponding five varieties grown at Manhattan is 42.54, the latter figure being fifty per cent higher. Whatever may be the cause of this variation in yield, there is nothing in the results of the milling tests which shows any material difference between poor and good yielders if the quality of the grain is the same.

GRAINS PER TEN GRAMS.

These results were obtained by counting out 100 average grains from a well-mixed sample and weighing on an analytical balance. From the weight of 100 grains the number of grains in ten grams were calculated by simple proportion. The wheats grown at McPherson show a larger variation than those grown at Manhattan. In the former the number of grains per ten grams varies from 327 in No, 14, Japanese

Velvet Chaff, to 439 in No. 4, Ghirka. In the latter they vary from 300 in No. 30, Weissenberg, to 377 in No. 25, Defiance. The average number of grains per ten grams for the Mc-Pherson wheats is 385 and for Manhattan 335, the better yielders showing the larger grains.

By dividing 10 by the number of grains in 10 grams the average weight of each grain may be obtained. The average weight of each grain of the McPherson wheat is 0.02597 grams and that of the Manhattan wheat is 0.02983, or in other words, 100 grains of the McPherson wheat weigh 2.597 grams and 100 grains of the Manhattan wheat weigh 2.983 gams. This is considerably below 3.866, which is the average given by Wiley for wheats grown in the United States. (Bull. 13, Part 9, Bureau of Chemistry.)

SPECIFIC GRAVITY.

These data were obtained by means of a 100 cc. glass-stoppered specific gravity bottle, 95 per cent ethyl alcohol, and an analytical balance. A known weight of wheat was put into the specific gravity bottle, the weight of which was known. Then alcohol was added until the bottle was completely filled, and the whole weighed. From this last weight was subtracted the previously obtained weight of the bottle plus that of the wheat, which gives the weight of the alcohol necessary to fill the space in the bottle not occupied by wheat. The weight of the alcohol divided by its specific gravity gives the volume of the bottle not occupied by wheat. The exact specific gravity of the alcohol for the temperature at which the weighing is done must be known. The volume occupied by the alcohol subtracted from the capacity of the bottle gives the volume occupied by the wheat. The weight of the wheat divided by its volume gives its specific gravity. The average specific gravity of the McPherson wheats is 1.3506, the highest being 1.3702 in No. 3, Crimean, and the lowest 1.3216 in No. 17, Currell. The average specific gravity for the Manhattan wheats is 1.3664, the highest being 1.3871 in No. 32, Ghirka, and the lowest 1.3264 in No. 14, Minnesota.

If we divide these wheats on the basis of the average yield, placing those above the average in one class, and those below the average in the other, and then obtain the averages for each class in respect to yield, grains per ten grams, and specific gravity, we have the results exhibited in table 3.

TABLE 3.

	McPherson wheats.		Manhattan wheats.	
	Above average yields.	Below average yields.	Above average yields.	Below average yields.
Bushels per acre............................	33.06	22.08	47.91	41.71
Grains per ten grams....	377.	394.	334.	336.
Specific gravity..	1.3611	·1.3491	1.3664	1.3665

The McPherson wheats show the greater variation. The high yielders average 50 per cent more bushels per acre. In regard to grains per ten grams, the low yielders have a larger number than the total average. The lower yields per acre accompany the smaller kernel. This statement also holds true if we compare the McPherson wheats with the Manhattan. The lower average bushels per acre and the corresponding higher number of grains per ten grams is in contrast to the higher average bushels per acre and the corresponding lower number of grains per ten grams. In the Manhattan wheats the high yielders and the low yielders show practically no variation from the average, both in regard to the number of grains per ten grams and the specific gravity.

If we divide these wheats on the basis of average number grains per ten grams, placing those above the average in one class and those below in another and these results are averaged separately, together with the corresponding specific gravity of the same wheats, we have the results shown in the accompanying table 4.

TABLE 4.

	McPherson wheats.		Manhattan wheats.	
	Above average number.	Below average number.	Above average number.	Below average number.
Grains per ten grams.........................	409	357	358	318
Average specific gravity of corresponding wheat	1.3501	1.3509	1.3758	1.3455

The McPherson wheats show no variation in specific gravity to correspond with the larger and the smaller kernels when all the wheat from this place are averaged in this manner. In the Manhattan wheats the smaller average kernels have a greater specific gravity. If we compare tables 3 and 4 we see that in the McPherson wheats the smaller grains have

a less specific gravity, This is in contradiction to the result in table 4, where the larger grains have a lower, specific gravity. But the low specific gravity in the small kernels of the Mc-Pherson wheats is in all probability due to a poorer grade of wheat shown in the low yields. Based on the above data, in good wheats the smaller kernels have a higher specific gravity. This point is touched again later. If we average the five soft wheats from the McPherson group we find that the average number of grains per ten grams is 387, very near the average of the whole, and the corresponding average specific gravity of the same wheats is 1.3359, considerably less than the average of the whole group.

MOISTURE.

About five grams of whole wheat were placed in a shallow aluminum dish and dried for forty hours at the temperature of boiling water. At the end of this time the constant weight showed that all moisture was driven off. The whole wheat berry holds the moisture very much more tenaciously than the same wheat when ground. Ground wheat will lose all its water in about seven hours if kept at the temperature of boiling water. There is a remarkable uniformity in the moisture content, the McPherson wheats having slightly less than the Manhattan wheats. The mean of all these thirty-one wheats is 10.60 per cent. It is interesting to note in comparison, that the mean with domestic wheats obtained by the Bureau of Chemistry on the one hundred and sixty-three samples collected for the World's Fair in 1893 was 10.62 per cent.

TEMPERING WATER.

The amount of water used for tempering varied from 35 cc. to 50 cc. for the hard wheats; 15 cc. is the usual amount used for the soft wheats, except in the case of No. 31. This is a soft wheat, but the kernels were very dry and more than the usual amount of water was necessary for tempering.

YIELD OF MILLING PRODUCTS.

The remaining columns in tables 1 and 2 show the per cent of milling products obtained from each sample. In these tests five products are recognized and weighed. After grinding to a finish the products were weighed on a balance sensitive to one gram. It is of no practical advantage to weigh closer than this. All milling products lose weight during the operation of grinding. This is due to loss of moisture and impalpable dust.

Considerable heat is generated by the milling process. This is familiar to anyone who has felt the stock as it comes from the rolls. The heat together with the exposure causes the loss of moisture. The losses are always heavier on days when the relative humidity of the atmosphere is low than on days when the humidity is high. The frequent handling of the stock causes loss of fine dust. This dust is so fine that it distributes itself to all parts of the room and recovery by sweeping is impossible. Both these losses fall heaviest on the products of the tail end, such as shorts and low-grade flour. These are ground more severely and are exposed longer. If the percentages of milling products are calculated by dividing the weight of the product by the weight of the wheat milled, shorts and low-grade flour will be affected by these losses in undue proportion. To obviate this to a large extent, the percentage of each product is obtained by dividing the weight of each product by the sum of the weights of the products. When this method is used for each sample of wheat milled, the results are more comparable than if the percentages are based on the wheat milled, as this does not distribute the losses.

The per cent total flour is obtained by adding the results for patent, second grade and low grade. The term second grade is used in preference to the term bakers', as the latter is now largely a misnomer. The patent flour includes that which is made from the best middlings as shown in the flow sheet. In tables 1 and 2 the second-grade flour includes all of the break flour and the best of the tailings flour. The low grade is the darkest and the finest flour, such as is obtained in the final reductions at XVI to XVII or at XX, XXI and at XVII repeated. The bran includes the coarse husks separated by sieve No. 30 after the fifth break and also the finer bran snips over sieve No. 44 after reductions XIV or XVIII according to the course taken in milling. This latter material might be classed with the shorts. If it is mixed with the latter we have brown shorts, if not, we have white shorts. The shorts in all these tables includes the material which is finer than the fine bran and too coarse and dark to be classed with the low-grade flour. The shorts over No. 30 in reduction XIII contains a large portion of the germ and is therefore put with the shorts, although it is coarser than some of the fine bran. The dust is made up of material unavoidably lost during the milling

process. As was indicated above, this dust does not represent all the material, other than moisture, which escapes during the milling process. The very finest escapes and does not settle in such a manner that it can be gathered. This latter, together with the moisture, is not included in these percentages. This loss varies with the temperature and the humidity. Some days there is actually a gain. The total flour per bushel is obtained by multiplying the percentage of total flour by 60, taken to represent the average weight per bushel.

The quantitative results obtained by milling cannot be regarded in the same light as the results obtained in quantitative chemical analysis, but it does not follow that because they are not in the same class in respect to accuracy they are of proportionately less value. Chemical analysis of soils is very accurate in representing the total amount of a constituent extracted by a definite solvent. The quantity of a given constituent, may be the same in two soils, but the crop-producing power may be very different. Yet chemical analysis of soils has a great value when used with knowledge and judgment, and that value is greatest to those who know most about chemical analysis of soils. Thus far very few results of milling are recorded in scientific literature.

Just how far the milling process shall be carried is a question in every test. Unless baking tests are made in connection with the milling tests, this question cannot be answered. In some wheats the test can be carried farther than in others. As more data accumulate standards will be established and we shall be on a more secure foundation.

The average per cent of total flour for the McPherson wheats is 74.9 and that of the Manhattan 74.22.   The average per cent of the patent flour for the same wheats is 51.17 and 50.82. This makes the patent flour a little over 68 per cent of the total flour. This, to be sure, is a much lower per cent patent than is made in commercial mills. The soft wheats average lower in yield of flour than the hard wheats. This is probably due to the fact that hard wheats can be milled cleaner than soft wheats. The soft wheat flour is more impalpable and has a peculiar adhesive property absent in the hard wheat flour. Bran from soft wheat is covered with fine flour dust. In good milling the bran from hard wheat is of a very clear amber color. The endosperm clings harder to the bran in soft wheat.

The bran coats in hard wheat have a springy stiffness which enables the rolls to shave off the endosperm quite close to the bran coat. These are tentative reasons why the yield of flour is less in the soft wheats.

MILLING TESTS, CROP OF 1907.

One of the gratifying results of the milling tests made on the crop of 1907 was the uniformly good flours produced. Any region which is known to the world's flour market to produce uniformly good milling wheats has an enviable reputation. Kansas wheats have this name. But in an investigation of this kind, variability will more often lead to the results desired than uniformity. For this reason Kansas wheats which had shown the greatest variation in the tests of 1906 were selected for the tests on the crop of 1907. Chemical differences were also considered. To obtain still greater variation it was thought best to secure wheats from other states. Samples of wheat were kindly furnished by the experiment stations of Tennessee, Minnesota, and Washington. This collection furnished samples of typical varieties representing hard, soft and medium wheats.

MILLING TESTS OF KANSAS WHEATS.

The results of the tests on the crop of 1907 are shown in table 5. The first four wheats were grown at McPherson and the rest at Manhattan. The column headings have the same meaning in general as in tables 1 and 2. The yields per acre are low for the McPherson wheats, especially the two soft wheats. The low yielders have a larger number of grains per ten grams and a lower specific gravity. In this case, as before, the low yields give smaller grains and lower specific gravity than the high yields. The grains of the lowest yielders were shrunken. The soft wheats from Manhattan form an exception to the general average results of low specific gravity being correlated with small kernels. If the hard wheat Weissenberg is excepted, these two soft wheats have the largest grains, but the lowest specific gravity, of the eight wheats grown at Manhattan.

TABLE 5.—Summary of milling data.   McPherson and Manhattan wheats, 1907.

Serial number	Number of wheat	VARIETY OR NAME	Bushels per acre	Grains per ten grams	Specific gravity	Condition of berry	Per cent moisture	Tempering water, grams	Per cent total flour	Per cent patent flour	Per cent break flour	Per cent tailings flour	Per cent bran	Per cent shorts	Per cent dust	Pounds total flour per bushel
53	1539	Torgova	17.38	418.9	1.3223	Not well filled,	10.64	50	72.80	54.55	6.59	11.66	14.64	11.77	0.78	43.68
54	1571	Turkey	20.63	390.2	1.3352	Fairly plump..	11.02	45	74.30	53.04	9.01	12.13	17.87	6.95	0.88	44.58
55	2906	Currell	7.13	452.7	1.2949	Shrunken.....	10.18	15	69.58	44.51	11.28	13.78	23.76	5.88	0.78	41.75
56	2907	Zimmerman	7.17	524.1	1.2973	Shrunken.....	10.13	15	69.85	42.78	11.49	15.57	25.41	4.02	0.72	41.91
57	367	Fultz	36.45	395.6	1.3044	Plump	9.98	15	73.72	43.97	15.08	14.67	21.17	4.19	0.92	44.23
58	368	Malakoff	45.84	261.5	1.3466	Plump	10.52	55	78.88	54.66	6.24	12.98	17.66	7.34	1.11	44.33
59	369	Minnesota	42.16	375.2	1.3468	Shrunken....	10.86	60	75.39	53.47	8.96	12.95	16.99	6.83	0.78	45.23
60	373	Defiance	46.52	367.1	1.3495	Shrunken....	10.50	60	75.37	55.61	9.11	10.65	17.36	6.25	1.02	45.22
61	380	Turkey	43.27	343.6	1.3324	Shrunken....	10.46	35	75.17	53.91	8.14	13.12	16.32	7.63	0.86	45.10
62	574	Crimean	41.77	355.8	1.3269	Fairly plump..	10.51	55	75.19	51.77	11.99	11.38	16.56	7.18	1.03	45.08
63	576	Weissenberg	39.57	303.8	1.3469	Plump	10.35	60	72.46	55.81	7.70	8.95	13.93	7.14	0.85	42.72
64	577	Currell	31.15	307.0	1.2974	Fairly plump..	10.95	15	71.04	49.92	9.03	12.08	20.86	6.82	1.26	42.62
		Average		375.5	1.3250		10.51		73.22	51.16	9.55	12.49	18.54	6.83	0.81	43.84

TABLE 6.—Summary of milling data.   Minnesota wheat, 1907.

Serial number	Number of wheat	VARIETY OR NAME	Grains per ten grams	Specific gravity	Condition of berry	Percentage moisture	Tempering water, grams	Per cent total flour	Per cent patent flour	Per cent break flour	Per cent tailings flour	Per cent bran	Per cent shorts	Per cent dust	Pounds total flour per bushel
65	163	Fife	367.9	1.3304	Plump....	13.30	20	73.85	55.86	8.00	9.99	19.41	5.58	1.15	44.31
66	165	Fife	344.7	1.3517	Plump....	12.23	20	73.85	54.79	7.08	11.97	18.85	6.25	1.04	44.31
67	169	Minnesota	348.1	1.3622	Plump....	12.94	30	75.38	57.92	7.94	9.51	17.72	5.85	1.04	45.23
68	188	Bearded Fife	368.2	1.3440	Plump....	13.63	20	74.29	54.84	7.03	12.41	17.93	6.46	1.30	44.57
69	529	Minnesota	324.5	1.3876	Plump....	12.03	25	74.92	55.44	8.08	11.40	16.37	6.94	1.24	44.95
70	1,006	Minnesota	332.7	1.3466	Shrunken,	11.88	25	73.07	55.45	7.28	10.39	17.51	8.11	1.30	43.84
		Averages	347.6	1.3537		12.66		74.22	55.71	7.57	10.94	16.83	6.53	1.17	44.53

Moisture.

The percentage of moisture was determined by drying a two-gram sample of ground wheat for seven hours at the temperature of boiling water. The average per cent of moisture is 10.51.

Tempering Water.

The tempering water required varies from 15 cc. per 2000 grams in the soft wheats to 60 cc. in the hard wheats. There does not seem to be any relation between the moisture content of the wheat berry and the amount of water needed for tempering. The hard varieties have nearly the same moisture content as the soft, but the amount of water used for the hard wheats is from three to four times that used for the soft.

Amount of Scouring Dust.

The amount removed by scouring varies from 18 to 57 grams per 2000 grams of wheat, the average being 33 grams, or a little over 1.5 per cent. The amount of scouring dust removed will vary with the time the wheat is scoured and the condition of the berry. A plump, well filled berry will, with the same amount of treatment, give a smaller amount of scouring dust than one which is shrunken and immature. Wheat which has been exposed to unfavorable conditions will lose much in scouring. The amount removed by scouring depends a great deal upon the judgment of the miller. Some advocate the removal of the entire outer bran coat. If this is done, whatever scourings are removed after the wheat is cleaned should be added to the bran. Hard and severe scouring will remove a large number of the germs.

Yield of Milling Products.

The per cent of total flour obtained varies from 69.58 to 75.19. As in the test on 1906 wheats, the soft varieties averaged lower than the hard. The low yields of 55 and 56 are due to the inferior condition of the berry. No. 57, a soft wheat with very plump and full berries, is up to the average of hard wheats in yield of total flour. The average per cent of total flour is lower than for the 1906 wheats, due to the lower average in the quality of the wheats for 1907 as compared with 1906. In all the milling tests made on the crop of 1907, both of Kansas wheats and those from other states, the break flour was kept separate from the patent and tailings. In the latter is included

all the flour made from middlings tailed over from the reductions in making patent flour. The tailings flour thus includes the low grade. In many mills the first runs of this flour would be placed with the patent. There is no objection to this except that the color is too yellow for the best patent. Where bleaching is practiced, this trade objection is overcome.

With the exception of Currell the soft wheats made a larger per cent of break flour than the hard wheats. The per cent of tailings flour is also larger as compared with the average of the hard wheats. A larger per cent of break and tailings flour means a smaller per cent of patent. This relative proportion can to a large extent be modified by the milling process. In commercial mills the equipment and the skill of the miller have more to do with this than any other factors. The per cent of bran in the soft wheats is also larger than in the hard varieties. The percentages of bran and shorts are interdependent; the more bran there is the less there will be of shorts. The per cent of dust is very variable. The per cent of dust has the same meaning in all these tests.

MILLING DATA FOR THE MINNESOTA WHEATS.

These data are found in table 6. These wheats were of excellent quality, equal to number one grade. The berry was of a larger average size than the average of all of the Kansas wheats of 1906 and 1907, but smaller than the average for the wheats grown at Manhattan in 1906. The specific gravity of these wheats is higher than that of the Kansas wheats of 1907. In comparison with the Kansas wheats of 1906, the specific gravity is a little lower than that of the wheats at Manhattan, and a little higher than that of the wheats grown at McPherson. The average number of grains per ten grams is 347, and the average specific gravity is 1.3537. Both results fall between the figures for the two groups of Kansas wheats for 1906.

The percentage of moisture in all of the Minnesota wheats is larger than in the Kansas wheats for either 1906 or 1907. The average for all the Kansas wheats for these two years is 10.57, and the average for the six Minnesota wheats is 12.66, a difference of over two per cent. Whether due to this high moisture content or not, it was not possible to classify these wheats into hard or soft by the test for hardness used in the milling room. These wheats were not hard like the Kansas hard wheats, nor were they soft like the Kansas soft wheats

or the wheats from Tennessee.   The hardness was a medium between hard and soft, and for that reason the amount of tempering water required is midway between that used for the hard and soft wheats of Kansas.

These were all good milling wheats, especially No. 169.   The per cent break and tailings flour is less than the average for the other groups of wheat used in these tests.   The flour had neither the characteristic lively, granular appearance of hard Kansas wheat flour, nor the soft, smooth appearance of soft wheat flour.   It is rather an average between the hard and soft wheat flour in its characteristics.

MILLING DATA FOR THE TENNESSEE WHEAT.

These were all good wheats equal to number one grade, with plump and large grains.   In number of grains per ten grams they were equal to the wheats grown at Manhattan in 1906, and the average specific gravity was higher than that of any of the previous groups.   In this respect they are very different from the Kansas soft wheats, which are lower in average specific gravity in comparison with the hard wheats.   These soft wheats have a higher average specific gravity than the hard wheats from Kansas and also the Minnesota wheats.   These wheats bear out the observation that large, heavy berries have a higher specific gravity than smaller berries.   (See table 7.)

The per cent of moisture is higher than in the Kansas wheats and lower than in the Minnesota wheats.   These wheats were typical soft wheats.   As the products are very much exposed during the process of milling they dry out considerably.   To counteract this to some extent and to toughen the outside bran coat a small amount of tempering water is added.   This water is added about half an hour before the wheat is milled.   This method was followed with all the soft wheats.   The average amount of scouring dust removed is a little larger than that of the Minnesota wheats, but less than that of the Kansas wheats.

In yield of flour these wheats were excellent, comparing well with the Minnesota and the Kansas wheats.   The flour was in every respect typical of that produced by the soft wheats.

MILLING DATA FOR THE WASHINGTON WHEATS.

These wheats presented a greater variety than any of the previous groups.   Forty-fold and Western Blue Stem were the most similar in appearance.   Turkey Red was of a bright

TABLE 7.—Summary of milling data. Tennessee wheats, 1907.

Serial number.	VARIETY OR NAME.	Grains per ten grams.	Specific gravity.	Condition of berry.	Percentage moisture.	Tempering water, grams.	Per cent total flour.	Per cent patent flour.	Per cent break flour.	Per cent tailings flour.	Per cent bran.	Per cent shorts.	Per cent dust.	Pounds total flour per bushel.
72	Mediterranean	348.9	1.3802	Plump	11.20	15	72.92	50.26	11.14	11.72	20.00	5.83	1.04	43.75
73	Poole	338.4	1.8736	Plump	11.12	20	72.62	47.06	9.76	15.79	19.06	7.87	0.93	43.57
74	Fulcaster	261.3	1.3770	Plump	12.03	15	74.97	49.38	13.23	12.35	18.56	5.43	1.03	44.98
75	Fultz	403.1	1.3915	Shrunken.	11.69	15	73.53	53.73	9.93	9.87	20.57	5.12	0.76	44.12
	Average	387.9	1.3807		11.51		73.51	50.11	11.02	12.43	19.54	5.93	0.94	44.11

TABLE 8.—Summary of milling data. Washington wheats, 1907.

Serial number.	VARIETY OR NAME.	Grains per ten grams.	Specific gravity.	Condition of berry.	Percentage moisture.	Tempering water, grams.	Per cent total flour.	Per cent patent flour.	Per cent break flour.	Per cent tailings flour.	Per cent bran.	Per cent shorts.	Per cent dust.	Pounds total flour per bushel.
76	Turkey Red	250.1	1.4277	Very plump.	11.51	60	76.16	54.84	6.46	14.84	16.82	6.26	0.76	45.70
77	Little Club	291.0	1.3622	Plump	10.98	50	74.79	50.94	14.00	9.87	18.84	5.60	0.76	44.87
78	Forty-fold	213.6	1.3008	Plump	13.24	10	73.86	43.73	12.26	17.86	18.67	6.13	1.33	44.32
79	Red Russian	232.7	1.3879	Very plump.	11.73	40	72.63	49.47	11.47	11.68	18.95	7.36	1.05	43.58
80	Western Blue Stem	212.5	1.3810	Plump	12.27	20	73.74	48.32	9.14	16.68	18.48	7.25	1.05	44.24
	Average	239.9	1.3719		11.95		74.23	49.46	10.67	14.22	18.37	6.52	0.99	44.34

amber color, with large, plump kernels. Little Club had the smallest kernels of any in this group, but still they were larger than the kernels of wheat from the Middle West. The kernels of Forty-fold and Western Blue Stem were unusually large. These two wheats, together with Little Club, were white, or rather cream-colored. Red Russian had the color of Turkey Red, but more of the smaller kernels.

The number of grains per ten grams shows that these wheats had the largest and the heaviest kernels of all the wheats reported in these pages. If Forty-fold is excluded, the remaining four will also average the highest in specific gravity.

If the data for kernels per ten grams and specific gravity for the different groups are brought together we have the following:

TABLE 9.

			Number of grains per ten grams.	Specific gravity.
Kansas wheats	1906	McPherson ...	385	1.3506
Kansas wheats	1906	Manhattan ...	335	1.3664
Kansas wheats	1907	....	375	1.3250
Minnesota wheats	1907	....	347	1.3587
Tennessee wheats	1907	....	338	1.3807
Washington wheats	1907	....	239	1.3719

In general there is a tendency for the larger kernels to have the higher specific gravity. But wheats can also be grouped so as to show that small compact kernels have a higher specific gravity than the large ones. (See above, under Manhattan and McPherson wheat for 1906.)

In view of the great irregularity among individual wheats in these respects, there does not seem to be any definite correlation between the size of the kernels and the specific gravity. If we compare the size of the kernels with the results of the milling tests there is no correlation. Small sound kernels will give as good flour yield as the same quality of large ones. In comparing wheats on the basis of size of kernels and specific gravity, only wheats of the same general class and of the same grade in respect to quality can be chosen. Low yields may mean small seeds not well filled out, and hence low in specific gravity. Wheats of different classes may differ in compactness and size of grain and hence the specific gravity will be different.

In moisture content these Washington wheats average a

little higher than the Tennessee and a little lower than the Minnesota. If we compare the moisture content of all the groups they arrange themselves as follows: Kansas, Tennessee, Washington and Minnesota. Too much stress must not be laid on moisture content, as that varies with the humidity of the air. Wheat shipped from a dry region to one more humid will increase in moisture content, and wheat shipped from a humid to a dry one will lose moisture.

With the exception of Turkey Red, all the Washingion wheats milled like soft wheats, but the amount of tempering water needed for Little Club and Red Russian was nearer the amount used for the hard wheats. The amount of scouring dust was small in comparison with that of the wheats from other states. This is particularly true in regard to the white varieties. The bran coat of the white wheats is very tough. The percentage of total flour averages well with the wheats from the other groups. As noted before, the hard Turkey Red gives a higher per cent of patent flour than do the soft wheats.

BAKING TESTS ON FLOURS FROM WHEATS GROWN AT McPHERSON AND MANHATTAN IN 1906.

The results of baking tests on flours from the crop of 1906 are summarized in tables 10 and 11. The method for making baking tests as outlined previously was followed. The column heading, the serial number, number of wheat and variety or name have the same meaning as in the tables giving the summaries of the milling tests, and refer to the wheat from which the flour was made. The per cent of moisture in flour was determined by drying two grams of flour in a shallow aluminum dish at the temperature of boiling water for seven hours. The average per cent of moisture of the patent flour from the wheats grown at McPherson was 11.08, and of those grown at Manhattan was 11.29. Both these amounts are lower by 1.5 per cent than the amount given by Wiley for patent and miscellaneous flours. (See Bul. 13, Part 9, Bureau of Chemistry.)

The moisture content shows but little variation. The water absorbed by 30 grams of flour denotes the amount needed to make a dough of standard stiffness. This varies from 15 cc. to 17 cc. All these were good patent flours. The percentage of

TABLE 10.—Summary of baking tests. McPherson wheats, 1906.

Serial number	Number of wheat	VARIETY OR NAME.	Per cent moisture in flour.	Water absorbed by 30 grams, cc.	Percentage of absorption.	Water used for loaf, cc.	Total water in materials, cc.	Per cent total water in materials.	Total materials, grams.	Weight of dough, grams.	Dough left in kneader.	Loss during rising, grams.	Time for rising.	Loss in baking, grams.	Weight of baked loaf hot, grams.	Weight of baked loaf corrected, grams.	Volume of loaf, cu. in.	Volume of loaf, cc.
1	1895-2	Mediterranean	10.64	15.75	52.5	178 0	214	39.26	545.0	536.7	8.3	3.8	3:01	27.50	505.9	509.5	83	1,360
2	1435	Crimean	11.84	16.75	55.8	190.0	230	41.29	557.0	550.8	6.7	3.2	2:46	31.50	515.6	521 6	80	1,311
3	1437	Crimean	10.90	16.25	54.2	184.0	221	40.01	551.0	540.0	11.0	5.4	1:58	37.40	497 2	513.3	85	1,393
4	1438	Ghirka winter	10.38	16.50	55.0	187.0	222	40.07	554.0	546.9	7.1	5.5	1:57	30.90	510.6	518.6	85	1,393
5	1442	Kharkov	10.30	16.25	54.2	184.0	219	39.74	551.0	540.6	10.4	2.3	0:58	31.50	506.8	517 8	83	1,360
6	1539	Torgova	10.74	15.75	52.5	178.5	214	39.04	545 5	534.9	10.6	2.4	1:03	30.00	502.5	502.5	83	1,360
7	1558	Turkey	11.45	16.50	55.0	187.0	226	40.91	554.0	543.3	10.7	1.7	1:02	30.60	511.0	518.4	83	1,360
8	1559	Crimean	11.82	16.50	55.0	187.0	227	41.10	554.0	545.0	10.0	3.7	2:51	30.80	510.5	519.6	81	1,327
9	1564	Pesterboden	11.26	16.25	54.2	184.0	222	40.29	551.0	545.0	6.0	5.0	4:44	31.00	509.0	518.6	81	1,327
10	1571	Turkey	11.05	17.00	56.6	193.0	231	41.25	560.0	552.1	7.9	3.5	2:50	30.00	518.6	524.5	78	1,278
11	1588	Kharkov	10.98	17.30	57.7	196.0	233	41 74	563 0	551.6	11.4	5.2	3:41	28.00	518.4	527.8	80	1,311
12	1739	Budapest	10.43	17.60	58.6	200.0	235	41.44	567.9	556.5	10.5	4.8	3:21	32.50	519.2	531.4	80	1,311
13	1756	Missouri	11.94	16.20	54.0	183.0	223	40.54	550.0	538.7	11.30	4.6	3:26	28.10	506.0	514.3	79	1,294
14	1757	Japanese Velvet Chaff	11.05	15.75	52.5	178.0	216	39.63	545.0	536.6	8.4	4.0	2:37	31.20	501.4	509.5	82	1,343
15	1824	Zimmerman X Turkey	11.60	16.50	55.0	186.0	225	40.68	553.0	543.7	9.3	3.1	2:53	27.90	512.7	518.4	82	1,343
16	1544	Beloglina	11.31	17 00	56.6	192.0	230	40.09	559.0	550.2	8.8	3.2	2:58	29.20	517.8	523.5	80	1,311
17	2906	Currell	10.49	16.00	53.3	181.0	216	39.46	548.0	542.0	6.0	3.7	3:44	27.90	510.3	512.5	79	1,294
18	2907	Zimmerman	10.74	15.70	52.3	178.0	213	39.08	545.0	538.0	7.0	3.4	3:26	28.90	505.7	509 6	83	1,343
19	2908	Malakoff	11.11	16.80	56.0	190 0	227	40.75	557.0	547.2	9.8	5.9	4:45	38.30	503.0	521.4	87	1,425
		Averages	11.08	16.40	54.7	185.7	223	40.14	552 6	543.8	8.9	4.9	......	30.59	509.5	516.9	81	......

TABLE 11.—Summary of baking tests.   Manhattan wheats, 1906.

Serial number	Number of wheat	VARIETY OR NAME.	Per cent moisture in flour	Water absorbed by 30 grams cc	Percentage of absorption	Water used for loaf, cc	Total water in materials, cc	Per cent total water in materials	Total materials, grams	Weight of dough, grams	Dough left in kneader	Loss during rising, grams	Time for rising	Loss in baking, grams	Weight of baked loaf hot, grams	Weight of baked loaf corrected, grams	Volume of loaf, cu. in	Volume of loaf, cc
21	366	Bearded Fife	11.73	17.0	56.6	198.0	2?3	40.15	560.0	544.2	15.8	3.0	1:48	32.70	509.5	525.1	80	1,311
22	367	Fultz	11.41	16.0	53.3	181.0	220	40.45	548.0	540.9	7.1	2.8	1:50	30.20	507.9	512.6	82	1,343
23	368	Malakoff	11.68	17.0	56.6	198.0	232	40.85	560.0	540.9	11.0	2.7	2:22	35.60	510.7	524.3	82	1,343
24	369	Minnesota	11.45	16.5	55.0	187.0	226	40.79	554.0	542.0	12.0	4.0	2:39	36.00	502.0	518.3	78	1,278
25	373	Defiance	11.70	17.0	56.6	198.0	232	40.85	560.0	547.5	12.5	2.8	1:37	30.90	513.8	524.3	80	1,311
26	378	Red Winter	11.40	16.5	55.0	187.0	225	40.61	554.0	540.2	13.8	2.7	2:03	31.00	506.5	518.5	80	1,311
27	570	Turkey	11.46	16.5	55.0	187.0	226	40.79	554.0	546.2	7.8	3.8	2:43	35.40	507.0	518.5	79	1,294
28	578	Kharkov	10.57	16.5	55.0	187.0	?23	40.25	554.0	544.4	9.6	4.2	2:59	38.00	501.8	518.0	78	1,278
29	574	Crimean	11.08	16.5	55.0	187.0	221	40.05	554.0	544.4	9.6	3.5	2:19	32.00	508.9	518.4	82	1,343
30	576	Weissenberg	10.42	16.5	55.0	187.0	222	40.07	554.0	547.4	6.6	3.5	2:55	34.20	509.7	518.6	82	1,343
31	577	Currell	11.12	16.0	53.3	181.0	219	39.95	548.0	539.9	8.1	3.5	2:19	29.60	506.8	512.5	80	1,343
32	578	Ghirka	11.50	16.5	55.0	200.0	239	40.71	587.0	576.9	10.1	3.8	3:04	37.10	536.0	551.4	77	1,262
		Averages	11.29	16.5	55.1	188.5	228	40.41	557.2	546.9	13.3	3.4	......	33.50	510.1	521.7	80	1,313

absorption is calculated by dividing the number of cubic cen-
timeters of water absorbed by the weight of the flour. Good
strong flour takes up more than half its weight of water. The
cubic centimeters of water used for the loaf means the amount
of water used for 340 grams of flour. This amount is calcu-
lated from the result of the absorption test. The total water
in materials is this water added in baking plus the hygroscopic
water present in the flour. The small amount of water present
in the yeast is not figured in. The hygroscopic water is found
by multiplying the percentage of moisture in the flour by 340,
the amount of flour used in the baking test. The per cent of
total water in the materials is calculated on the basis of total
water present and the sum of the weights of all the materials
used. These include the weights of the flour, water, sugar,
salt and yeast.

The weight of the dough is the amount put into the pan,
and is equal to the total materials less the amount left in the
kneader. The amount of materials lost in the kneading varies
more than any other factor, but as this is corrected for in the
weight of the loaf produced, no error affecting the final result
arises from this source. The average amount varies from nine
to thirteen grams, or from one-third to less than one-half an
ounce. This small variation will not affect the volume of the
loaf as determined. The loss during rising represents the loss
by evaporation during the time of proving in the expansion
case. This loss, other things being equal, varies with the time
of rising. This latter depends on the strength and vigor of
the yeast and the resistance offered by the gluten. With yeast
of the same strength, a dough made from a weak flour rises
quicker than a dough from a strong flour. The relative stiff-
ness or strength of the gluten does not influence the time of
rising as much as the vigor of the yeast. In these two groups
of tests the time varied from one to three hours under normal
conditions. When the time was one hour, the yeast showed
unusual strength and vigor. When the time was a little over
three hours, the yeast was becoming weak. This also modified
the volume of the loaf. The loss in baking is also due to loss
of moisture. The average loss for these two groups is 30.6
and 33.5 grams. The larger variations in some cases are due
to harder baking.

As soon as the bread was taken from the oven it was
weighed, with the pan. This total weight, minus the weight

of the pan obtained before baking, gives the weight of the hot loaf. This weight depends on the total materials, the amount left in the kneader, and the losses of moisture in rising and baking. The amount of dough left in the kneader and the losses of moisture in rising and baking have nothing to do with the baking qualities of the flour. Corrections for these must be made if the weights of the loaves are to be comparable and dependent on the absorptive power of the flour.

The loss of moisture will vary a few grams under the best conditions, and as much as eight or ten grams when the circumstances are less favorable. If no dough were left in the kneader, no correction would be necessary for this. As that is practically an impossibility this dough is figured with the bread. If the dough left in the kneader had been proved and baked under the same conditions as the loaf of bread, it would have lost the same per cent of moisture. To correct for the dough left in the kneader we ascertain the average amount lost during rising and baking. Calculated on the basis of the average amount of materials used in these tests, this loss is a little over six per cent. The loss during rising and baking is very nearly 35 grams. As fractions have no significance in these calculations the round numbers, six per cent and 35 grams, are used. Subtract six per cent from the weight of the dough left in the kneader and add the remainder to the weight of the loaf. Ascertain the loss during rising and baking. Find the difference between this and 35. The amount less than 35 is subtracted and the amount greater than 35 is added to the weight of the loaf together with the correction for the weight of the dough left in the kneader. If less than 35 grams of moisture are baked out, less than the average amount of water is removed and the loaf is heavier than the other loaves by so much, and the weights would not be comparable unless the amount is subtracted. On the other hand, if more than 35 grams are baked out the loaf is lighter by that much and the difference in loss should be added.

The volume of loaf was obtained as described above under methods of making baking tests.

With all the care and the corrections noted above, the difficulties of obtaining strictly comparable tests are more evident to the one who has made the tests than to any one else. Scientific tests should be subject to uniform and accurate measurements, and all the conditions should be under the operator's

control. That these conditions are not fulfilled in the baking tests is true, but nevertheless the baking test stands to-day as the most reliable test that we have for flour.

That the differences in the tests on the flours in these two groups are not more pronounced is an evidence of their uniform good quality. Preliminary tests were made on some of the best patent flours made in this state. The results showed that the patent flour made from these two groups was of a high grade.

The figures of most value in the above tables are the per cent of water in the flour, the percentage of absorption, the per cent of total water in the materials, the corrected weight of the loaf, and the loaf volume. The absorption test is capable of accurate measurement in experienced hands, and the variations are due to differences in the gluten of the flour if their moisture content is the same. That the percentage of absorption depends to a considerable extent on the amount of hygroscopic water present in the flour is shown by the columns showing "total water present" and "per cent of total water present in materials." There is much less variation in these than in the percentage of absorption. The per cent of total water shows the relative absorptive power due to inherent qualities of the flour. The corrected weight of the loaf shows that the weight of the bread obtained depends more on the amount of water used than any other factor. The average amount of water in the dough as made is a little over 40 per cent. As the dough loses about six per cent in rising and baking the moisture content of the fresh bread is about 34 per cent. This is lower than in some varieties of baker's bread, and higher than in some home-made bread. The hot loaf loses moisture very rapidly the first half hour after it is taken from the oven. The cold loaf has less moisture than the above figure. As soon as the bread becomes cold the rate of loss of moisture becomes slow if the bread is kept in a covered place. The loaf volume shows the power of the dough to expand in the oven and thus produce a large loaf. These results are valuable if the measurements are uniformly and accurately made and the figures are used with judgment.

Sometimes, as will appear later, a poorer quality of flour will show a larger loaf volume than a better flour. The loaf volume may also be influenced by the amount the dough is allowed to rise in the expansion case.

TABLE 12.—Summary of baking tests. Gluten expansion dough. McPherson flours, 1906.

Serial number	Number of wheat	Per cent of moisture	Per cent of absorption	Water used for loaf, grams	Total materials, grams	Total time first rising	Total height first rising	Total time second rising	Total height second rising
1	1,395-2	10.64	53.30	181.0	563.0	3:40	19.60	1:50	22.80
2	1,435	11.84	55.80	190.0	572.0	3:05	17.80	2:55	19.80
3	1,437	10.90	54.16	184.0	566.0	2:30	19.20	1:25	21.40
4	1,488	10.38	55.00	187.0	569.0	2:10	18.60	1:35	20.50
5	1,442	10.30	54.16	184.0	566.0	1:50	19.80	1:25	21.00
6	1,539	10.74	52.50	178.5	560.5	1:55	19.00	1:40	20.50
7	1,558	11.45	55.00	187.0	569.0	6:13	17.00	2:20	19.60
8	1,559	11.82	55.00	187.0	569.0	2:55	18.70	1:40	20.70
9	1,564	11.26	54.16	184.0	566.0	2:50	18.50	1:35	20.00
10	1,571	11.05	56.60	193.0	575.0	5:10	17.20	2:10	19.70
11	1,588	10.98	57.60	193.0	575.0	5:30	18.50	2:10	20.00
12	1,739	10.43	58.60	200.0	582.0	4:30	17.10	2:40	19.50
13	1,756	11.94	54.00	183.0	565.0	3:55	20.00	1:50	19.50
14	1,757	11.05	52.50	178.0	560.0	5:00	17.80	2:10	21.50
15	1,824	11.60	55.00	186.0	568.0	4:45	17.60	1:55	20.80
16	1,544	11.31	56.60	192.0	574.0	3:20	20.00	2:13	21.10
17	2,906	10.49	53.30	181.0	563.0	4:50	17.00	1:40	20.50
18	2,907	10.74	52.30	178.0	560.0	5:00	18.00	1:50	22.00
19	2,908	11.11	56.00	190.0	572.0	3:10	19.50	2:45	22.80
	Average..	11.05	54.82	186.1	568.1	4:26	18.46	1:59	20.72

TABLE 13.—Summary baking tests. Gluten expansion dough. Manhattan flours, 1906.

Serial number	Number of wheat	Per cent of moisture	Per cent of absorption	Water used for loaf, grams	Total materials, grams	Total time first rising	Total height first rising	Total time second rising	Total height second rising
21	366	11.73	58.30	198.0	580.0	3:05	20.60	2:00	21.50
22	867	11.41	53.30	181.0	563.0	3:50	19.30	2:10	22.00
23	368	11.68	56.60	193.0	575.0	3:55	19.00	2:15	20.70
24	369	11.45	56.60	193.0	575.0	4:10	18.00	2:15	19.50
25	373	11.70	56.60	193.0	575.0	2:55	19.50	2:00	22.00
26	378	11.40	55.00	187.0	569.0	3:15	19.40	2:30	18.50
27	570	11.46	55.00	187.0	569.0	4:10	18.50	2:20	22.00
28	573	10.57	55.00	187.0	569.0	4:05	18.70	2:00	20.80
29	574	11.08	55.00	187.0	569.0	3:40	18.40	1:40	20.60
30	576	10.42	55.00	187.0	569.0	3:40	19.50	2:00	21.00
31	577	11.12	53.30	181.0	563.0	3:30	18.50	1:50	21.40
32	578	11.50	55.00	187.0	569.0	3:15	16.50	1:45	18.70
	Average,	11.29	55.39	188.40	570.4	3:37	18.80	2:45	20.72

GLUTEN EXPANSION DOUGH.

The gluten expansion tests were conducted as previously outlined. The purpose was to test the quality of the gluten. The first six columns have the same meaning as in the previous tables. The total time first rising denoted the time the dough took to rise to the point where it began to fall. When this happened the reading was taken and the dough was kneaded for a few minutes and the process of rising was repeated. The time for the first rising is more than twice that of the second rising. This must be due to the increased vigor of the

yeast, or the decreased resistance of the dough, or both. The total height in the second rising is also greater. This same phenomenon is observed in a different way in the ordinary baking. The second rising takes less than half as long as the first, and the loaf volume is greater in a loaf which has been knocked down than in a loaf which has not been.

The tests with the gluten expansion dough do not seem to furnish any aditional information which is valuable beyond what was learned in the straight dough baking test. For this reason this method of testing has been discontinued for the present.

SPECIAL BAKING TESTS.

The purpose of these experiments was to obtain data for working out a more satisfactory method of making baking tests. The results of these tests are shown in table 14. All the tests, excepting numbers 12 to 15 and 24 to 28, were made on a sample of patent unbleached flour obtained from the Manhattan Milling Company. The general plan was to make the tests for each group identical except in the one particular under investigation.

INFLUENCE OF VARYING AMOUNTS OF WATER.

Tests 1 to 3 show the effect of using different amounts of water in making the dough. In No. 1 as much water was used as good working of the machine would allow. In No. 2 the dough was made of the same stiffness as the standard used in the baking tests. The absorption test showed that 17.5 cc. of water for 30 grams of flour would make a dough of standard stiffness. This, then, was the amount for No. 2. For No. 1, 18.5 cc. were used, and for No. 3 16.5 cc., and on this basis the amounts of water needed for the loaves were calculated. Photographs of the loaves are shown in plate 12. The coarser texture of loaf No. 1 shows the softening effect of water on the gluten. The closer texture of No. 3 shows a greater resistance of the gluten due to a smaller amount of water. It is evident that when comparative tests are made the dough must be made of a standard stiffness, if texture is to be included in the comparison. It is also evident that good bread may be made by this method of baking, even if the water content varies considerably. Unless great care is used in making the absorption test, this has very little value in determining the amount of water to be used in making the baking test.

TABLE 14.—Special baking tests.

Number	Point Tested.	Water absorbed by 30 grams, cubic centimeters	Percentage of absorption	Water used for loaf, cubic centimeters	Total materials	Weight of dough, grams	Time for rising	Loss in rising, grams	Weight of baked loaf	Weight of baked loaf, corrected	Rise in expansion case, millimeters	Total reading rise in oven	Net rise in oven
	To show effects of—												
1	different amounts of water	18.5	61.6	210	577	556	1:18	15	539	559	5	37	32
2	different amounts of water	17.5	58.3	198	565	552	1:18	14	537	548	5	40	35
3	different amounts of water	16.5	55.0	186	553	536	1:34	14	522	537	5	38	33
4	knocking down 3 times	16.0	53.3	180	547	537	3:08	28	508	530	5	45	40
5	knocking down 2 times	16.0	53.3	180	547	538	2:18	23	514	530	5	46	41
6	knocking down 1 time	16.0	53.3	180	547	538	1:45	17	520	535	5	47	42
7	knocking down 0 time	16.0	53.3	180	547	538	1:08	14	523	530	5	38	33
8	rising in expansion case 5 mm	16.5	55.0	187	554	542	1:27	19	522	537	5	33	28
9	rising in expansion case 10 mm	16.5	55.0	187	554	542	1:38	19	522	537	10	34	24
10	rising in expansion case 15 mm	16.5	55.0	187	554	550	1:47	12	537	543	15	37	22
11	rising in expansion case 20 mm	16.5	55.0	187	554	543	1:58	12	530	543	20	37	17
12	5 gm. yeast on soft wheat flour	15.0	50.0	180	532	518	3:58	21	496	515	4	24	20
13	10 gm. yeast on soft wheat flour	15.0	50.0	170	537	524	1:46	15	508	520	0	27	27
14	knocking down, soft wheat	15.0	50.0	200	621	611	3:24	18	589	601	5	59	54
15	8 gm. yeast on soft wheat flour	16.5	55.0	187	535	527	2:38	.....	503	507	5	23	18
15a	6 gm. yeast on soft wheat	16.5	55.0	187	543	536	1:32	18	517	526	5	28	23
16	2 gm. yeast, patent flour, hard wheat	16.5	55.0	187	546	536	3:12	14	521	530	5	29	24
17	4 gm. yeast, patent flour, hard wheat	16.5	55.0	187	548	536	2:06	14	521	532	5	29	24
18	8 gm. yeast, patent flour, hard wheat	16.5	55.0	187	552	537	1:30	16	520	535	5	35	30
19	16 gm. yeast, patent flour, hard wheat	16.5	55.0	187	560	548	0:45	14	533	543	5	42	37
20	starting to bake { initial temperature 265°, final temperature 430°	16.5	55.0	187	554	544	1:05	17	526	537	5	41	36
21	starting to bake { initial temperature 370°, final temperature 466°	16.5	55.0	187	554	539	1:02	18	520	537	5	38	33
22	starting to bake { initial temperature 428°, final temperature 460°	16.5	55.0	187	554	542	1:03	18	528	537	5	40	35
23	starting to bake { initial temperature 475°, final temperature 276°	16.5	55.0	187	554	538	1:04	.....	530	545	5	44	39
24	flour sifted over 12 cloth	16.5	55.0	55	165	163	1:43	10	153	154	5	26	21
25	flour sifted over 14 cloth	16.5	55.0	55	165	163	1:31	9	154	155	5	23	18
26	flour sifted through 14 cloth	16.5	55.0	55	165	163	1:43	9	154	155	5	17	12
27	flour mixed with siftings of shorts	16.5	55.0	55	165	161	2:20	7	154	156	2	fell	....
28	regular patent Manhattan No. 1	16.5	55.0	55	165	163	1:30	11	152	153	5	19	14

The oven expansion shows very little difference in these loaves. The oven expansion seems to be relatively independent of the amount of water used for the loaf.

A NEW DESIGN FOR TEST BAKING-PANS.

The baking tests conducted on the flour from the crop of 1906 demonstrated that loaf volume depends to a very large extent on the amount of rise before the loaf is put in the oven to bake. The desirability of more correctly measuring the amount of rise in the oven was also made evident. To accomplish these two ends a special baking pan was designed and constructed. These pans were made in two sizes, one to bake a pound loaf using 340 grams of flour, and the other using 100 grams of flour for making tests on small amounts.

The lower part is in the form of a truncated cone and the upper part is cylindrical. This form of the lower half facilitates the removal of the loaf after baking, and this has also such capacity that the dough fills it entirely when the proving is complete. The subsequent rise in the oven is vertical. Through the center of the cover frame passes a small shaft to the lower end of which is attached a cupped disk. This shaft is held in a vertical position by means of a short piece of brass tubing, through which it passes. This allows a free up-and-down motion. This disc is cupped so as to fit the top of the roundish dough as it rises. The measurements as to the amount of rise before baking and in the oven are made on the shaft above the brace which holds the brass tube in place. The distance is measured between the cap of the shaft and the brass tube, and the measurement is taken by means of a pair of dividers. These distances are measured in millimeters. (See plates 10 and 11.)
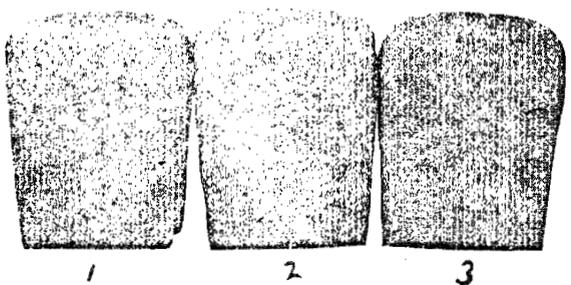
PLATE 12. Effect of varying the amount of water used in making dough. No. 1, 18.5 cc. to 30 g. flour. No. 2, 17.5 cc. to 30 g. flour. No. 3, 16.5 cc. to 30 g. flour.

—3—177
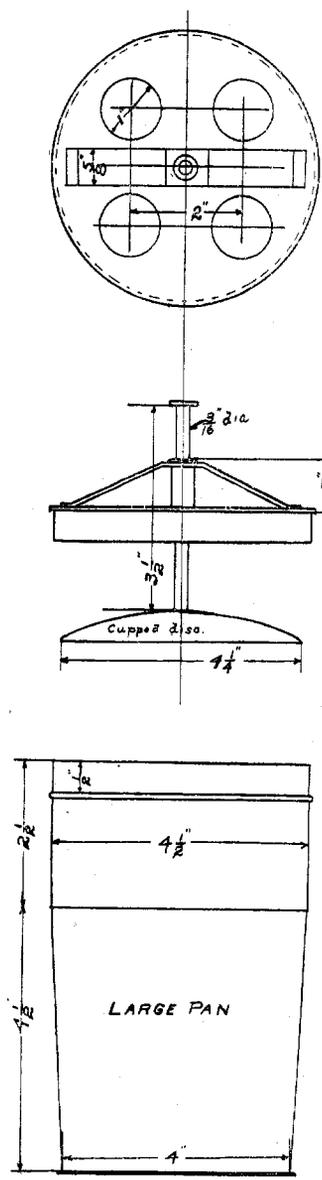
PLATE 10.   Section through larger size
of baking tins.
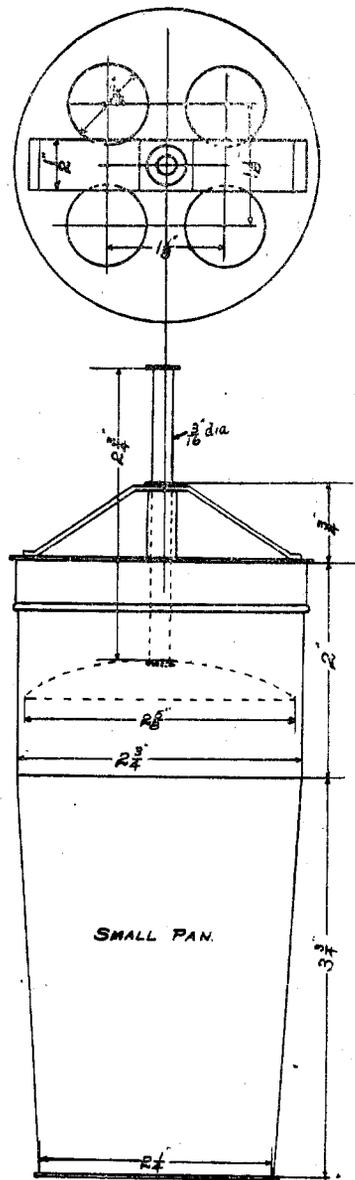
PLATE 11.   Section through small baking
tins.

EFFECT OF WORKING THE DOUGH REPEATEDLY.

Tests 4 to 7 show the effect on the dough of allowing it to rise a standard amount and knocking it down again. As soon as the dough had risen the standard five millimeters it was put in the kneader and worked for two minutes, when it was put in the pan and allowed to rise again. No. 4 was knocked down in this manner three times, No. 5 two times, No. 6 once, and No. 7 was baked as soon as the dough had risen the standard amount. The resulting loaves are shown in plate 13. The dough was made hard in each case to facilitate the subsequent handling. The loaves show little difference in texture. The loss in rising and baking is proportional to the number of treatments. The most noticeable effect is the net rise in the oven. Those that were knocked down show no material difference, but in No. 7 the effect of not knocking down is very decided. That the effect of knocking down once has a very decided effect on the net rise in the oven was noted in several preliminary trials, but that several repetitions of such treatments should show no difference was not known. If Nos. 4, 5 and 6 show any significant differences, the effect of knocking down more than once is to show a weakening in the expansive power of the dough or of the vitality of the yeast. It may be that with a weaker flour greater difference would have appeared. If that is the case, the flour which stands better the longer period of fermentation shows the greater strength.

EFFECT OF DIFFERENCES IN THE EXTENT OF THE RISING.

Tests Nos. 8 to 11 show the effects of different amounts of rising before the loaf was baked. No. 8 was allowed to rise five millimeters, No. 9 10 mm., No. 10 16 mm., and No. **11** 20 mm. The most noticeable effect was on the texture and the net rise in the oven. There was a progressive increase in coarseness of texture corresponding to the increased rising before baking. The net rise in the oven showed a constant decrease while the total rise increased. The time of rising averaged ten minutes more in each case. This comparatively small increase in time would not materially affect the yeast, so the result of oven expansion is due to causes altering the condition of the dough. The results show that if the dough is allowed to prove longer than the standard amount, there will
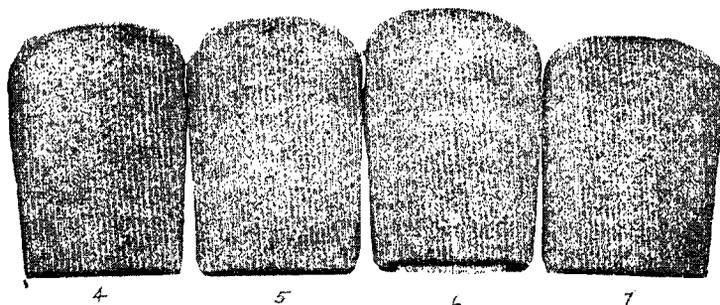
PLATE 13. Effect of allowing the dough to rise a standard amount and then re-kneading one or more times. No. 7, not reworked. No. 6, reworked once. No. 5, reworked twice. No. 4, reworked three times.

be a small increase in the net rise in the oven, but not corresponding to the additional rise before baking. The oven expansion results from the retention of the gas by the dough. As the time of proving is prolonged this power is weakened, and there is a corresponding less net rise in the oven.

TESTS OF PATENT FLOUR FROM SOFT WHEATS.

Two tests from soft wheats were made which differed in two particulars: the amount of yeast, and the amount of rising before baking. For No. 12, five grams of yeast were used; for No. 13, ten grams. In No. 12 the rise was four millimeters when put in the oven; in No. **13 it** was zero, that is, the dough had risen just enough to touch the disk. The time of proving was three hours and fifty-eight minutes in No. 12, and in No. 13 the time was one hour and forty-six minutes, a difference of over two hours, due to the amount of yeast. No. 12 was coarse in texture while No. 13 was very fine and light. The net rise in the oven was greater in No. 13 than in No. 12. This increased rise is evidently due to the presence of a greater amount of yeast. Stiff dough and a short rising period give a fine texture to bread made from soft wheat flour.

Test No. 14 was made on a break flour from Tennessee soft wheat. After rising the standard amount the loaf was knocked down. This loaf shows a greater net rise in the oven than any flour so far tested. A large expansion in the oven is not always an indication of superiority in quality of flour. A second-grade flour may give a larger loaf volume than a patent flour from a stronger wheat.

In tests Nos. 15 and 15a the same kind of flour was used as in 12 and 13. In these latter the dough was mixed hard, while

in 15 and 15a it was made as soft as it could well be worked. In preparing 15, three grams of yeast were used, and in 15a, six grams. As in 12 and 13, the loaf having the larger amount of yeast showed the greater amount of expansion. Loaves from 15 and 15a were of coarse texture. This would be expected from the results obtained in Nos. **1, 2 and 3.**

EXPERIMENTS USING DIFFERENT AMOUNTS OF YEAST.

Four tests, Nos. 16 to 19, were made on patent hard wheat flour, using two, four, eight, and sixteen grams of yeast for the respective loaves. These loaves are shown in plate 14. The notable differences in the results are time for rising, total and net expansion in the oven, and texture. The time of rising varies inversely with the amount of yeast, being 45 minutes where 16 grams are used and three hours and 12 minutes where two grams are used. The time of rising is not exactly inversely proportional to the amount of yeast used. If this were the case the time for rising for No. 16 would be six hours. The time of rising is very nearly in an arithmetrical ratio, while the amount of yeast used is a geometrical ratio. The total and net expansion shows an increase, if we except No. 17, which does not show any increase over No. 16. The best texture was found in Nos. 17 and 18, the other two being notably coarser. From the tests on the soft wheat flours we found that a longer period of fermentation due to a less amount of yeast results in a coarser texture, and a shorter period in a finer texture. This is found true of hard wheat flours if we compare Nos. 16 and 17. No. 18 is not very much different from No. 17, but the texture of No. 19 is coarser than No. 16. We find then that coarse texture may be due to a long period of fermentation because of a small amount of yeast, and also due to a very large amount of yeast. In a long period of fer-

16   *17*   *18*   *19*
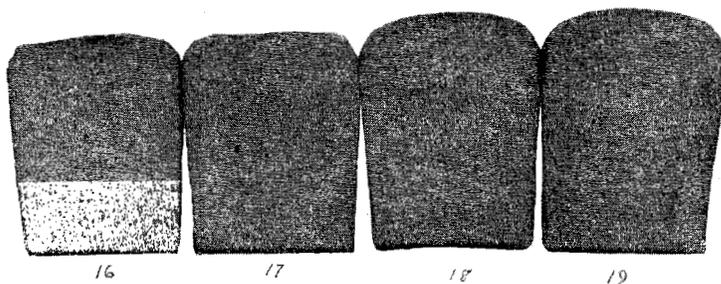
PLATE 14.   Effect of differing amounts of yeast.   No. 16, had 2 g. yeast; No. 17, 4 g.; No. 18, 8 g., and No. 19, 16 g.

mentation the gluten is weakened and the result is a coarse texture. A large amount of vigorous yeast will also produce coarse texture, as the gluten is weak when measured against the force due to the extra amount of yeast. It should also be noted that patent flours from hard wheats are not so sensitive to these different influences as are the flours from soft wheats.

EFFECT OF DIFFERENCE IN INITIAL BAKING TEMPERATURE.

Tests Nos. 20 to 23 were made to show the effects of different initial temperatures for baking. Nos. 20, 21 amd 22 were put into the oven at a lower temperature than usual and then the temperature was raised to the usual point at which the loaf was finished. No. 20 was started at 265° C., and the final temperature was 430° C. No. **21** was started at 370° C., and the final temperature was 466° C. **No.** 22 was started at 428° C., and the final temperature was 460° C. This was nearly the normal temperature. No. **23** was started at 475° C., and then lowered to 276° C., at which it was kept. The results naturally show a difference in the time of baking. They also show differences in the total and the net expansion in the oven. This latter shows no apparent correlation with the conditions under which the loaf was baked. The time for baking No. **20** was 45 minutes, No, **21, 40** minutes, No. **22,** 38 minutes, and No. 23, 45 minutes. This last loaf developed no brown crust on the outside, although the crumb was good.

TESTS OF FLOURS DIFFERING IN FINENESS.

Tests Nos. **24 to** 28 were made in the small baking pans. The quantity of each ingredient was the same in the five trials. One hundred grams flour, four grams yeast, four grams sugar and two grams of salt were used, together with 55 cc. of water. For Nos. 24, 25 and 26 patent flour was separated into three grades of granulation by means of sieves. For No. **24** such flour was used as remained on a No. 12 sieve after prolonged siftings. For No. **25** the flour used passed through a No. 12 sieve but was retained by a No. **14** sieve, and for No. 26 flour that passed **a** No. 14 sieve was used. For No. 27 the same kind of flour was used as in No. 26, but this was mixed with one-third its weight of siftings from shorts. These siftings were obtained by putting some fine shorts on a No**. 14** sieve together with a handful of wheat kernels and sifted for some time. No. **28** was baked from a normal flour and serves as a check on the others.

The differences in results are found in the time of rising, total net reading in the oven. The time of rising is the longest in the case of No. 27. The fine flour together with the fine branny material has a retarding effect on the yeast. This loaf would not rise as high as the others in the expansion case, and instead of rising more in the oven, it fell. In the others there is a regular increase in the rise in the oven corresponding with the size of granulation. Whatever the reason may be the larger granulation results in a larger loaf. These results point in a definite direction and the results should be confirmed by more extended trials.

BAKING TESTS ON FLOURS FROM WHEATS OF CROP OF 1907.

FLOURS FROM MANHATTAN AND MCPHERSON WHEATS.

The summarized data for baking tests on flour from Manhattan and McPherson wheats, crop of 1907, are found in table 15. The meaning of the column headings will be clear from what has been said about the previous tables. The percentage of absorption is in all cases lower for the soft wheats as compared with the hard. The average percentage of absorption for the soft wheats is 50.80 and the hard is 55.88. The average per cent of total water for the soft wheats is 38.49 and that for the hard is 40.58, a real difference of over two per cent in favor of the hard wheats. From the other data presented it is clear that the tests were conducted with quite uniform conditions. The factors of largest variation beyond control are the amount of dough left in the kneader and the loss during rising. An attempt is made to correct for this in the column headed weight of baked loaf corrected. These corrected weights vary very nearly in the same ratio as the weight of the total materials. That bread loses considerable moisture the first few hours after baking is shown by the column headed "weight of baked loaf, cold." The average loss in this way is 30 grams, or nearly twice the amount lost in rising and baking. The greater part of this loss takes place the first few hours after the bread is baked.

Expansion in Oven and Volume.

As before noted, the rise in millimeters in the oven is the net amount of rise of the loaf in the oven measured on the shaft. This factor is very closely related to volume. That

large expansion and loaf volume is not always related to strength of flour is seen from these figures. The largest rise and loaf volume is in No. 56, a soft wheat flour. This has the lowest percentage of absorption. The texture of this bread was quite coarse, showing a weak gluten. In milling this wheat it was noticed that a musty smell was present. The kernels appeared shrunken and immature. In consulting the yield we find 7.17 bushels per acre. This loaf had the shortest time for expansion. This was not due to the yeast, because tests Nos. 55, 56, 57, and 64 were all made the same day, in the order given, with the same lot of yeast; yet the time for proving for No. 56 is one-third less than for any of the others. The expansion in the pan does not mean exactly the same as the loaf volume. If the loaf is more rounded on top the pan-expansion will be larger than with another loaf, the actual volume of which is the same, but which is flatter on top. Hence the disagreement between the rise in millimeters in the oven and the volume of the loaf.

In ascertaining loaf volumes, these loaves, being round, were placed in a tin can made nearly the size of the loaves. Then flaxseed was added from a 1000 cc. graduated cylinder reading to 10 cc. The capacity of the can being known the loaf volume was calculated from the readings of the cylinder. The volume in cubic inches was calculated from the volume in cubic centimeters. All the six hard wheats grown at Manhattan in 1907 were of excellent quality, and the flours produced from these wheats were correspondingly good. If we arrange these six wheats in the order of percentage of absorption we have the following result:

Serial number.	Percentage of absorption.	Rise in oven, Millimeters.
62	60.00	24
59	58.30	38
60	56.60	34
63	56.60	20
58	55.00	35
61	55.00	28

It is evident that in order to compare these flours we must take into consideration both the percentage of absorption and the oven expansion. Thus in choosing between 62 and 59 we easily see that No. 59 is the better flour. The percentage of absorption shows that it is a strong flour. While the absorption is not equal to No. 62, the greater expansion more

TABLE 15.—Summary of baking tests. Manhattan and McPherson wheats. 1907.

Serial number	Number of wheat	Variety or Name	Per cent moisture in flour	Water absorbed by 30 grams, cubic centimeters	Percentage absorption	Water used for loaf, cubic centimeters	Total water in materials	Per cent total water	Total materials, grams	Weight of dough, grams	Dough left in kneader	Loss during rising, grams	Time for rising	Loss in baking, grams	Weight of baked loaf, hot, grams	Weight of baked loaf, corrected, grams	Weight of baked loaf, cold, grams	Rise in expansion case, mm	Rise in oven, millimeters	Volume of loaf, cubic centimeters	Volume of loaf, cubic inches
53	1,539	Torgova	10.64	15.75	52.30	178	214	39.26	545	528	17	2.00	1:43	15.00	511	529	483	5	26	1220	74
54	1,571	Turkey	11.02	16.00	53.80	181	218	39.78	548	536	12	1.00	1:36	18.00	517	531	486	5	34	1300	79
55	2,906	Currell	10.18	15.50	51.60	176	211	38.85	543	531	12	1.02	1:02	15.00	515	528	490	5	35	1400	85
56	2,907	Zimmerman	10.13	15.00	50.00	170	204	36.12	537	519	18	1.00	0:41	18.00	500	520	475	5	49	1515	92
57	367	Fultz	9.98	15.50	51.60	176	210	38.67	543	531	12	1.00	1:15	13.00	517	528	493	5	23	1250	76
58	368	Malakoff	10.52	16.50	55.00	187	222	40.00	554	542	12	1.00	1:21	14.00	527	538	486	5	35	1830	81
59	369	Minnesota	10.86	17.50	58.30	198	235	41.59	565	548	17	1.00	1:07	12.00	535	550	500	5	38		
60	373	Defiance	10.50	17.00	56.60	193	229	40.89	560	542	18	1.00	1:10	15.00	526	542	498	5	34		
61	380	Turkey	10.46	16.75	54.10	190	225	40.39	557	540	17	1.00	1:22	15.00	524	540	496	5	28		
62	574	Crimean	10.51	18.00	60.00	204	240	42.03	571	559	12	1.00	1:40	13.00	545	556	506	5	24	1210	74
63	576	Weissenberg	10.35	17.00	56.60	193	228	40.92	560	547	13	1.00	1:19	15.00	531	543	495	5	20	1180	71
64	577	Currell	10.95	15.50	51.60	176	213	39.22	543	533	10	1.00	1:20	14.00	518	526	496	5	26	1250	76
		Averages	10.51	16.30	54.19	185	219	39.69	552	538	14	1.05	1:18	14.75	522	536	492	5	31	1295	79

TABLE 16. Summary of baking tests. Minnesota wheats. 1907.

Serial number	Number of wheat	Variety or Name	Per cent moisture in flour	Water absorbed by 30 grams, cubic centimeters	Percentage of absorption	Water used for loaf, cubic centimeters	Total water in materials, cubic centimeters	Per cent total water	Total materials, grams	Weight of dough, grams	Dough left in kneader, gms.	Loss during rising, grams	Time for rising	Loss in baking, grams	Weight of baked loaf, hot, grams	Weight of baked loaf, corrected	Weight of baked loaf, cold, grams	Rise in expansion case, mm	Rise in oven, millimeters	Volume of loaf, cubic centimeters	Volume of loaf, cubic inches
65	163	Fife	13.30	16.00	53.30	181	226	41.24	548	538	10	1.00	1:08	14.00	523	534	488	5	31	1290	79
66	165	Fife	12.23	15.00	50.00	170	211	39.12	539	530	9	1.00	1:37	14.00	515	522	402	5	21	1230	75
67	169	Minnesota	12.94	16.50	55.00	187	231	41.66	554	542	12	1.00	1:06	15.00	526	537	490	5	35	1310	79
68	188	Bearded Fife	13.63	16.00	53.30	181	227	41.42	548	537	11	1. 0	1:07	13.00	523	531	492	5	28	1300	79
69	529	Minnesota	12.03	16.50	55.00	187	228	41.15	554	543	11	1.00	1:08	14.00	528	537	495	5	32	1300	79
70	1,006	Minnesota	11.88	17.00	56.60	193	233	41.45	562	555	7	1.00	1:35	15.00	539	545	506	5	30	1260	76
		Averages	12.66	16.16	53.80	143	226	41.00	551	541	10	1.00	1:16	15.80	526	534	492	5	30	1281	78

than offsets this difference. Nos. 60, 63, 58 and 61 are easily rated in the order of oven expansion.

The results on the flours from soft wheat do not show the same correlation between the percentage of absorption and the oven expansion. But the texture of the loaves Nos. 55 and 56 shows that the large oven expansion was due to weakened gluten, and so these are classed as inferior to Nos. 57 and 64.

The loaves illustrated in plate 15 were made from soft wheat flour. No. 56 is from the poorest wheat and shows the largest oven expansion and loaf volume.

Plate 16 illustrates loaves made from hard wheat flour. The uniform, even character of these loaves is apparent.
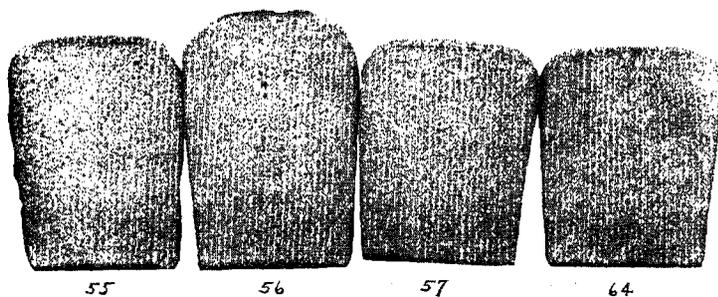
PLATE 15. Loaves from wheat raised at McPherson, Kan. No. 55, Currell; No. 56, Zimmerman; No. 57, Fultz; No. 64, Currell.
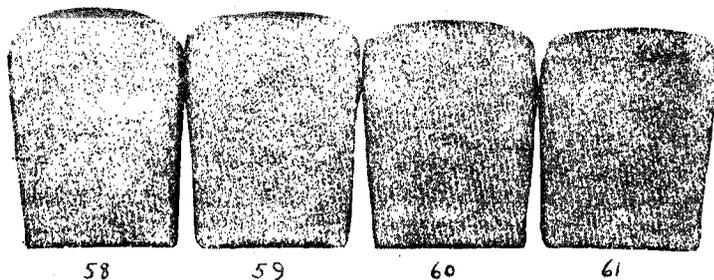
PLATE 16. Loaves from Kansas wheats, crop of 1907. No. 58, Malakoff; No. 59, Minnesota; No. 60, Defiance; No. 61, Turkey.

FLOURS FROM THE **MINNESOTA** WHEATS.

The data for the tests on the Minnesota and Dakota wheats are found in table 16. All these flours have a high percentage of absorption, but not as high as the average of the flours from hard wheats grown at Manhattan. The percentage of absorption is greater than that of the flours from the Kansas soft wheats, and less than that of the hard wheat flours. In per

cent of total water used for the loaf these flours average well.
These flours are very uniform, a desirable quality.   If they
are arranged in the order of percentage of total water we have
the following:

TABLE 17.

Serial number.	Per cent total water.	Oven expansion.
67	41.66	35
70	41.45	30
68	41.42	28
65	41.24	31
69	41.15	32
66	39.12	21

With the exception of No. 66 all are strong flours, both in
absorptive power and oven expansion.   In grinding No. 66 it
was noticed that it had more the characteristics of a soft wheat
than a hard.   In kneading, the dough had a tendency to sticki-
ness.

The loaves from four of the Minnesota wheats are shown in
plate 17.   No. 67, from Minnesota 169, has the most even
texture.   As this flour leads the others both in per cent of
total water and oven expansion, it is easily the best of the
group.
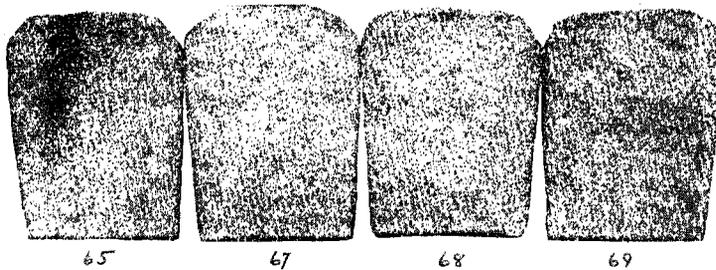
PLATE 17.   Loaves from Minnesota wheats, crop of 1907. No. 65, Fife;
No. 67, Minnesota ; No. 68, Bearded Fife ; No. 69, Minnesota.

FLOURS FROM TENNESSEE WHEATS.

The summary of these is found in table 18.   Although
the per cent of moisture is lower than the Minnesota wheats
the percentage of absorption as well as the total water is less.
These were typical of soft wheat flours and had all the desir-
able qualities looked for in such flours.   These four loaves
were baked the same day from the same lot of yeast, and so
all the differences are due to the flour itself.   The relation

between the rise in millimeters in the oven and the percentage of total water present is uniform. The loaves are shown in plate 18. They are uniform and typical for bread made from soft wheat. The texture is somewhat poorer as the percentage of total water decreases. Thus we classify Nos. 72 and 73 as superior flours as compared with 74 and 75.
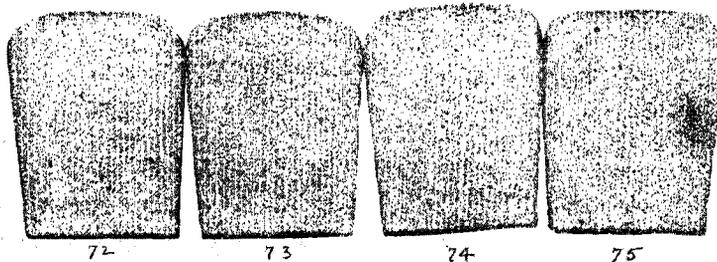
PLATE 18. Loaves from Tennessee wheats. No. 72, Mediterranean; No. 73, Poole; No. 74, Fulcaster; No. 75, Fultz.

FLOURS FROM THE WASHINGTON WHEATS.

These tests are summarized in table 19. With the exception of Turkey Red, these flours are weaker in percentage of absorption than any others of the flours in these series. Turkey Red is a hard wheat and gives a correspondingly strong flour. The other wheats produce a flour typical of soft wheats. As soft wheats these are inferior in oven expansion to the flours from the Tennessee soft wheats. The oven expansion shows a uniform relation between the percentage of total water and the percentage of absorption, if Turkey Red is left out of comparison. A strong flour may have a smaller oven expansion than a weak one when the flours are from different classes of wheat. The Red Russian is easily classed as the poorest. The loaves from four of these wheats are shown in plate 19. The coarse texture of the loaves from the soft wheats shows the weak character of the gluten. The texture of No. 76, Turkey
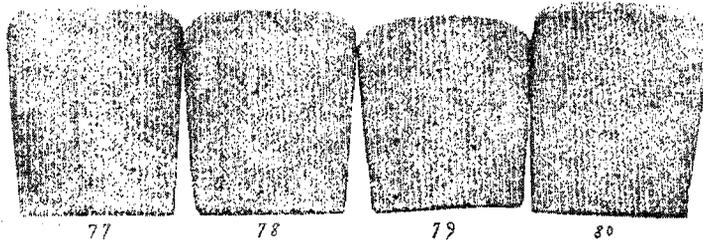
PLATE 19. Loaves from Washington wheats. No. 77, Little Club. No. 78, Forty Fold; No. 79, Red Russian; No. 80, Western Blue-stem.

TABLE 18.—Summary of baking tests. Tennessee wheats. 1907.

Serial number	VARIETY OR NAME.	Per cent moisture in flour	Water absorbed by 30 grams, cubic centimeters	Percentage of absorption	Water used for loaf, cubic centimeters	Total water in materials, cubic centime'rs	Per cent total water	Total materials, grams	Weight of dough, grams	Dough left in kneader, grams	Loss during rising, grams	Time for rising	Loss in baking	Weight of baked loaf, hot	Weight of baked loaf, corrected	Weight of baked loaf, cold	Rise in expansion case, mm	Rise in oven, millimeters	Volume of loaf, cubic centimeters	Volume of loaf, cubic inches
72	Mediterranean	11.20	15.50	51.60	176	214	39.41	543	531	12	1.00	1:14	15	515	526	490	5	32	1300	79
73	Poole	11.12	15.50	51.60	176	213	39 22	543	530	13	1.00	1:15	16	513	526	486	5	30	1360	76
74	Fulcaster	12.03	15.00	50.00	170	210	39.10	537	526	11	1.00	1:13	15	515	525	486	5	29	1300	79
75	Fultz	11.69	14.50	48.30	165	204	38.22	532	518	14	1.00	1:12	15	517	525	477	5	26	1260	76
	Averages	11.51	15.10	50.37	172	210	39.00	539	526	13	1.00	1:13	15	515	525	485	5	29	1280	78

TABLE 19.—Summary of baking tests. Washington wheats. 1907.

Serial number	VARIETY OR NAME.	Per cent moisture in flour	Water absorbed by 30 grams, cubic centimeters	Percentage of absorption	Water used for loaf, cubic centimeters	Total water in materials, cubic centime'rs	Per cent total water	Total materials, grams	Weight of dough, grams	Dough left in kneader, gms.	Loss during rising, grams	Time for rising	Loss in baking, grams	Weight of baked loaf, hot	Weight of baked loaf, corrected	Weight of baked loaf, cold	Rise in expansion case, mm	Rise in oven, millimeters	Volume of loaf, cubic centimeters	Volume of loaf, cubic inches
76	Turkey Red	11.51	17.50	58.30	198	237	41.79	567	560	7	1.00	1:46	12	547	550	516	5	18	1140	69
77	Little Club	10.98	14.50	48.30	165	202	37.96	532	528	4	1.00	1:27	17	510	515	483	5	20	1210	72
78	Forty-fold	13.24	14.50	48.30	165	210	39.47	532	524	8	1.00	1:28	16	507	515	487	5	16	1140	69
79	Red Russian	11.73	14.00	46.60	159	199	37.85	526	519	7	1.00	1:30	17	501	505	474	5	9	1070	65
80	Western Blue Stem	12.27	15.50	51.60	176	217	39.96	543	536	7	1.00	1:18	15	520	526	487	5	21	1190	72
	Averages	11 94	15.20	50.30	173	213	39.51	540	533	7	1.00	1:29	15	517	521	489	5	17	1150	70

Red, was equal to that of the best bread from hard wheat flours. If the oven expansion is to mean anything, it is evident that standards have to be adopted for different grades of flour. Also the best ratio between the total water present and the oven expansion should be determined for different classes of flours.

BAKING TEST COMPARING PATENT, BREAK AND TAILINGS FLOUR FROM THE SAME WHEATS.

The summaries of these tests are found in tables 20, 21, 22, and 23. The column headings will be understood from what has been said regarding previous tables. The amount of water used was the same for the three kinds of flour from the same wheat. Its amount was determined from the previous baking tests, but a less amount was used for the patent flour in these tests in order that with the same amount of water a workable dough might be made with the break and tailings flours. One-half cubic centimeter less than the amount absorbed by the 30 grams of patent flour in the previous tests was used as a basis of calculating the amount of water needed. Thus if 16 cc. was found to be the correct amount in the previous test, the proportion $15.5 : 30 :: x : 100$ would give the amount of water added.

These tests were made in the small baking tins. Unfortunately not enough flour was available to make comparative absorption tests, but from the results obtained the strength of the patent flour as compared with the others is clearly apparent.

The most notable features in these comparative tests are the per cent moisture, per cent total water, time for rising, net rise in oven, volume of loaf, and color of loaf. These data are summarized in tables 24, 25, 26, and 27. The patent flours, with the exception of those from Washington, average higher in moisture than the break flours. The tailings flour is in all cases lower than the other two. This low moisture content of the tailings flour is due to loss of moisture in grinding. As the same amount of water was added to each of the flours the difference in per cent of total water was determined by the amount of water in the flour. The high per cent of water in the break flour from the Washington wheats is due to the large amount of water added in tempering. This is larger than usual for wheats of the same moisture content and hardness.

TABLE 20.—Baking tests. McPherson and Manhattan wheats. Comparing the three grades of flour.

Serial number	Number of wheat	VARIETY OR NAME	Kind of flour	Per cent of moisture in flour	Water used for loaf, cubic centimeters	Total water in materials	Per cent total water	Total materials, grams	Weight of dough, grams	Dough left in kneader	Time for rising	Loss in baking	Weight of baked loaf, hot	Weight of baked loaf, cold	Rise in expansion case, millimeters	Total reading, rise in oven	Net rise in oven	Volume of loaf, cubic centimeters	Color, per cent	Texture, per cent
53	1,539	Torgova	Patent	10.95	51	61.95	38.4	161	155	6	2:15	11	127	144	5	27	22	396	92	92
53	1,539	"	Second	9.50	51	60.50	37.5	161			2:53	9	137	151	5	10	5	318	75	80
53	1,539	"	Tailings	8.77	51	59.77	37.1	161	160	1										
54	1,571	Turkey	Patent	11.45	51	62.45	38.7	161	157	4	1:49	6	136	151	5	26	21	374	95	96
54	1,571	"	Second	11.25	51	62.25	38.5	161	156	5	1:46	7	136	149	5	22	17	372	85	94
54	1,571	"	Tailings	8.95	51	59.95	37.2	161	157	4	2:15	5	140	152	5	7	2	282	70	80
55	2,906	Currell	Patent	10.28	50	60.28	37.6	160	157	3	1:26	8	127	149	5	28	23	361	90	90
55	2,906	"	Second	10.66	50	60.66	37.9	160	157	3	1:36	7	128	150	5	21	16	350	80	85
55	2,906	"	Tailings	9.05	50	59.05	36.9	160	156	4	2:25	7	127	149	5	12	7	292	65	75
56	2,907	Zimmerman	Patent	10.08	47	57.08	36.3	157	157		1:18	8	133	149	5	26	21	369	95	97
56	2,907	"	Second	10.50	47	57.50	36.6	157	155	2	1:22	8	133	147	5	25	20	376	93	85
56	2,907	"	Tailings	9.36	47	56.36	35.2	157	156	1	1:52	9	134	147	5	16	11	329	75	75
57	367	Fultz	Patent	11.17	50	61.17	38.2	160	157	3	1:58	9	135	148	5	24	19	369	95	95
57	367	"	Second	11.05	50	61.05	38.1	160	156	4	1:34	8	135	148	5	22	17	360	93	90
57	367	"	Tailings	10.29	50	60.29	37.6	160	155	7	1:50	7	136	148	5	12	7	313	75	75
58	368	Malakoff	Patent	11.31	51	62.31	38.7	161	158	3	1:24	8	134	150	5	19	14	348	96	98
58	368	"	Second	10.16	51	61.16	38.1	161	159	2	1:31	7	136	152	5	14	9	327	80	93
58	368	"	Tailings	9.82	51	60.82	37.1	161	158	8	2:32	8	136	150	5	11	6	294	65	88
59	369	Minnesota	Patent	11.31	56	67.31	40.5	166	158	5	1:21	8	140	153	5	19	14	353	94	92
59	369	"	Second	10.87	56	66.87	40.2	166	161	5	1:13	6	142	155	5	17	12	348	85	90
59	369	"	Tailings	8.74	56	64.74	39.0	166	160	6	1:49	5	143	155	5	5	0	279	70	75
60	373	Defiance	Patent	11.39	55	66.39	40.2	165	163	2	1:20	9	139	154	5	23	18	364	90	94
60	373	"	Second	11.20	55	66.20	40.1	165	161	4	1:33	8	140	153	5	14	9	324	85	89
60	373	"	Tailings	8.99	55	63.99	38.7	165	161	4	1:44	8	142	153	2	4	2	279	70	75
61	380	Turkey	Patent	11.35	54	65.35	39.8	164	159	5	1:28	10	139	149	5	19	14	361	96	92
61	380	"	Second	11.47	54	65.47	39.9	164	157	7	1:32	7	140	150	5	12	7	341	90	84
61	380	"	Tailings	9.11	54	63.11	38.4	164	159	5	1:46	8	143	151	5	2	0	268	80	65
62	574	Crimean	Patent	10.64	56	66.64	40.1	166	163	3	1:35	9	139	154	5	23	18	376	96	96
62	574	"	Second	10.82	56	66.82	40.2	166	162	4	1:45	8	138	153	5	17	12	361	85	85
62	574	"	Tailings	8.83	56	64.83	39.1	166	161	5	2:06	8	140	153	0	3	3	281	75	70
63	576	Weissenberg	Patent	11.44	55	66.44	40.2	165	158	7	0:55	9	136	149	5	22	17	376	96	96
63	576	"	Second	10.84	55	65.84	39.2	165	161	4	1:51	11	138	150	5	17	12	367	85	85
63	576	"	Tailings	9.56	55	64.56	39.1	165	161	4	1:41	8	142	153	3	3	0	280	75	65
64	577	Currell	Patent	10.43	51	61.43	38.1	161	156	5	1:28	8	135	148	5	22	17	361	95	96
64	577	"	Second	10.62	51	61.62	38.2	161	155	6	1:23	12	133	143	5	20	15	365	90	92
64	577	"	Tailings	8.60	51	59.60	37.1	161	155	6	1:58	9	137	146	4	6	2	303	75	70

TABLE 21.--Baking tests. Minnesota wheats. 1907. Comparing the three grades of flours.

Serial number	Number of wheat	VARIETY OR NAME	Kind of flour	Per cent of moisture in flour	Water used for loaf, cubic centimeters	Total water in materials	Per cent total water	Total materials, grams	Weight of dough, grams	Dough left in kneader	Time for rising	Loss in baking	Weight of baked loaf, cold	Weight of baked loaf, hot	Rise in expansion case, millimeters	Total reading, rise in oven	Net rise in oven	Volume of loaf, cubic centimeters	Color, per cent	Texture, per cent
65	163	Fife	Patent	11.80	51	62.80	39.3	161	156	5	1:26	8	134	148	5	25	20	375	96	96
65	163	"	Second	11.34	51	62.34	38.7	161	156	5	1:36	7	136	149	5	21	16	352	90	90
65	163	"	Tailings	8.83	51	59.83	37.1	161	157	4	2:06	9	138	148	5	10	5	288	75	75
66	165	"	Patent	11.20	48	59.20	37.4	158	153	5	1:28	9	133	144	5	17	12	342	90	85
66	165	"	Second	11.15	48	59.15	37.4	158	153	5	1:38	8	134	145	5	15	10	331	85	80
66	165	"	Tailings	8.67	48	56.67	35.8	158	152	6	2:55	7	136	145	0	0	0	247	70	60
67	169	Minnesota	Patent	11.87	53	64.87	39.8	163	159	4	1:35	9	137	150	5	19	14	333	90	96
67	169	"	Second	11.90	53	64.90	39.8	163	159	4	1:25	8	137	151	5	18	18	330	92	92
67	169	"	Tailings	8.50	53	61.50	37.6	163	157	6	2:16	8	139	149	0	1	1	269	75	70
68	188	Bearded Fife	Patent	11.93	51	62.93	39.0	161	155	6	1:38	7	137	148	5	14	9	319	96	96
68	188	"	Second	10.97	51	61.97	38.1	161	155	6	1:53	8	138	147	5	14	9	348	85	90
68	188	"	Tailings	8.57	51	59.57	37.0	161	154	7	3:13	5	140	149	0	0	0	244	75	65
69	529	Minnesota	Patent	11.35	53	64.35	39.4	163	159	4	1:24	6	136	153	5	22	17	384	96	96
69	529	"	Second	11.15	53	64.15	39.3	163	159	4	1:37	6	137	153	5	19	14	346	95	92
69	529	"	Tailings	8.87	53	61.87	37.9	163	159	4	2:07	5	140	154	3	3	0	258	80	70
70	1,006	"	Patent	11.82	53	64.82	39.7	163	159	4	1:37	10	138	149	5	17	12	346	98	98
70	1,006	"	Second	11.39	53	64.89	39.5	163	160	3	1:55	9	139	151	5	17	12	353	90	90
70	1,006	"	Tailings	8.95	53	62.13	38.1	163	159	4	2:54	7	141	152	5	8	3	293	70	75

TABLE 22.—Baking tests. Tennessee wheats. 1907. Comparing the three grades of flours.

Serial number	VARIETY OR NAME.	Kind of flour.	Per cent moisture in flour.	Water used for loaf, cubic centimeters.	Total water in materials.	Per cent total water.	Total materials, grams.	Weight of dough, grams.	Dough left in kneader.	Time for rising.	Loss in baking.	Weight of baked loaf, cold.	Weight of baked loaf, hot.	Rise in expansion case, millimeters.	Total reading, rise in oven.	Net rise in oven.	Volume of loaf, cubic centimeters.	Color, per cent.	Texture, per cent.
72	Mediterranean	Patent	10.74	50	60.74	37.9	160	156	4	1:36	8	135	148	5	27	22	388	95	90
72	"	Second	10.83	50	60.83	38.0	160	156	4	1:35	8	135	148	5	24	19	384	92	88
72	"	Tailings	9.19	50	59.19	36.9	160	152	8	1:41	7	133	145	5	9	4	300	75	70
73	Poole	Patent	11.18	50	61.18	38.2	160	157	3	1:49	7	135	150	5	22	17	376	95	93
73	"	Second	11.01	50	61.01	38.1	160	158	2	1:44	7	135	151	5	21	16	377	90	90
73	"	Tailings	9.84	50	59.84	37.4	160	157	3	2:19	8	137	149	5	4	4	274	75	70
74	Fulcaster	Patent	12.12	48	60.12	38.1	158	153	5	1:26	8	134	145	5	19	14	370	95	90
74	"	Second	11.98	48	59.98	37.9	158	152	6	1:45	9	133	143	5	22	17	883	93	88
74	"	Tailings	9.68	48	57.68	36.5	158	153	5	2:58	7	137	146	0	0	0	264	75	65
75	Fultz	Patent	11.64	47	58.64	37.3	157	154	3	1:47	9	133	145	5	22	17	394	90	80
75	"	Second	11 60	47	58.60	37.3	157	157	0	1:37	8	137	149	5	23	18	401	85	80
75	"	Tailings	9 05	47	56.05	35.7	157	157	0	1:31	9	137	148	5	15	10	347	70	75

TABLE 23.—Baking tests. Washington wheats. 1907. Comparing the three grades of flours.

Serial number	VARIETY OR NAME.	Kind of flour.	Per cent of moisture in flour	Water used for loaf, cubic centimeters	Total water in materials	Per cent total water	Total materials, grams	Weight of dough, grams	Dough left in kneader	Time for rising	Loss in baking	Weight of baked loaf, cold	Weight of baked loaf, hot	Rise in expansion case, millimeters	Total reading, rise in oven	Net rise in oven	Volume of loaf, cubic centimeters	Color, per cent	Texture, per cent
76	Turkey Red	Patent	12.35	56	68.35	41.1	166	162	2	1:15	5	140	152	5	18	13	356	95	98
76	''	Second	12.94	56	68.94	41.5	166	161	5	1:30	6	141	155	5	15	10	343	92	95
76	''	Tailings	10.33	56	66.33	39.9	166	162	4	1:13	6	143	156	5	-15	10	313	85	85
77	Little Club	Patent	10.53	47	57.53	36.6	157	155	2	1:39	10	137	145	5	15	10	373	90	85
77	''	Second	12.18	47	59.18	37.6	157	154	3	1:44	9	136	145	5	18	13	387	90	85
77	''	Tailings	9.24	47	56.24	35.8	157	153	4	2:37	8	137	145	5	4	-1	296	75	65
78	Forty Fold	Patent	11.07	47	58.07	36.9	157	153	4	1:27	8	135	145	5	20	15	326	90	90
78	''	Second	12.92	47	59.92	38.1	157	155	2	1:25	13	134	142	5	11	6	314	90	90
78	''	Tailings	9.13	47	56.13	35.7	157	156	1	2:25	10	138	146	5	0	0	258	70	65
79	Red Russian	Patent	10.20	47	57.20	36.4	157	153	4	1:45	8	132	145	5	10	5	314	90	85
79	''	Second	11.60	47	58.60	37.3	157	154	3	1:55	9	133	145	5	8	3	310	85	85
79	''	Tailings	8.76	47	55.76	35.5	157	152	5	3:00	5	136	147	0	0	0	256	70	65
80	Western Blue Stem	Patent	11.74	50	61.74	38.5	160	155	5	1:28	8	134	147	5	17	12	346	90	90
80	'' ''	Second	12.61	50	62.61	39.1	160	155	5	1:19	14	131	141	5	16	11	328	90	90
80	'' ''	Tailings	10.80	50	60.80	38.0	160	153	7	2:27	6	138	147	0	0	0	229	75	60

TABLE 24.—Summary of baking tests, comparing the three grades of flours. Kansas wheats. 1907.

Serial number	Number of wheat	VARIETY OR NAME.	Per cent moisture.			Per cent total water.			Time for rising.			Net rise in oven.			Volume of loaf.			Color of loaf.		
			Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.
53	1,539	Torgova	10.95	9.50	8.77	38.47	37.50	37.10	2:15	....	2:53	22	....	5	396	......	318	92	....	75
54	1,571	Turkey	11.45	11.25	8.95	38.70	38.50	37.20	1:49	1:46	2:15	21	17	2	374	372	282	95	85	70
55	2,906	Currell	10.28	10.66	9.05	37.60	37.90	36.90	1:26	1:36	2:25	23	16	7	361	350	292	90	80	65
56	2,907	Zimmerman	10.08	10.50	9.36	36.30	36.60	35.20	1:18	1:22	1:52	21	20	11	369	376	329	95	93	75
57	367	Fultz	11.17	11.05	10.29	38.20	38.10	37.60	1:58	1:34	1:56	19	17	7	369	360	313	95	93	75
58	368	Malakoff	11.31	10.16	9.82	38.70	37.10	37.10	1:24	1:31	2:32	14	9	6	348	327	294	96	80	65
59	369	Minnesota	11.31	10.87	8.74	40.50	40.20	39.00	1:21	1:13	1:49	14	12	0	353	348	279	94	85	70
60	373	Defiance	11.39	11.20	8.99	40.20	20.10	39.70	1:20	1:33	1:44	18	9	2	364	324	279	90	85	70
61	380	Turkey	11.35	11.47	9.11	39.80	39.90	38.40	1:28	1:32	1:46	14	7	0	361	341	268	96	90	80
62	574	Crimean	10.64	10.82	8.83	40.10	40.20	39.05	1:35	1:45	2:06	18	12	3	376	361	281	96	85	75
63	576	Weissenberg	11.44	10.84	9.56	40.20	39.20	39.10	0:55	1:51	1:41	17	12	0	376	367	280	96	85	75
64	577	Currell	10.43	10.62	8.60	38.10	38.20	37.06	1:28	1:23	1:58	17	15	2	361	365	303	95	90	75
		Averages	10.90	10.74	9.17	39.05	38.69	37.70	1:31	1:33	2:03	18	13	5	367	324	293	94	86	73

TABLE 25.—Summary of baking tests, comparing the three grades of flours.   Minnesota wheats.   1907.

Serial number	Number of wheats	Variety or name	Per cent moisture.			Per cent total water.			Time for rising.			Net rise in oven.			Volume of loaf.			Color of loaf.		
			Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.
65	163	Fife	11.80	11.34	8.88	39.30	38.70	37.10	1:26	1:36	2:06	20	16	5	375	352	288	96	90	75
66	165	"	11.20	11.15	8.67	37.40	37.40	35.80	1:28	1:38	2:55	12	10	0	342	331	247	90	85	70
67	169	Minnesota	11.87	11.90	8.50	39.80	39.80	37.60	1:35	1:25	2:16	14	13	1	333	330	269	96	92	75
68	188	Bearded Fife	11.93	10.97	8.57	39.00	38.10	37.00	1:38	1:52	3:13	9	9	0	319	348	244	90	85	75
69	529	Minnesota	11.35	11.15	8.87	39.40	39.80	37.90	1:24	1:37	2:07	17	14	0	334	346	258	96	95	80
70	1,006	"	11.82	11.39	8.95	39.70	39.50	38.10	1:37	1:55	2:54	12	12	3	346	353	293	98	90	70
		Averages	11.66	11.31	8.76	39.10	38.80	37.25	1:31	1:40	2:51	14	12	3	342	343	267	94	90	74

TABLE 26.—Summary of baking tests, comparing the three grades of flours.   Tennessee wheats.   1907.

Serial number	Variety or name	Per cent moisture.			Per cent total water.			Time for rising.			Net rise in oven.			Volume of loaf.			Color of loaf.		
		Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.
72	Mediterranean	11.74	10.83	9.19	37.90	38.01	36.90	1:36	1:35	1:41	22	19	4	388	384	300	95	92	75
73	Poole	11.18	11 01	9.84	38.20	38.10	37.40	1:49	1:44	2:19	17	16	4	376	377	274	95	90	75
74	Fulcaster	12.12	11.98	9.68	38.05	37.90	36.50	1:26	1:45	2:53	14	17	0	370	383	264	95	93	75
75	Fultz	11.64	11.60	9.05	37.30	37.30	35.70	1:47	1:37	1:31	17	18	10	394	401	347	90	85	70
	Averages	11.67	11.35	9.44	37.81	37.77	36.57	1:39	1:40	2:06	17	18	6	382	386	296	94	90	74

TABLE 27.—Summary of baking tests, comparing the three grades of flours. Washington wheats. 1907.

Serial number	VARIETY OR NAME.	Per cent moisture.			Per cent total water.			Time for rising.			Net rise in oven.			Volume of loaf.			Color of loaf.		
		Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.	Patent.	Break.	Tailings.
76	Turkey Red	12.35	12.94	10.33	41.10	41.50	39.90	1:15	1:30	1:13	13	10	10	356	343	313	95	92	85
77	Little Club	10.53	12 18	9.24	36.60	37.60	35.80	1:39	1:44	2:37	10	13	—1	373	387	296	90	90	75
78	Forty Fold	11.27	12.92	9.13	36.90	38.10	35.70	1:27	1:25	2:25	15	6	0	326	314	258	90	90	70
79	Red Russian	10.20	11.60	8.76	36.40	37.30	35.50	1:45	1:55	3:00	5	3	0	314	310	256	90	85	70
80	Western Blue-stem	11.74	12.61	10.80	38.50	39.10	38.00	1:28	1:19	2:27	12	11	0	346	328	229	90	90	75
	Averages	11 17	12.45	9.65	37.90	38.70	36.84	1:30	1:34	2:20	11	9	0	343	336	270	91	89	75

In time of rising or proving there is little difference between the patent and break flour. But in the case of the tailings flour the time averages 30 minutes more. This is due to the slower action of the yeast on the tailings flour. It may be due to three causes: (1) the inhibiting action of the bran particles; (2) the finer granulation making a more sticky and undesirable medium for the yeast cells; (3) the food furnished by the tailings flour is less available.
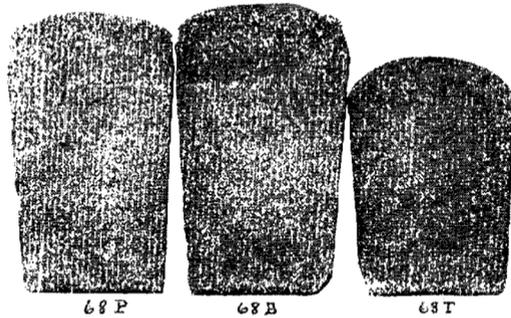
PLATE 20. Loaves from patent, break and tailings flours from Bearded Fife wheat. The appearance of others was similar.

The net rise in the oven furnishes the most striking differences between the patent, break and tailings flour. In all cases but three the patent flour shows a higher rise than the break flour. The exceptions are all from the soft wheats. The volume of loaf of the patent and break flour do not vary much, but there is a decided diminution in the case of the tailings flour. The loaves made from the three grades of flour from the same wheat is shown in plate 20. The letters P, B and T stand for patent, break and tailings. These loaves are typical of those made from these flours.

CHEMICAL COMPOSITION OF WHEATS FROM CROP OF 1906.

COMPOSITION OF WHEATS GROWN AT MCPHERSON.

Moisture.

The moisture means hygroscopic water. As air always contains water, substances in contact with it will absorb more or less, the amount depending on the relative humidity of the air and the nature of the substances. Other things being equal, the more moisture present in the air, the more absorbed. Thus wheat from the Plains area of the United States contains less moisture than wheat from the Central and Eastern states. Some substances have more power to absorb moisture than others. Thus flour will contain from 10 to 13 per cent of moisture while the better grades of sugar will contain less than one per cent, even when the two substances are stored under the same conditions. The moisture in all these samples was determined by drying a two-gram ground sample of the material continuously in an atmosphere of hydrogen for seven hours. The oven is heated by steam. It was found by several trials that after seven hours the weight remained constant. The last traces of moisture could not be driven off in less time than this. These samples of wheat do not vary a great deal in moisture content. The average is 10.93 per cent and the difference between the highest and the lowest is about two per cent. (See table 28.)

Fat or Ether Extract.

The fat means the amount of matter extracted by continuous treatment of a dried sample with absolute anhydrous ether for sixteen hours. The material so extracted is not pure fat. This ether extract is richer in fat when the substance consists of seeds and products from the same than when the substance extracted consists of stems, leaves and similar materials. In the latter case the ether extract often contain such a large per cent of substances other than fat that the term fat has only a remote application to the ether extract. The fat from wheat is an oil, almost solid at ordinary temperature and of a brownish color. That of the flour is a light yellow color, that from the bran is dark brown. In proportion to the amount present, the ether extract varies more than any other constituent. The difference between the highest and the lowest

TABLE 28.—Chemical composition of McPherson wheats. 1906.

Serial number	Number of wheat	VARIETY OR NAME.	Moisture	Fat or ether extract	Fiber	Protein	Ash	Nitrogen-free extract
1	1,395-2	Mediterranean	10.91	2.17	2.17	11.57	1.56	71.63
2	1,435	Crimean	10.89	1.85	2.12	10.94	1.92	72.28
3	1,437	"	10.63	1.88	2.18	11.09	1.67	72.54
4	1,438	Ghirka	10.87	1.89	2.00	11.06	1.56	72 63
5	1,442	Kharkov	10.88	1.96	2.00	10.94	1.52	72.70
6	1,539	Torgova	10.98	2.06	2.13	10.72	1.60	72.51
7	1,558	Turkey	12.47	1.75	2.03	10.83	1.55	71 88
8	1,559	Crimean	10.56	1.66	2.04	10.66	1.62	73.47
9	1,564	Pesterboden	10.99	1.68	2.24	13.11	2.14	69.84
10	1,571	Turkey	11.08	1.96	2.18	11.57	2.06	71.27
11	1,583	Kharkov	10.72	1.56	2.06	11.26	1.66	72.74
12	1,739	Budapest	11.22	1.75	2.11	11.97	2.07	70.88
13	1,756	Missouri	10.49	1.96	1.99	10.86	1.78	72.92
14	1,757	Japanese Velvet Chaff	10.87	1.76	2.14	10.89	1.69	72.65
15	1,824	Zimmerman X Turkey	10.75	2.06	1.96	10.72	1.55	72.96
16	1,544	Beloglina	10.75	2.01	2.12	11.26	1.62	72.24
17	2,906	Currell	10.97	2.05	2.16	11.91	2.06	70.85
18	2,907	Zimmerman	10.93	1.57	2.19	12.65	1.57	71.09
19	2,908	Malakoff	10.72	1.78	2.24	11.86	1.52	73.45
		Averages	10.93	1.85	2.11	11.36	1.72	72.09

is 0.6 per cent, or over one-third. The average per cent of ether extract is 1.85 per cent.

Crude Fiber.

This is the material insoluble in boiling 1.25-per-cent sulphuric acid and 1.25-per-cent boiling sodium hydroxide. The material is extracted by ether before the crude fiber is determined. The substance remaining after the moisture and ether extract determination is used for the determination of the crude fiber. It is boiled successively for thirty minutes in the dilute acid and the dilute alkali. What remains insoluble after this treatment and is combustible is classed as crude fiber. When a substance like wheat is boiled in dilute acid the starch, pentosans, gums and sugars, as well as certain nitrogenous matter, are rendered soluble. These are then removed by filtration and washing. The subsequent treatment with the dilute alkali removes the albuminous matters and other products. What is left after filtering and washing is crude fiber and some ash. The fiber is burned and the correction for the weight of ash present is obtained. Crude fiber is not a definite chemical compound but a mixture of compounds classed with the carbohydrates. The average per cent of crude fiber in the wheats is 2.11 per cent. The content of crude fiber is one of the most uniform as compared with other constit-

uents, the difference between the highest and the lowest being only 0.23 per cent.

Crude Protein.

This is not a pure chemical compound but a mixture of different substances. The nitrogen is determined and the result multiplied by 5.7 to get the protein, For most feeding stuffs the factor 6.25 is used, as on the average the nitrogenous compounds in feeds contain 16 per cent of nitrogen. But the nitrogenous compounds of wheat are richer in nitrogen, averaging nearly 17.6 per cent, and for this reason the factor 5.7 is used. These wheats are fairly uniform in protein content. The average is 11.36 per cent, the highest being 13.11 and the lowest 10.66 per cent. These wheats are grown under the same climatic conditions, and the soil was also of uniform character. The larger differences in protein content must therefore be characteristics of the wheats themselves.

The desirability of producing a high-protein wheat is self-evident, provided that the high-protein wheat be a good yielder and also possess good milling qualities. If these 19 wheats are divided on the basis of yield, putting the ten lower yielders in one class and the nine higher in the other, we find the average yield for the former 22.7 bushels per acre and for the latter 33.6 bushels per acre. While the average protein content of the lower yielders is 11.64 per cent and that of the high yielders 11.05 per cent, there is a difference of 10.9 bushels per acre, but only 0.59 per cent protein. While there undoubtedly is a tendency for the low yielders to produce a higher per cent of protein, the larger differences in favor of the high yielders more than offset this. There is nothing in the milling or baking tests which shows that the higher protein wheats are either inferior or superior in milling and baking qualities, compared with the low-protein wheats.

Ash.

The ash is the incombustible material. It is determined by igniting two grams of the ground sample in a muffle oven at low redness until it ceases to lose weight. This time in the case of wheat ranges from one to two hours. Excepting nitrogen, the ash includes all the material which the plant gets from the soil. As a class the seeds of grains are much lower in ash than the stems and leaves, but a larger percentage of the more

soluble ash constituents is present in the seeds than in the stems and leaves.

Phosphorus and potassium, which occur in larger percentages in the seeds, are elements in which the soil is likely· to be deficient. Thus selling off the grain depletes the soil in fertility. The average per cent of ash in these wheats is 1.72 per cent. The ash next to ether extract, considering the amount present, is the most variable constituent, but variation in ash may not be altogether due to the wheat itself. Wheat, that has been exposed to sand and dust storms will apparently contain more ash than wheat not so exposed. Even the flour from wheat so exposed will contain an undue amount of ash, even when the very best cleaning appliances are used. The lowest per cent of ash is 1.52 per cent and the highest is 2.14,

Nitrogen-free Extract.

This is determined by difference. The percentages of moisture, ether extract, crude fiber, protein and ash are added together, and the sum is subtracted from 100. The difference is called nitrogen-free extract. In consists mostly of starch, in case of wheats, and small amounts of sugar, dextrin, gums and pentosans. It is evident that the nitrogen-free extract will vary in proportion as the other factors vary. The protein content effects a larger variation in the nitrogen-free extract than any of the other, constituents.

CHEMICAL COMPOSITION OF WHEATS GROWN AT MANHATTAN.

The results of analyses of wheat grown at Manhattan are summarized in table 29. In moisture, fat or ether extract, fiber and ash there is very little difference between members of this group and those grown at McPherson. In average protein content there is also very little difference. But in the protein content of the different samples there is a large variation. The lowest in protein content contains but 7.92 per cent while the highest contains 14.70, a difference of 6.78 per cent. These wheats were all high yielders, the average being 17.47 bushels per acre more than that of the wheats grown at McPherson, yet the average protein content is higher.

If we separate the wheats into two groups on the basis of yield we find the average yield for the six lower to be 42.44 bushels per acre and that of the higher 48.22, yet the difference in the average protein content is less than one per cent for the

two groups. If we examine individual wheats we find that higher protein content is as often associated with a large yield as with a low yield. There is nothing in the milling and baking tests which shows any material difference in these twelve wheats. All were excellent wheats judged by market standards, and produced a flour that was good both in yield and baking qualities.

As noted above, five of the wheats grown at Manhattan were from the same varieties as those grown at McPherson; serial numbers 3, 4, 5, 7, and 17 being the same varieties as numbers 29, 32, 28, 27, and 31, respectively. The average yield of the former is 28.7 and that of the latter 42.54, yet the average protein content or the same varieties grown at Manhattan is 12.59 per cent and for those grown at McPherson 11.14. A large yield does not necessarily mean a low protein content, in this case the opposite is true.

TABLE 29.—Chemical composition of Manhattan wheats. 1906.

Serial number.	Number of wheat.	VARIETY OR NAME.	Moisture.	Fat or ether extract.	Fiber.	Protein.	Ash.	Nitrogen-free extract.
21	366	Bearded Fife	10.45	1.90	2.13	10.89	1.60	73.02
22	367	Fultz	10.07	1.91	2.13	13.28	1.69	70.92
23	368	Malakoff	10.41	1.96	2.12	9.92	1.59	72.04
24	369	Minnesota	10.46	1.85	2.04	7.92	1.60	76.13
25	373	Defiance	10.20	1.88	2.09	12.26	1.52	72.05
26	378	Red Winter	10.13	1.94	2.07	10.94	1.72	73.20
27	570	Turkey	10.35	1.91	2.04	12.88	1.72	71.10
28	573	Kharkov	10.14	1.80	2.15	11.17	1.56	74.74
29	574	Crimean	10 65	1.87	2.11	13.08	1.62	73.91
30	576	Weissenberg	10.03	1.97	2.07	13.81	1.61	71.01
31	577	Currell	10.03	1.98	2 17	14.70	1.56	69.56
32	578	Ghirka	10.50	1.87	2.07	11.14	1.69	72.73
		Averages	10.28	1.90	2.10	11.79	1.62	72.53

MOISTURE CONTENT OF WHEAT AND OF MILL PRODUCTS OF KANSAS WHEATS.

These data are summarized in tables 30 and 31. The moisture was determined in the manner described above. The data for moisture in the wheat are the same as in the previous tables and are inserted here for comparison. The increase of moisture content of the mill products, especially the patent flour, is due to the addition of tempering water. The smaller moisture content of the by-products such as low-grade flour, shorts and bran is due to the heat generated during grinding

and the exposure incident to the frequent handling necessary in the milling process. The lowest per cent of moisture in any of the patent flours is **10.30** and the highest is 11.94, a difference of 1.64 per cent. As a class these flours are uniform. The average moisture content of the patent flours in table 30 is 11.05 and those in table 31 is 11.29. Both these results are lower than the averages given by Wiley in Bull. 13, part 9, Bureau of Chemistry. In both tables, 30 and 31, the second-grade flours show more variation in moisture than the patent flours.

PROTEIN CONTENT OF WHEAT AND OF MILL **PRODUCTS** OF
KANSAS WHEATS.

These data are summarized in tables 32 and 33. The data for the protein of wheat are the same as in tables 28 and 29. Without exception the protein content of the patent flour is less than that of the wheat itself, and also less than that of the second-grade flour and the by-products. The second-grade flour from the wheats represented in tables 32 and 33 includes the best of the flour produced from the tailings, and in this respect is different from the flours produced from the wheats of 1907.

TABLE 30.—Moisture content of wheat and mill products. McPherson wheats. 1906.

Serial number.	NUMBER OF WHEAT.	Wheat.	Patent flour.	Second-grade flour.	Low-grade flour.	Shorts.	Bran.
1	1,395-2	10.91	10.64	11.07	9.89	9.63	9 47
2	1,435	10.89	11.84	12.12	11.16	10.60	10.75
3	1,437	10.63	10.90	11.75	11.34	10.59	10.75
4	1,438	10.87	10.38	10.74	10.60	9.50	10.07
5	1,442	10.88	10.30	11.31	10.43	9.57	10.57
6	1,539	10.98	10.74	11.33	11.04	10.54	9.91
7	1,558	12.47	11.45	10.62	10.40	10.27	10.55
8	1,559	10.56	11.82	11.34	10.47	10.70	10.40
9	1,564	10.99	11.26	10.51	10.13	9.93	10.01
10	1,571	11.08	11.05	10.99	8.91	9.78	9.49
11	1,588	10.72	10.93	9.86	9.84	9.08	9.58
12	1,738	11.22	10.43	9.93	9.80	9.16	9.55
13	1,756	10.49	11.94	10.96	10.20	9.92	10.05
14	1,757	10.87	11.05	10.18	9.90	9.96	9.98
15	1,824	10.75	11.80	10.59	10.28	10.13	9.86
16	1,544	10.75	11.31	11.24	9.88	9.64	9.86
17	2,906	10.97	10.49	9.66	9.79	9.30	9.09
18	2,907	10.93	10.74	9.72	10.09	9.98	9.20
19	2,908	10.72	11.11	11.09	10.20	10.11	10.34
	Averages	10.93	11.05	10.78	10.20	9.91	9.86

TABLE 31.—Moisture content of wheat and mill products. Manhattan wheats. 1906.

Serial number.	NUMBER OF WHEAT.	Wheat.	Patent flour.	Second-grade flour.	Low-grade flour.	Shorts.	Bran.
21	366	10.45	11.73	10.73	9.88	9.73	10.85
22	367	10.07	11.41	10.98	10.89	10.99	11.01
23	368	10.41	11.68	10.79	10.35	10.44	10.70
24	369	10.46	11.45	11.27	10.19	10.84	10.77
25	373	10.20	11.70	12.03	10.43	10.89	10.86
26	378	10.13	11.40	12.38	10.48	10.60	10.66
27	570	10.35	11.46	12.12	10.41	10.21	10.74
28	573	10.14	10.57	11.42	10.48	9.84	10.30
29	574	10.65	11.08	11.99	10.47	10.10	10.86
30	576	10.08	10.42	11.27	10.21	9.75	9.83
31	577	10.03	11.12	11.14	10.67	9.97	10.14
32	578	10.50	11.50	10.53	10.10	9.60	10.23
	Averages.	10.28	11.29	11.39	10.38	10.21	10.53

TABLE 32.—Protein content of wheat and mill products. McPherson wheats. 1906

Serial number.	NUMBER OF WHEAT.	Wheat.	Patent flour.	Second-grade flour.	Low-grade flour.	Shorts.	Bran.
1	1,395-2	11.57	10.83	10.69	15.31	17.87	14.36
2	1,435	10.94	9.52	11.29	12.77	16.36	14.36
3	1,437	11.09	9.69	10.40	12.83	15.44	14.28
4	1,438	11.06	9.95	12.32	13.65	15.79	14.61
5	1,442	10.94	9.49	11.12	15.28	16.34	13.71
6	1,538	10.72	9.74	11.00	12.86	16.05	13.43
7	1,558	10.83	9.44	11.00	14.42	14.91	13.88
8	1,559	10.66	9.82	11.03	12.60	16.82	13.91
9	1,564	13.11	11.20	13.88	15.59	18.16	14.99
10	1,571	11.57	10.20	12.83	15.05	15.93	13.91
11	1,583	11.26	9.89	12.60	14.65	16.19	13.68
12	1,739	11.97	10.40	12.88	16.82	15.80	13.62
13	1,756	10.86	9.41	11.46	12.88	16.19	14.08
14	1,757	10.89	9.80	10.43	14.14	16.64	13.09
15	1,824	10.72	9.29	9.63	11.92	15.79	13.57
16	1,544	11.26	9.58	11.32	13.11	15.73	14.03
17	2,906	13.11	12.06	12.86	17.44	18.24	14.17
18	2,907	12.65	10.86	11.12	15.82	17.08	14.93
19	2,908	11.86	10.55	13.34	14.76	17.39	14.99
	Averages	11.42	10.06	11.64	14.31	16.43	14.07

The protein content of the second-grade flour is very nearly equal to that of the wheat itself. In table 32 the average protein content of the patent flour is 10.06, which is 1.36 per cent lower than that of the wheat. In table 33 the average for the patent flour is 10.14 per cent, 1.48 per cent less than the wheat. The average protein content for the second-grade flour in table 32 is 11.64, or **0.22** per cent more than the wheat, and in table 33 the average is 11.91, or 0.29 per cent more than the wheat. In the by-products, low-grade flour, shorts and

TABLE 33.—Protein content of wheat and mill products. Manhattan wheats. 1906.

Serial number.	NUMBER OF WHEAT.	Wheat.	Patent flour.	Second-grade flour.	Low-grade flour.	Shorts.	Bran.
21	366	10.89	9.21	11.23	14.19	15.71	13.79
22	367	13.28	11.66	13.31	14.59	17.70	16.48
23	368	9.92	.8.04	9.63	12.71	15.14	12.83
24	369	7.92	7.41	8.44	10.95	14.62	11.83
25	373	12.26	10.12	12.06	13.28	17.48	14.99
26	378	10 94	10.63	10.46	12.54	15.83	14.02
27	570	12.77	11.03	13.71	16.53	16 59	15.37
28	573	11.17	9.58	11.23	15.11	15.85	13.74
29	574	13.08	11.17	13.25	16.13	17.99	14.88
30	576	13.31	11.17	14.22	16.59	17.70	15.25
31	577	14.70	12.60	13.79	15.65	18.01	17.56
32	578	11.14	9.12	11.66	13.82	15.79	13.97
	Average	11.62	10.14	11.91	14.33	16.49	14.56

bran, the protein content is considerably higher than that of the wheat itself. The average for each of these different products in the two tables is very nearly the same. The shorts has by far the highest protein content. This is due to the method of handling the stock in grinding. Some of the high protein material could be put with the bran, and in this way the protein content of bran and shorts would be more nearly equal.

If we summarize some of the more important data of the Kansas wheats for 1906 we have the following table:

TABLE 34.

	Wheat.	Patent flour.	Second-grade flour.	Low-grade flour.	Shorts.	Bran.
Average protein content	11.52	10.10	11.77	14.32	16.46	14.31
Difference from wheat	....	—1.42	+0.25	+2.80	+4.94	+2.79
Average per cent products	....	50.94	21.47	2.07	5.46	18.97
Grams protein from 100 grams wheat	11.52	5.15	2.53	0.30	0.90	2.72
Distribution of protein, per cent	....	44.43	21.82	2.55	7.76	23.44

Less than half of the protein of the wheat is found in the patent flour. In a more perfect system of milling more protein would find its way to the patent flour. In the patent and second-grade flours together the protein is 66.25 per cent, while they constitute 72.41 per cent of the total products. The difference is made up by the higher protein content of the low-grade flour, shorts and bran. These latter make up 26.5 per cent of the total products, while their protein content is 33.75 per cent of the whole. There is a slight error in these figures,

due to the fact that the per cent of dust is not figured. Such facts as the above have led to the erroneous conclusion that milling removes the most valuable part of the wheat berry. While it is true that patent and second-grade flour are relatively poorer in protein than the other products, the protein in the flour is valuable in a proportion that more than makes up for the difference is amount.

GLIADIN CONTENT OF FLOUR FROM KANSAS WHEATS.

These data are summarized in tables 35 and 36. The gliadin means the protein soluble in 70 per cent by volume ethyl alcohol. Four grams of flour were put in a 300 cc. Erlenmeyer flask and 100 cc. of the alcohol added. The flask was closed with a rubber stopper and shaken vigorously. The shaking was repeated every half hour for four hours, after which the digestion was allowed to proceed for from 20 to 24 hours. The clear supernatant liquid was filtered through a dry filter. Fifty cc. of the clear filtrate was put into a Kjeldahl flask, together with three cubic centimeters of concentrated sulphuric acid. The flask was placed on a sand bath and the alcohol evaporated. The evaporation was considered complete when steam instead of alcohol condensed in the neck of the flask. This can easily be seen on account of the greater surface tension of water, Seventeen cc. more of the sulphuric acid was now added, and the determination of nitrogen was finished in the usual way.

The per cent of protein is the same as in tables 28 and 29, and is inserted here for comparison. The gliadin per cent of protein is calculated by dividing the per cent of gliadin by the per cent of protein. In the column "Gliadin per cent of Protein" a difference of two per cent has no significance as that amount is within the analytical error of the nitrogen determination. See discussion of this farther on. In both tables the actual gliadin content is larger for the second-grade flour, but as the protein content of this flour is proportionally greater than that of patent flour the gliadin per cent of protein is smaller. Somewhat more than half of the protein of the flour is soluble in 70 per cent by volume alcohol. In a few cases of the second-grade flour the amount is less than half. The gliadin per cent of protein averages higher in table 35 than in table 36. The ratio between total protein and gliadin is fairly constant. In the flours of higher protein content there is a

correspondingly higher content of gliadin. The baking tests do not show any apparent relation between the gliadin per cent of protein and the baking qualities in these patent flours, at least the methods are as yet not refined enough to reveal any relation. The baking tests were not made on the second-grade flours. It is reasonable to assume, from the origin of these flours, that they are inferior to the patent flours in baking qualities. Their gliadin per cent of protein is also much lower.

TABLE 35.—Gliadin content of flour. McPherson wheat.

Serial number.	Number of wheat.	Patent flour.			Second grade flour.		
		Per cent protein.	Per cent gliadin.	Per cent of gliadin in protein.	Per cent protein.	Per cent gliadin.	Gliadin per cent of protein.
1	1,395-2	10.85	6.76	62.37	10.69	6.10	57.60
2	1,435	9.52	5.73	60.18	11.29	6.10	54.04
3	1,487	9.69	5.79	59.71	10.40	6.02	57.88
4	1,438	9.95	6.10	61.31	12.32	6.41	52.08
5	1,442	9.49	5.70	60.06	11.12	5.99	53.85
6	1,539	9.74	5.30	54.41	11.00	5.76	52.33
7	1,558	9.44	5.70	60.42	11.00	5.64	51.30
8	1,559	9.32	5.50	59.02	11.03	5.73	51.94
9	1,564	11.20	6.44	57.51	13.88	7.13	51.33
10	1,571	10.20	5.90	57.82	12.83	6.33	49.33
11	1,583	9.89	5.87	59.36	12.60	6.27	49.78
12	1,789	10.40	5.93	56.99	12.88	6.78	52.65
13	1,756	9.41	5.64	60.00	11.46	5.99	52.24
14	1,757	9.80	6.21	63.37	10.43	6.04	57.92
15	1,824	9.29	5.81	62.58	9.63	5.64	58.58
16	1,544	9.58	5.59	58.33	11.32	5.96	52.64
17	2,906	12.06	7.07	58.49	12.86	6.64	51.68
18	2,907	10.86	6.96	64.04	11.12	6.59	59.23
19	2,908	10.55	5.99	56.76	13.34	7.10	53.21
	Averages	10.06	5.94	59.61	11.64	6.22	53.66

TABLE 36.—Gliadin and protein content of flour. Manhattan wheats.

Serial number.	Number of wheat.	Patent flour.			Second-grade flour.		
		Per cent protein.	Per cent gliadin.	Per cent of gliadin in protein.	Per cent protein.	Per cent gliadin.	Gliadin per cent of protein.
21	366	9.21	5.08	55.11	11.23	5.53	49.24
22	367	11.66	6.44	55.25	13.31	7.21	54.17
23	368	8.04	4.50	56.03	9.63	5.11	53.06
24	369	7.41	4.05	54.62	8.44	4.17	49.41
25	373	10.12	5.64	55.77	12.06	6.55	54.31
26	378	10.63	5.59	52.55	10.46	5.00	47.89
27	570	11.03	6.21	56.33	13.71	6.98	50.91
28	573	9.58	5.39	56.25	11.23	5.86	52.18
29	574	11.17	6.21	55.61	13.25	6.85	51.69
30	576	11.17	6.50	58.16	14.22	7.35	51.70
31	577	12.60	7.38	58.87	13.79	8.60	62.39
32	578	9.12	5.27	57.81	11.66	5.80	49.57
	Averages	10.14	5.68	55.98	11.91	6.25	52.21

The relation between the gliadin per cent of protein and the baking qualities is discussed farther on.

CHEMICAL COMPOSITION OF WHEATS FROM CROP OF 1907.

COMPOSITION OF KANSAS WHEATS.

The composition of Kansas wheats of the crop of 1907 is summarized in table 37. The average moisture content for all the Kansas wheats from the crop of 1906 was 10.61. In this table the average is 10.51 per cent. The average per cent of ether extract for the wheats from the crop of 1906 was 1.87 per cent. In this table the average is 1.82. In ash the average for the crop of 1906 is 1.67 per cent, for the crop of 1907 it is 1.88. This difference is small when the influence of external conditions on ash content is considered. In regard to crude fiber and protein there is a notable increase. The increase in average crude fiber content is 0.32 per cent and that of protein is 0.91 per cent. Numbers 55 and 56, soft wheats grown at McPherson, have very large increase in protein. The yields of these wheats were a little above seven bushes per acre. This probably accounts for their change in protein content. On the other hand, No. 58, Malakoff, shows a large increase in protein and also a large yield. No. 58 is taken as the highest protein wheat for this group as that has a normal yield and was also grown in the same locality as No. 62, the low-protein wheat.

COMPOSITION OF MINNESOTA WHEATS.

These data are found in table 38. In per cent of ash and crude fiber these wheats are identical with the wheats from Kansas. They average higher in moisture and fat. In percentage of fat these wheats average higher than any in the series. Their protein content is uniform. The difference between the highest and the lowest is 1.94 per cent. While the difference between the lowest and the highest of the Kansas wheats represented in table 37 is 5.62 per cent. In chemical composition as well as in the other qualities these wheats are very uniform. It should be remembered that the twelve Kansas wheats represented in table 37 were selected because of their differences. The Kansas wheats grown at McPherson in 1906 show very great uniformity. If the two wheats low

in yield, numbers 55 and 56, are excluded from the average in table 37, the average protein content of the Kansas and the Minnesota wheats is the same.

TABLE 37.—Composition of McPherson and Manhattan wheats, 1907.

Serial number	Number of wheat	VARIETY OR NAME.	Per cent moisture.	Per cent fat or ether extract.	Per cent crude fiber.	Per cent protein.	Per cent ash.	Per cent nitrogen-free extract.
53	1,539	Torgova	10.64	1.94	2.20	10.80	1.72	72.70
54	1,571	Turkey	11.02	1.86	2.39	12.54	1.80	70.89
55	2,906	Currell	10.18	2 04	2.34	15.90	2.04	68.50
56	2,907	Zimmerman	10.13	1.62	2.78	14.19	2.08	79.20
57	367	Fultz	9.98	2.01	2.62	10.54	1.95	72 90
58	368	Malakoff	10.52	1.74	2.34	15.65	1.72	68.03
59	369	Minnesota	10.86	1.78	2.40	14.62	1.79	68.60
60	373	Defiance	10.50	1.79	2.36	12.69	1.95	70.71
61	380	Turkey	10.46	1.64	2.23	10.83	1.82	73.02
62	574	Crimean	10.51	1.82	2.46	10.03	1.86	73 32
63	576	Weissenberg	10.35	1.67	2.34	10.32	1.87	73 45
64	577	Currell	10.95	1.99	2.69	11.72	2.01	70.64
		Averages	10.51	1.82	2.42	12.48	1.88	70.95

TABLE 38.—Composition of Minnesota wheats. 1907.

Serial number	Number of wheat	VARIETY OR NAME.	Per cent moisture.	Per cent fat or ether extract.	Per cent crude fiber.	Per cent protein.	Per cent ash.	Per cent nitrogen-free extract.
65	163	Fife	13.30	2.49	2.46	12.24	1.90	67.61
66	165	Fife	12.23	2.44	2.54	12.32	1.91	68.54
67	169	Minnesota	12.94	2.28	2.59	12.62	1.89	67.68
68	188	Bearded Fife	13.63	2.34	2.20	10.68	1.89	69.26
69	529	Minnesota	12.03	1.90	2.27	11.70	1.78	70.37
70	1,006	Minnesota	11.88	2.35	2.45	12.22	1.91	69.19
		Averages	12.66	2.30	2.42	11.96	1.87	68.77

TABLE 39.—Composition of Tennessee wheats. 1907.

Serial number	VARIETY OR NAME.	Per cent moisture.	Per cent fat or ether extract.	Per cent crude fiber.	Per cent protein.	Per cent ash.	Per cent nitrogen-free extract.
72	Mediterranean	11.20	2.19	2.08	10.98	1.74	71.81
73	Poole	11.12	2.17	2.05	9.29	1.72	73.65
74	Fulcaster	12.03	2.04	2.19	9.52	1.79	72.43
75	Fultz	11.69	2.28	2.29	12.06	1.71	69.97
	Averages	11.51	2.17	2.15	10.46	1.74	71.96

TABLE 40.—Composition of Washington wheats. 1907.

Serial number.	VARIETY OR NAME.	Per cent moisture.	Per cent fat or ether extract.	Per cent crude fiber.	Per cent protein.	Per cent ash.	Per cent nitrogen-free extract.
76	Turkey Red	11.51	1.79	2.24	11.15	1.81	71.50
77	Little Club	10.98	1.95	2.21	8.90	1.83	74.13
78	Forty-fold	13.23	1.85	1.99	9.52	1.54	71.86
79	Red Russian	11.73	2.05	2.27	12.84	1.64	69.47
80	Western Blue Stem	12.27	1.78	2.16	8.84	1.77	73.18
	Averages	11.94	1.88	2.17	10.25	1.71	72.02

COMPOSITION OF TENNESSEE WHEATS.

The chemical composition of these wheats is given in table 39. In per cent of fat these wheats are higher than the wheats from Kansas and lower than those from Minnesota. In crude fiber they are lower than both of the latter wheats. In ash content there is no material difference. In all the chemical constitutents except protein these wheats are very uniform. In protein content the difference between the highest and the lowest is 2.97 per cent. Their average protein content is lower than that of the wheats both from Minnesota and Kansas.

COMPOSITION OF WASHINGTON WHEATS.

The chemical composition of these wheats is summarized in table 40. Both physically and chemically these wheats presented greater variability than any of the proceeding groups. With the exception of Forty-fold and Western Blue Stem these wheats were very unlike in physical appearance. In chemical composition they show great differences. The moisture content is very near to that of the Minnesota wheats; the per cent of fat is very near that of the Kansas wheats, while in crude fiber they are like the wheats from Tennessee. The average ash content is the lowest of any of these groups. In protein content these wheats average the lowest. This is due to the average low protein content of the white varieties. The amber-colored wheats, Turkey Red and the Red Russian, are equal in protein content to the wheats from the Mississippi valley.

AVERAGES FOR COMPARISON OF KANSAS, MINNESOTA, TENNESSEE AND WASHINGTON WHEATS.

The averages for chemical composition of these different groups are brought together in the following table:

TABLE 41.

Origin of wheat.	Moisture per cent.	Fat or ether extract.	Crude fiber.	Crude protein.	Ash.	Nitrogen-free extract.
Kansas, 1907	10.51	1.82	2.42	12.48	1.88	70.95
Minnesota, 1907	12.66	2.30	2.42	11.96	1.87	68.77
Tennessee, 1907	11.51	2.17	2.15	10.46	1.74	71.96
Washington, 1907	11.94	1.88	2.17	10.25	1.71	72.02

MOISTURE CONTENT OF WHEATS AND OF MILL PRODUCTS.

These data are summarized in tables 42, 43, 44 and 45. The figures for the moisture content are the same as those in previous tables and are here used for comparison. The same general relation between the moisture content of the wheat and milling products holds true here, the same as in the tables for the crop of 1906. For the hard wheats there is an increase in moisture content of the patent flour over that of the wheat. This is also true, but to a less extent, for the break flours. That these results do not follow with greater regularity is due to the fact that the relative humidity of the air at the time the sample was ground largely influences the moisture content of the flour. But the results show the general tendency. For those wheats where a small amount of tempering water was used the moisture content of the patent and break flour is as a rule less than that of the wheat itself. In the Washington wheats the increase of moisture falls heavier on the break flours. The moisture content of the tailings flour, the shorts and the bran is in all cases lower than that of the wheat. The loss of moisture in the tailings flour and the shorts is due to the heat generated during the severe treatment these two products undergo. The bran is not subjected to as severe a treatment as the patent flour; the smaller moisture content is therefore due to the mechanical conditions. The bran exposes a large surface and the water evaporates more quickly than from the flour. If we bring together the averages of the moisture content of

wheat and mill products from tables 42 to 45 we have the
following:

TABLE 46.

Origin.	Wheat.	Patent flour.	Break flour.	Tailings flour.	Shorts.	Bran.
Kansas	10.51	10.98	10.74	9.17	7.80	8.79
Minnesota	12.66	11.66	11.31	8.68	7.58	8.42
Tennessee	11.51	11.42	11.35	9.44	7.72	8.74
Washington	11.94	11.17	12.45	9.65	8.12	8.76

In view of the diversity of character in the wheats used
these results are quite uniform and show the general relation
of moisture content of the wheat and the different mill prod-
ucts.

TABLE 42.—Moisture content of wheat and mill products. McPherson and Manhattan wheats.
1907.

Serial number.	Number of wheat.	VARIETY OR NAME.	Wheat.	Patent flour	Break flour	Tailings flour.	Shorts.	Bran.
53	1,539	Torgova..................	10.62	10.95	9.50	8.77	8.13	8.91
54	1,571	Turkey..................	11.02	11.45	11.25	8.95	7.89	9.02
55	2,906	Currell.................	10.18	10.28	10.66	9.05	7.86	8.77
56	2,907	Zimmerman	10.13	10.08	10.50	9.36	7.61	8 74
57	367	Fultz....................	9.98	11.17	11.05	10.29	8.25	9.01
58	368	Malakoff................	10.52	11.31	10.16	9.82	8.12	9 32
59	369	Minnesota..............	10.86	11.31	10.87	8.74	7.20	8.65
60	373	Defiance...	10.50	11.39	11.20	8.99	7.73	8.79
61	380	Turkey..................	10.46	11.35	11.47	9.11	8.28	8.71
62	574	Crimean................	10.51	10.64	10.82	8.83	7.65	8.39
63	576	Weissenberg	10.35	11.44	10.84	9.56	8.14	8.92
64	577	Currell	10.95	10.43	10.62	8.60	6.81	8.32
		Averages............	10.51	10.98	10.74	9.17	7.80	8.79

TABLE 43.—Moisture content of wheats and mill products. Minnesota wheats. 1907.

Serial number.	Number of wheat.	VARIETY OR NAME.	Wheat.	Patent flour	Break flour.	Tailings flour.	Shorts.	Bran.
65	163	Fife......................	13.30	11.80	11.34	8.88	7.73	8.33
66	165	Fife......................	12.23	11.20	11.15	8.67	7.39	8.38
67	169	Minnesota...............	12.94	11.87	11.90	8.50	7.43	8.44
68	188	Bearded Fife............	13 63	11.93	10.97	8.57	7.68	8.48
69	529	Minnesota...............	12.03	11.35	11.15	8.87	7.66	8.56
70	1,006	Minnesota...............	11.88	11.82	11.39	....	7.60	8.38
		Averages............	12.66	11.66	11.31	8.68	7.58	8.42

TABLE 44.—Moisture content of wheat and mill products. Tennessee wheats. 1907.

Serial number.	VARIETY OR NAME.	Wheat.	Patent flour.	Break flour.	Tailings flour.	Shorts.	Bran.
72	Mediterranean.....................	11.20	10.74	10.83	9.19	....	8.55
73	Poole.............................	11.12	11.18	11.01	9.84	8.03	8.53
74	Fulcaster	12.03	12.12	11.98	9.68	7.65	9.26
75	Fultz.............................	11.69	11.64	11.60	9.05	7.50	8.62
	Averages	11.51	11.42	11.35	9.44	7.72	8.74

TABLE 45.—Moisture content of wheat and mill products. Washington wheats. 1907.

Serial number.	VARIETY OR NAME.	Wheat.	Patent flour.	Break flour.	Tailings flour.	Shorts.	Bran.
76	Turkey Red......................	11.51	12.35	12.94	10.33	8.97	8.94
77	Little Club......................	10.98	10.53	10.18	9.24	7.77	8.75
78	Forty-fold.......................	13.24	11.07	12.92	9.13	7.64	8.74
79	Red Russian.....................	11.73	10.20	11.60	8.76	7.46	7.92
80	Western Blue Stem..............	12.27	11.74	12.61	10.80	8.77	9.47
	Averages	11.94	11.17	12.45	9.65	8.12	8.76

PROTEIN CONTENT OF WHEATS AND OF MILL PRODUCTS.
CROP OF 1907.

These data are given in tables 47, 48, 49 and 50.   There is the same general relation between the protein content of the wheat and mill products as was noted in the previous tables. In all cases the percentage in patent flour is lower than that of the wheat.   The difference between the protein content of the wheat and the patent flour for the Kansas wheats is 1.38 per cent, for the Minnesota wheats 1.42 per cent, for the Tennessee 1.54 per cent, and for the Washington 1.57, and the average difference for all is 1.43 per cent.   Most of the break flours have a higher protein content than the patent.   The exceptions to this rule are more often among the soft wheats than the hard, though the rule is not general.   For the Minnesota wheats the average protein content of the break flours is higher than that of the wheat; for the groups the averages are lower.   The break flours in all the groups average higher than the patent.   As a class the break flours come nearer to the wheat in protein content than do any other of the mill products.

In every case the tailings flour is higher in protein than the wheat. If the better part of the tailings flour is put with the patent, the percentage of protein in the later will be increased. This practice is common in many mills where bleachers are used. There is no objection to the better part of the tailings flour as such, except color. The tailings flour produced nearer the end of the mill lacks in granulation. The flour is more impalpable and also contains branny particles. These latter qualities lower the baking qualities.

With but one exception the protein content of the shorts is higher than in any other of the mill products. The protein content of bran is nearer that of the tailings flour than any of the other groups.

The more important data relative to protein for the different groups of wheat and mill products from the crop of 1907 are summarized in the following tables:

TABLE 47.—Protein content of wheat and mill products. McPherson and Manhattan wheats. 1907.

Serial number...	Number of wheat...	VARIETY OR NAME.	Wheat...	Patent flour...	Second-grade flour...	Tailings flour...	Shorts...	Bran...
53	1,539	Torgova............	10.80	10.08	11.84	12.99	16.13	14.34
54	1,571	Turkey.............	12.54	10 68	12.26	14.59	17.30	14.96
55	2,906	Currell............	15.90	13.84	14.74	18.43	20.52	18.61
56	2,907	Zimmerman.........	14.19	12.91	12.43	14.96	20.64	18.12
57	367	Fultz..............	10.54	9.46	8.03	11.66	16.11	13.65
58	368	Malakoff...........	15.65	13.40	16.80	19.07	19.64	17.73
59	369	Minnesota..........	14.62	12.71	15.16	18.29	19.36	16.34
60	373	Defiance...........	12.69	10.89	12.77	15.25	16.93	15.42
61	380	Turkey.............	10.88	11.45	12.96	15.11	17.90'	14.71
62	574	Crimean............	10.03	8.61	8.46	11.69	15.05	12.74
63	576	Weissenberg	10.82	8.78	9.12	12.00	14.02	13.63
64	577	Currell............	11.72	10.40	8.95	13.62	16.34	14.48
		Averages........	12.48	11.10	11.95	14.80	17.49	15 39

TABLE 48.—Protein content of wheat and mill products. Minnesota wheats. 1907.

Serial number...	Number of wheat...	VARIETY OR NAME.	Wheat...	Patent flour...	Break flour...	Tailings flour...	Shorts...	Bran...
65	163	Fife................	12.24	10.92	12.76	15.35	15.05	14.63
66	165	Fife................	12.82	10.70	11.87	14.60	18.05	14.69
67	169	Minnesota..........	12.62	11.09	14.40	16.28	17.45	13.39
68	188	Bearded Fife.......	10.68	9.20	10.56	13.31	16.17	14 24
69	529	Minnesota..........	11.70	10.52	12.86	14.00	16.09	13 98
70	1,006	Minnesota..........	12.22	10.84	14.20	15.63	16.25	13.49
		Averages.........	11.96	10.54	12.69	14.86	16.51	14.07

TABLE 49.—Protein content of wheat and mill products. Tennessee wheats. 1907.

Serial number.	VARIETY OR NAME.	Wheat.	Patent flour.	Break flour.	Tailings flour.	Shorts.	Bran.
72	Mediterranean	10.98	9.68	9.11	12.70	16.32	13.85
73	Poole	9.29	7.94	8.30	10.48	14.45	12.62
74	Fulcaster	9.52	8.36	8.06	11.45	14.91	12.70
75	Fultz	12.06	10.52	11.35	14.38	14.28	15.44
	Averages	10.46	9.12	9.21	12.25	14.66	13.47

TABLE 50.—Protein content of wheat and mill products. Washington wheats. 1907.

Serial number.	VARIETY OR NAME.	Wheat.	Patent flour.	Break flour.	Tailings flour.	Shorts.	Bran.
76	Turkey Red	11.15	9.54	14.54	13.45	17.53	13.73
77	Little Club	8.90	7.94	7.56	10.92	14.44	12.08
78	Forty-fold	6.52	8.32	8.02	11.17	14.34	12.58
79	Red Russian	12.84	10.40	11.37	14.84	17.18	16.09
80	Western Blue Stem	8.84	7.24	6.92	10.40	13.45	12.16
	Averages	10.25	8.86	9.68	12.15	15.37	13.32

TABLE 51.—Protein data concerning certain wheats and mill products obtained from them.

	Wheat.	Patent flour.	Break flour.	Tailings flour.	Shorts.	Bran.
KANSAS, 1907.						
Average protein content, per cent	12.48	11.10	11.95	14.80	17.49	15.14
Differences from wheat	....	—1.38	—0.53	+1.32	+5.01	+2.66
Average per cent of products	....	51.16	9.55	12.49	6.83	18.54
Grams protein from 100 grams wheat	12.48	5.68	1.14	1.85	1.19	2.81
Distribution of protein	....	44.98	9.00	14.40	9.31	22.17
MINNESOTA, 1907.						
Average protein content	11.96	10.54	12.69	14.86	16.51	14.06
Differences from wheat	....	—1.42	+0.73	+2.90	+4.55	+2.10
Average per cent of products	....	55.71	7.57	10.94	6.53	16.83
Grams protein from 100 grams wheat	11.96	5.87	0.96	1.63	1.09	2.47
Distribution of protein	....	48.83	7.98	13.50	9.06	20.54
TENNESSEE, 1907.						
Average protein content	10.46	9.12	9.21	12.25	14.66	13.65
Differences from wheat	....	—1.34	—1.25	+1.79	+4.20	+3.19
Average per cent of products	....	50.11	11.02	12.43	5.93	19.55
Grams protein from 100 grams wheat	10.46	4.57	1.01	1.56	0.87	2.67
Distribution of protein	....	42.79	9.46	14.60	8.14	25.00

WASHINGTON, 1907.

Average protein content...... 10.25	8.68	9.68	12.15	15.37	13.32
Differences from wheat.......	—1.57	—0.57	+1.90	+5.12	+3.07
Average per cent of products..	49.46	10.66	14.22	6.52	18.37
Grams protein from 100 grams					
wheat 10.25	4.29	1.03	1.72	1.00	2.44
Distribution of protein........	40.93	9.82	16.41	9.54	23.27

We see the same general relation as was noted in the summary table for the Kansas wheats of **1906.** The amount of protein recovered in the patent flour is proportional to the amount of patent flour produced. The amount of patent flour depends not only on the nature of the wheat but also on the skill of the miller and the equipment at his disposal. Other things being equal, the less protein recovered in the patent flour, the more will be found in the break and tailings flours. As was noted in regard to the Kansas wheats from the crop of 1906, the bran and the shorts contained a proportion of protein that is larger than their proportion of the milling products. The percentage of total flour for the different groups is as follows: Kansas 73.22; Minnesota 74.22; Tennessee 73.51; Washington 74.23. The corresponding percentages of protein recovered in the total flour for these groups are: Kansas 68.38; Minnesota 70.31; Tennessee 66.95; Washington 67.16. The excess per cent of protein in the bran and shorts for these groups of wheat is as follows: Kansas 4.84; Minnesota 3.91; Tennessee 6.56; Washington 7.07. These numbers have the same general relation as the qualities of the flours from these wheats. Better wheats will not only produce a better yield of flour, but a larger per cent of the protein of the wheat will also be recovered in the flour.

GLIADIN CONTENT OF THE FLOURS AND PERCENTAGE OF GLIADIN IN THE PROTEIN.

The per cent of gliadin in the flour and the per cent of gliadin in the protein are found in tables 52, 53, 54, and 55. The gliadin was determined in the same manner as before described. In the same class of flour there is much less variation in the per cent of gliadin in the protein than in the percentage of gliadin and protein. Two flours may differ very much in their content of gliadin and protein and yet have very nearly the same gliadin per cent in the protein. The per cent of protein and gliadin in No. 61 Turkey is 11.45 and

6.33 respectively; that of No. 62, Crimean is 8.61 and 4.57, a difference in protein of 2.84 and of gliadin 1.76 per cent, yet the difference in the gliadin per cent in the protein is almost within the limits of the analytical error. As is shown elsewhere a difference of 0.10 per cent in the protein determination makes nearly two per cent in the gliadin per cent of protein. In view of this, differences of less than two per cent should be neglected.

The patent and break flours of each group average the same gliadin per cent in the protein. The tailings flours average 10 per cent lower in the Kansas flours, 18 per cent in the Minnesota, 14 per cent in the Tennessee, and 12 per cent in the Washington flours. The ratio shows the greatest variation in the tailings flour and the least in the patent.

RELATION OF THE PERCENTAGE OF-GLIADIN IN THE PROTEIN TO THE BAKING QUALITIES OF THE FLOUR.

If we compare the gliadin per cent of the protein with the baking qualities, using figures from the same classes of flours, we find no correspondence. At least, the power of absorption, the rise in the oven, and the loaf volume furnish a closer measurement of the baking qualities than the gliadin per cent of the protein. It is true that the methods of conducting the baking tests leave much to be desired, but two flours may have the same gliadin per cent in the protein and yet one may have good baking qualities and the other very poor. The per cent for the patent flour of No. 57, Fultz, is 50.52 and the per cent for the tailings flour of No. 56, Zimmerman, is 50.38. The former shows good baking qualities and the latter very poor.

If we compare flours of different classes there is some correspondence between the baking qualities and the gliadin per cent of the protein. The tailings have the lowest per cent; these are also the poorest in baking qualities. If these classes are compared the average gliadin per cent of protein of good flours is 56.00 and of the poor flours 42.00 While the gliadin per cent in the protein shows a difference between classes of flours it fails entirely in showing differences in flours of the same class. It should be remembered, however, that the physical properties of the tailings flour are very inferior. These lack decidedly in granulation. They have also a large amount of bran, material which has a deleterious effect. From what has

TABLE 52.—Gliadin and protein content of flours. Manhattan and McPherson wheats. 1907.

Serial number.	Number of wheat.	VARIETY OR NAME.	Patent flours.			Break flours.			Tailings flours.		
			Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.
53	1,539	Torgova	10.08	5.87	53.27	11.84	6.20	52.36	12.99	5.32	40.95
54	1,571	Turkey	10.68	5.60	52.43	12.26	6.50	53.02	14.59	5.98	40.30
55	2,906	Currell	13.84	7.71	55.70	14.74	8.20	55.63	18.43	8.26	44.81
56	2,907	Zimmerman	12.91	7.20	55.77	12.43	7.19	57.84	14.96	7.54	50.38
57	367	Fultz	9.46	4.78	50.52	8.04	4.26	52.98	11.66	4.96	42.53
58	368	Malakoff	13.40	7.53	56.19	16.80	9.27	55.17	19.07	9.16	48.03
59	369	Minnesota	12.71	7.14	56.17	15.16	8.88	58.57	18.29	8.80	48.10
60	373	Defiance	10.89	6.13	56.28	12.77	7.61	59.59	15.25	6.97	45.70
61	380	Turkey	11.45	6.33	55.10	12.96	7.62	58.79	15.11	7.64	50.63
62	574	Crimean	8.61	4.57	53.07	8.46	4.80	56.73	11.69	4.74	40.54
63	576	Weissenberg	8.78	4.82	54.89	9.12	5.13	56.25	12.00	4.98	41.50
64	577	Currell	10.40	5.56	53.47	8.95	5.15	57.54	13.62	5.68	41.70
		Averages	11.10	6.02	54.40	11.96	6.64	56.20	14.80	6.66	44.59

TABLE 53.—Gliadin and protein content of flours. Minnesota wheats. 1907.

Serial number.	Number of wheat.	VARIETY OR, NAME.	Patent flours.			Break flours.			Tailings flours.		
			Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.
65	163	Fife	10.92	6.25	57.23	12.76	7.30	57.20	15.35	6.38	41.56
66	165	Fife	10.70	6.51	60.84	11.37	6.97	61.30	14.60	6.17	42.26
67	169	Minnesota	11.09	6.26	56.44	14.40	8.44	58.61	16.28	6.02	36.97
68	188	Fife, bearded	9.20	4.97	54.02	10.56	5.96	56.43	13.31	4.66	35.01
69	529	Minnesota	10.52	6.03	57.31	12.86	7.16	55.59	14.00	5.99	42.71
70	1,006	Minnesota	10.84	6.34	58.48	14.20	7.94	55.91	15.63	6.06	38.77
		Averages	10.54	6.06	57.38	12.69	7.29	57.50	14.86	5.87	39.54

TABLE 54.—Gliadin and protein content of flours. Tennessee Wheats. 1907.

Serial number.	VARIETY OR NAME.	Patent flours.			Break flours.			Tailings flours.		
		Per cent protein.	Per cent gliadin.	Per cent gliadin in protein..	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.....	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.....
72	Mediterranean	9.68	5.37	55.47	9.11	5.19	56.97	12.70	5.44	42.83
73	Poole	7.94	4.26	53.66	8.30	4.28	51.56	10.48	4.27	40.74
74	Fulcaster	8.36	4.44	53.11	8.06	4.47	55.45	11.45	4.26	37.20
75	Fultz	10.52	6.08	57.79	11.35	6.75	59.47	14.38	6.28	43.62
	Averages	9.12	5.03	55.00	9.20	5.17	55.86	12.22	5.06	41.09

TABLE 55.—Gliadin and protein content of flours. Washington wheats. 1907.

Serial number.	VARIETY OR NAME.	Patent flours.			Break flours.			Tailings flours.		
		Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.....	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.....	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.....
76	Turkey Red	9.54	5.16	54.08	14.54	8.06	55.43	13.45	5.82	43.27
77	Little Club	7.94	4.54	57.17	7.56	4.23	55.95	10.45	4.54	41.57
78	Forty-fold	8.32	5.04	60.57	8.02	4.95	61.72	11.17	5.33	47.71
79	R d Russian	10.40	6.29	60.48	11.37	6.56	57.69	14.84	7.58	51.08
80	Western Blue Stem	7.24	3.88	53.59	6.92	3.94	56.93	10.40	4.22	40.59
	Averages	8.68	4.98	57.17	9.68	5 54	57.54	12.15	5.49	44.84

been noticed, the baking qualities of the flour depend at least as much upon the physical properties as upon the percentage of protein or gliadin, or upon the percentage of gliadin in the protein, *i. e.,* the gliadin-protein ratio.

A STUDY OF GERMINATED WHEAT AS COMPARED WITH SOUND WHEAT.

TREATMENT OF THE SAMPLES USED.

For this experiment, portions were selected from several varieties of hard wheat from the crop of 1906. Varieties similar in chemical composition were chosen. They were all equal to No. **1** wheat. The whole was thoroughly mixed and divided into eight portions of three thousand grams each. Five shallow boxes were made with sides one inch high and a bottom area of one square yard. These boxes were filled with fine, clean sand. On top of the sand was placed one thickness of unsized paper and a sheet of cheesecloth. With a garden sprinkler water was applied to the whole till thoroughly moistened. The wheat was spread evenly and covered with another sheet of cheesecloth and on top of this muslin bags, the latter soaked in a solution of formaldehyde. This was for the purpose of preventing mold. Only one small patch of mold appeared, and this was on the wheat treated longest. The extra thickness of cloth also served to keep the wheat more uniformly moist. The strength of the formaldehyde solution was twice that used in treating grain for smut, or in the proportion of one pound for 20 gallons.

The experiment was started at two o'clock, July 29, 1907. Two additional sprinklings were given that day, and the sprinkling was repeated four times a day during the experiment. As much water was applied each time as the sand would hold. The weather was very warm, varying from 90° F. to 100° F. in the shade every day. The germination was carried out in the attic of Physical Science Hall. The portions were numbered from one to eight. The first five are those germinated 1, 2, 3, 4, 5 days, respectively. Portions 6 and 7 were treated as described below. No. 8 received no treatment. This is the check. Wheat numbered 9 in the following tables was a sample of damp wheat sold for feed. This was very damp and musty when received. It was kept in a dry, airy

place, where it soon lost its dampness and most of the musty smell.

I. Portion one was removed from the sand after twenty-four hours. No signs of germination were apparent to the naked eye. The wheat was spread out on a sheet of cloth on the floor. As the room was warm, airy and dry the wheat was in a condition to place in the muslin bag after twenty-four hours. Here it was left for a week, after which it appeared dry and plump, like sound wheat.

II. Portion two was removed from the sand after forty-eight hours and treated as No. 1. The signs of germination were evident on a large number of seeds. When the wheat was dry it differed little from good sound wheat.

III. Portion three was removed after seventy-two hours and treated as above. Germination was now visible in most of the seeds. In a very large number of the seeds the plumule and rootlets were from one-eighth to one inch long. After drying these shriveled up so as to appear quite insignificant.

IV. Portion four was removed after ninety-six hours. The plumules and rootlets were now, on the average, one inch long. In places the wheat was grown together in one matted mass. As the day was damp and warm the wheat did not dry very fast; the plumules were quite green after eight hours. The wheat was kept for several days on the floor before it was placed in the bag.

V. Portion five was removed after one hundred and twenty hours. The plumules and rootlets on a large number of seeds were two inches long. The whole was one matted mass and had to be torn apart. This was slow in drying, like No. **IV.**

The fact that Nos. IV and V were slower in drying explains to some extent the great change between III and IV. These five can be divided into two groups, the first three and the last two. This appears most striking in the baking test. There is a gradual change from I to III, then between III and IV there is a great change. Between IV and V the change is again gradual.

VI. Portion six was treated in all respects like No. 1 except that the treatment with formaldehyde was omitted. Germination was apparent on a very large number of seeds. This shows the rapidity with which germination will start under favorable conditions.

VII. Portion seven was treated in all respects like No. 1 up to the time it was taken from the sand. Instead of drying on the floor it was placed in two tin basins and dried for two days in a steam oven, when it was dry, hard and brittle.

VIII. Portion eight was the untreated wheat. This is used as the check.

IX. Portion nine is a sample of damp, musty wheat sold for feed and received from Fielding & Sons, Manhattan. This wheat was kept for some time in a dry, airy place, when it had the appearance of good wheat with but a slight musty smell.

When all the portions of wheat were thoroughly dry they were weighed, sampled for analysis, and the remainder scoured in the machine described above. The results are set forth in table 56. Columns 4 and 5 show the weight in grams lost in the process of germination and drying. With the exception of wheat No. 2 the loss shows a constant increase; three times as large in No. 5 as in No. 1. The apparently small loss in No. 2 is due to less drying than the other portions, as shown in the table on moisture. Correcting for this the loss in No. 2 is seventy-three grams. While less than No. 1, the difference is small when the conditions of the experiment are taken into consideration. The results show beyond a doubt that when the wheat is subjected to heat and moisture large losses occur.

TABLE 56.—Summary of data for preliminary treatment of germinated wheat.

Serial number...	Number of wheat in test..	Weight untreated wheat, grams ...	Weight after germination and drying, grams	Loss in germination and dryig, grams....	Weight of wheat before scourig. grams....	Weight of wheat after scourig, grams....	Less in scourig........	Toal loss, grams........	Toal loss, per cent........
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
33	1	3,000	2,917	83	2,640	2,565	75	158	5.30
34	2	3,000	2,957	43	2,670	2,584	86	129	4.30
35	3	3,000	2,900	100	2,645	2,565	80	180	6.00
36	4	3,000	2,851	149	2,592	2,390	200	349	11.60
37	5	3,000	2,750	250	2,492	2,040	452	702	23.40
38	6	3,000	2,946	54	2,655	2,608	52	106	3.50
39	7	3,000	2,840	160	2,593	2,530	63	223	7.40
40	8	....	....	....	2,000	1,977	23	23	1.60
41	9	....	....	....	2,000	1,960	40	40	2.00

The result of scouring these wheats is shown in columns 6, 7, and 8. The last three lost nearly the same amount. Nos. 1 and 2 scoured as clean as ordinary wheat. No. 2 had a slightly musty smell, but not more than is often found in wheat offered for sale. No. 1 appeared normal in every respect. No. 3

had a musty smell, but not enough to make it an unsalable wheat from that standpoint. It was clean when scoured, but more kernels were broken than in No. 8, the normal wheat. No. 4 scoured quite clean. The kernels appeared plump and well formed, but more broken than in No. 3. The musty smell was also more pronounced. No. 5 was very much broken in scouring. It did not scour very clean. A number of the root-lets were not broken off. In all these five portions there is a progressive softening of the outer seed coat. The greater change between 3 and 4 is due, in all probability, to the causes noted above. No. 6 was almost like No. 2. No. 7 was hard and brittle. No. 7 scoured as a normal wheat. No. 9 showed a large loss in scouring, otherwise when scoured was clean and plump, with only a suggestion of mustiness.

THE MILLING TEST.

The wheats were next milled on the experimental mill. In general they milled more like soft wheats than hard. As a rule the bran coats were brittle and caused an undue darkening of the break flour. The milling data are given in table 57. The percentages are figured on the products obtained and not on the wheat milled. This makes an approximate distribution of the unavoidable losses due to dust and evaporation of moisture. In this case the dust obtained in scouring is not added to the weight of the bran. Had this been done there would be a progressive increase in the bran corresponding to the length of the period of germination. The percentages of flour obtained differ little from those obtained in milling good wheat, and the appearance of the patent flours was that of hard wheat flours, granular and lively. In fact they were so much like flour from ordinary sound wheat that no one but an expert

TABLE 57.— Summary of milling data germinated wheat.

Serial number	Number of wheat in test	Weight of wheat milled	Moisture per cent	Tempering water	Per cent total flour	Per cent patent flour	Per cent break flour	Per cent tailings flour	Per cent bran	Per cent shorts
33	1	2,000	11.07	40.00	76.28	56.90	16.34	2.98	16.38	7.38
34	2	2,000	12.00	45.00	76.75	56.81	16.22	3.72	17.41	5.83
35	3	2,000	11.87	40.00	73.60	51.80	17.64	4.15	20.26	6.13
36	4	2,000	11.67	50 00	72.82	54.17	14.96	3.17	19.27	8.40
37	5	2,000	10.65	45.00	75.40	53.42	17.75	4.23	18.47	6.12
38	6	2,000	11 55	50.00	75.89	54.43	19 08	1.89	19.38	5.22
39	7	2,000	8.50	100.00	78.13	61.67	13.50	2.95	17.23	4.63
40	8	1,977	11.71	60.00	74.98	56.59	16.56	1.81	20.61	4.41
41	9	1,960	12.92	50.00	71.47	49.06	20.85	1.55	23.65	4.87

could detect any difference by mere inspection.   This would be especially true if they were mixed with flour from sound wheat.

The moisture of these wheat samples and mill products is given in table 58.   The moisture in the wheat was determined on a portion of the unscoured wheat ground and sampled for analysis.   The moisture content shows the variation found in the wheat and mill products from sound wheat.

THE BAKING TEST.

The patent flours from these portions of wheat were then subjected to a baking test according to the methods described above.   The gluten expansion tests were omitted.   The summary of these tests is given in table 59.   Per cent of moisture in column 3 is the amount of moisture found in the flour. Columns 4 and 5 show the amount of water absorbed by a weighed amount of flour.   There is a progressive decrease in the first five flours.   First the absorption was determined in flour No. 1.   Then the same amount of water was added to thirty grams of each of the following flours.   No. 2 was a little too soft.   No. 3 was soft and sticky.   No. 4 too soft and sticky to make a dough, and No. 5 was more of a thick paste than a dough.   Next, seeing this progressive change, the absorption on No. 5 was determined.   From the difference between 1 and 5 it was seen that each flour would take about 0.5 cc. less in each case.   This amount was now used and a dough of workable properties was obtained.   There was another quality in these doughs not expressed by the figures.   When the dough of 3, 4, and 5 was worked it had a rubbery consistency, enabling it to be pulled into long threads.   This quality was weakest in 3 and strongest in 5, in 4 about midway between.   This

TABLE 58.— Moisture content of wheat and mill products.   Germirated wheat.

Serial number	Number of wheat in test	Wheat	Patent flour	Break flour	Tailings flour	Shorts	Bran
33	1	11.07	11.52	11.25	9.97	10.05	9.40
34	2	12.00	12.36	11.66	9.57	8.82	9.50
35	3	11.37	11.79	11.24	9.27	9.09	9.30
36	4	11.67	11.57	10.61	9.35	9.71	8.95
37	5	10 65	11.42	10 80	9.32	8.62	8.65
38	6	11.55	11.59	10.79	9.59	9.39	9.13
39	7	8.50	10.98	9.79	8.95	8.55	8.72
40	8	11.71	11.53	10.49	8.57	8.78	9.19
41	9	12.92	12.42	11.28	8.60	8.76	9.62

TABLE 59.—Summary of baking tests.   Germinated wheat flours.

Serial number.	Number of wheat.	Per cent of moisture.	Water absorbed by 30 grams, cubic centimeters.	Percentage of absorption.	Water used for loaf, grams.	Total materials.	Weight of dough.	Dough left in kneader.	Loss during rising.	Time for rising.	Loss in baking.	Time for baking.	Temperature for baking.	Weight of baked loaf.	Volume of loaf, cubic inches.
33	1	11.52	16.25	54.20	184	551	534.7	16.3	3.70	1:52	29.0	0:25	460 F	515.02	83
34	2	12.36	15.75	52.50	178	545	530.9	14.1	3.40	2:13	30.0	0:25	460 F	509.20	88
35	3	11.79	15.25	50.83	173	540	522.4	17.6	4.00	2:03	33.7	0:27	440 F	504.90	98
36	4	11.57	14.75	49.17	167	534	520.5	13.5	3.90	2:17	34.7	0:25	460 F	498.10	84
37	5	11.42	14.25	47.50	161	528	517.0	11.0	5.80	2:55	32.5	0:25	460 F	492.80	84
38	6	11.59	16.25	54.17	184	551	534.2	16.8	6.20	1:58	31.1	0:25	460 F	515.00	97
39	7	10.98	17.00	56.67	193	560	548.2	11.8	3.00	2:25	34.7	0:25	460 F	524.80	69
40	8	11.53	17.00	56.67	193	560	546.4	13.6	3.50	1:25	28.8	0:25	460 F	524.20	85
41	9	12.42	16.00	53.33	184	551	538.5	12.5	3.00	2:42	29.0	0:25	460 F	515.20	86

quality seemed to be of a temporary character existing as long as the dough was worked, and after standing a few minutes it became brittle. This brittleness also appeared strongest in 5 and weakest in 3. The resemblance to putty was quite close. The dough on being worked again assumed the rubbery consistency. When the amount of water to be used for each flour in making a good dough had been determined, the baking test was performed as previously described.

Notes on the Dough from the Different Flours.

No. **1.** The dough was of about the right stiffness, not sticky, but lacked smoothness. The texture was good, but was somewhat coarser than normal, showing a weakening of the gluten In rising and baking the loaf was normal. The texture of the bread showed a small weakening of the gluten. This was very slight however. This loaf is marked No. **1** on plates 21 and 22.

No. 2. The dough was smoother than No. 1, but somewhat less elastic. The texture of the baked loaf was good, but showed a coarser texture, indicating a further weakening of the gluten. This latter was also indicated by the larger loaf volume. This loaf is marked No. 2 on the two large plates, 21 and 22.

No. 3. The dough was the right stiffness, but a very rubbery consistency. The dough rose very rapidly. The texture was good, but showed a weaker gluten than No. 2. This fact is also shown by the larger loaf volume. This loaf is marked No. 3 on plates 21 and 22.

No. 4. The dough was soft, smooth, and very much like rubber in consistency. It was not at all springy. It would run in the pan: The texture of the loaf was poor. The large holes in the crust and in the crumb showed a very weak gluten. The shape of the loaf indicates a very marked change in the properties of the gluten. No undesirable flavor was apparent in the bread. This loaf is marked No. 4 on plates 21 and 22.

No. **5.** The dough was very soft, smooth, and would run. It was of a rubbery consistency like No. 4, but less strong. The loaf was the poorest in texture of all five. The large holes in crust and crumb indicate a very weak gluten. No undesirable flavor was apparent in the bread. This loaf is marked No. 5 in plates 21 and 22.

No. **6.** The dough and loaf were normal except that they showed a weakening of the gluten giving a very large loaf volume. The texture was good.
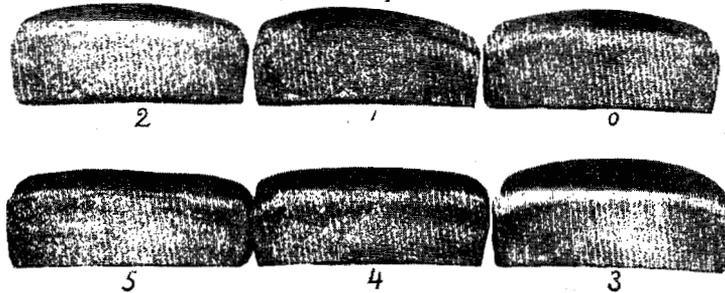
PLATE 21. Loaves from wheat subjected to germination conditions, compared with that from sound wheat. See text for description.
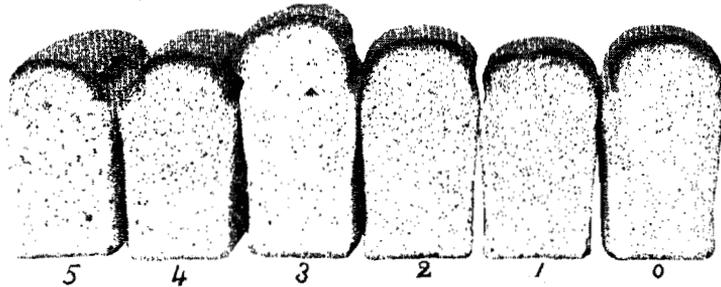

PLATE 22. Loaves from wheat subjected to germination conditions compared with that from sound wheat. See text for description.

No. 7. The dough was very weak; granular, like cake dough. Had not the coherence to be worked in the machine. Rose but little. The loaf was very brittle and when dry became very hard. This shows a more profound change in the gluten than any other, This loaf appears on plate 23, to the right of the normal loaf.

No. 8. This is the standard loaf for the series. The dough and loaf were normal in every way. The texture was very fine. The loaf is marked 0 in plates 21 and 22.

No. 9. The dough was apparently normal. The loaf was of good texture and taste. The only difference between this loaf and one from sound wheat was a little coarser texture, showing a slightly weaker gluten.

In general the baking qualities of these flours, with the exception of 4, 5, and 7, were good, and show that wheat may have undergone incipient germination and still make fairly good flour. However, it must be remembered that these wheats received the best of treatment after the germinating period. It shows, moreover, the power of wheat to withstand

unfavorable conditions. This, however, is no excuse for giving wheat poor treatment. The strength of the flour is weakened by incipient germination. Germination may be carried so far as to destroy the baking qualities of the flour. The losses in scouring are greatly increased and the proportion of flour obtained is decreased. The protein content of the germinated wheat and mill products is shown in table 60. The protein of the wheat was determined on a sample of unscoured wheat. The mill products are from the scoured wheat. Nothing in these figures shows the effect of the germination. The variations show no relation to the germination and can be accounted for by the methods to which they were subjected before analysis.

CHEMICAL COMPOSITION OF THE FLOURS.

The gliadin content of the patent and break flours is shown in table 61. The per cent of gliadin was determined according
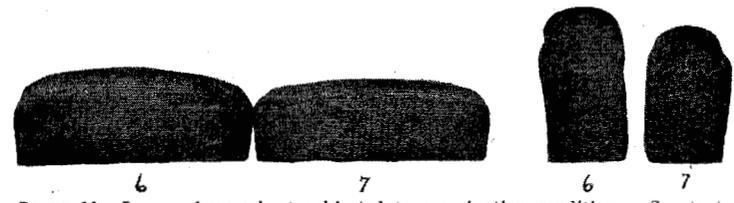

PLATE 23. Loaves from wheat subjected to germination conditions. See text for description.

to the method described previously. The gliadin per cent of protein is obtained by dividing the per cent of gliadin by the per cent of protein. No relation between the baking qualities of the flour and the gliadin per cent of protein is apparent. Take No. 4 and No. 8. The latter had very good baking qual-

TABLE 60.—Protein content of wheat and mill products.
Germinated wheat.

Serial number	Number of wheat	Wheat	Patent flour	Break flour	Tailings flour	Shorts	Bran
33	1	11.42	9.73	11.73	12.06	16.24	15.49
34	2	11.34	9.39	11.20	11.45	16.83	15.49
35	3	11.57	9.49	11.04	11.63	15.95	14.56
36	4	11.80	9.27	11.02	11.00	15.96	15.80
37	5	11.72	9.43	10.82	11.87	16.08	15.89
38	6	11.48	9.77	11.84	11.92	17.57	15.40
39	7	11.62	9.90	12.11	14.12	16.04	15.28
40	8	11.39	9.76	12.14	12.53	15.93	15.23
41	9	10.62	7.90	10.38	12.99	16.57	14.69

TABLE 61.—Gliadin content. Germinated wheat.

Serial number	Number of wheat	Patent flour.			Break flour.		
		Per cent protein	Per cent gliadin	Per cent gliadin in protein	Per cent protein	Per cent gliadin	Per cent gliadin in protein
33	1	9.73	5.22	52.65	11.73	6.15	52.43
34	2	9.39	5.33	56.79	11.20	5.91	52.77
35	3	9.49	5.47	57.66	11.04	6.17	55.85
36	4	9.27	5.35	57.73	11.02	6.16	55.88
37	5	9.48	5.58	59.18	10.82	6.12	56.55
38	6	9.77	5.56	56.91	11.84	5.99	50.67
39	7	9.90	4.53	35.77	12.11	5.25	43.36
40	8	9.76	5.48	56.12	12.14	5.87	48.35
41	9	7.90	4 67	59.07	10.38	4.79	46.11

ities and the former very poor. The gliadin per cent of protein of No. 4 is 57.73 and of No. **8** is 56.12, a difference which has no weight whatever. An error of 0.01 per cent in the nitrogen determination is within the error permissible in ordinary work. This would amount to 0.06 per cent protein. Assuming this error to be allowed either way, the figures for No. 4 would be, total protein 9.33 per cent and per cent of gliadin 5.29, which would give a gliadin per cent of protein of 56.69; and the figures for No. 8 would under the same conditions be, total protein 9.70 and per cent of gliadin 5.54, which give a gliadin per cent of protein of 57.11. The ratio of gliadin to protein may be identically the same in a flour of very poor baking qualities and in one of very good baking qualities when these poor baking qualities are due to germination.

The difference between No. **1** and No. 5 represents the extremes. From the figures obtained it seems that the gliadin per cent of protein is on the increase corresponding with the length of the germination period. However, the difference between No. 1 and No. 5 bears very little relation to the baking qualities. The difference between. No. **1** and No. **2** is 4.14, and between No. 2 and No. **5** is 2.39. But the difference between the baking qualities of No. 1 and No. 2 are small while between No. 2 and No. 5 there is a very large difference. Further, in patent flour from wheat serial No. 26 the gliadin per cent of protein is 52.55, corresponding very closely with No. 1 in this test. Also, in a patent flour from wheat serial No. 11 the gliadin per cent of protein is 59.36, which corre-

sponds very closely to No. 5 in this series. Both the flours from 11 and 26 were excellent in baking qualities, both giving the same loaf volume and nearly the same weight of the baked loaf, while No. 5 in this series was very poor.

The protein in amino compounds and the protein soluble in 1.5 per cent salt solution, as well as the acidity of these flours, are given in table 62. The protein in amino compounds was determined as follows: Eleven grams of flour was put in a 600 cc. Erlenmeyer flask and thoroughly shaken up with 400 cc. of distilled water. The shaking was repeated several times during one hour. Then the flour was allowed to settle and the supernatant liquid filtered off. To 200 cc. of the filtrate 20 cc. of a 10 per cent solution of phosphotungstic acid was added and allowed to stand over night. This precipitated all the proteids dissolved or suspended in the water, and an absolutely clear filtrate was obtained. Two hundred cc. of this filtrate was taken and the nitrogen determined by the regular Kjeldahl method. The nitrogen was multiplied by 5.7, to reduce to equivalent protein comparable with other determinations. In the patent flour the protein in amino compounds increases in amount with the length of the germinating period. No. 4 and No. 5 have a relatively larger increase than the first three. This is probably due to causes noted above. No. 7 has the largest amount of these compounds showing the power of moist heat in the production of amino compounds. In the break flour the increase is not so regular, but the difference between the first three and the last two are clearly evident. In this case there is at first a decrease from the amount contained in the

TABLE 62.

Serial number	Number of wheat	Protein in amino compounds.		Protein in compounds soluble in 1.5 per cent salt solution.		Acidity of flour.	
		Patent flour	Break flour	Patent flour	Break flour	Patent flour	Break flour
33	1	.186	.225	2.14	2.71	1.10	2.10
34	2	.144	.208	2.14	2.50	1.15	1.55
35	3	.184	.240	2.14	2.48	1.30	1.95
36	4	.247	.327	2.26	2.63	1.62	2.25
37	5	.351	.384	2.42	2.83	1.55	2.45
38	6	.192	.338	2.17	2.87	1.10	2.05
39	7	.512	.536	1.68	2.38	2.15	2.50
40	8	.128	.276	2.19	3.10	0.90	2.00
41	9	.176	.288	2.19	2.66	0.90	1.80

patent flour. The break flour starts out with a larger quantity of these compounds than the patent. The amount is decreasing the first two days, however, the amount being all the time above that of the patent flour. After the second day the amount of amino compounds begins to increase. The decrease during the first two days may be explained in this way: Baker's flour comes from the portion of the wheat berry nearest the bran and germ. During incipient germination the new vegetative cells would draw for their supply from the already stored up amino compounds nearest them. Thus in that portion of the wheat berry nearest the bran these amino compounds would at first be used up faster than produced. After the second day the increase in amino compounds would probably equal the production. But the vitality of the cells in the plumule and rootlets would decrease faster than the vitality of the cells in the wheat berry when the wheat was placed on the floor. Hence the amount of these soluble amino compounds would increase.

These amino compounds were produced in the largest amount in No. 7, that portion which was germinated one day and then heated. From this it is seen that moist heat is very potent in the production of these compounds.

The protein in compounds soluble in 1.5 per cent sodium chloride solution is also shown in table 62. These compounds show no increase in the first three of the patent flours; in the last two there is a slight increase. In the break flour there is a slight decrease in the first three, while in the last two there is a slight increase. These changes may be explained by the same theory as in the case of the amino compounds. In the patent flours from No. 7 there is decrease beyond that of the normal flour. This is due to the coagulating effect of heat upon albumens.

The acidity in these flours is shown in the last two columns in table 62. In the patent flour there is a slight regular increase in acidity. In the break flour there is the same regular increase if No. 1 is omitted. The highest of acidity appears in No. 7.

For the determination of acidity ten grams of the flour were shaken up with 100 cc. of distilled water and allowed to stand one-half hour. The supernatant liquid was filtered and 50 cc. of the filtrate was titrated against a $\frac{20}{n}$ solution of KOH using

phenolpthalein as indicator. The numbers refer to the number of cubic centimeters of KOH solution neutralized in each case. One cc. of $\frac{n}{20}$ KOH is equivalent to 0.0045 grams lactic acid.

MILLING AND BAKING QUALITIES OF WHEAT AS AFFECTED BY MOISTURE AND HEAT.

The plan of this experiment was to treat portions of wheat with water for varying lengths of time and to subject one-half of them to a temperature of 100° C. to 120° C. until all added moisture was driven off. Ten portions of three kilos each were used. All were from the same lot of wheat.

TREATMENT OF SAMPLES USED.

Portion 1. This portion received no treatment, and was used for a check.

Portion 2. This was placed in the electric oven for seven hours. The temperature varied from 100° C. to 120° C. This serves as a check for the portions treated with heat.

Portions 3, 4, 5, and 6. These were placed in two-quart Mason jars, one kilo in each jar. To each jar 100 cc. of water was added. By rotating and shaking the jar the water was evenly distributed. After four hours 50 cc. more water was added to each jar, and after 12 hours 50 cc. more, making 200 cc. of water for each kilo of wheat. This was found to be the maximum amount of water they would absorb. After standing awhile, a little water would collect in the bottom of the jars. That one part of the wheat should not be subjected to more water than the other, the jars were inverted twice every day. Portion 3 was kept in the jar for two days, portion 4 for four days, portion five for eight days, and portion 6 for twelve days. After treatment with water, the wheat was spread in a layer on cheesecloth and allowed to dry. When the wheat was thoroughly air-dry it was placed in muslin bags and hung in a dry place.

Portions 7, 8, 9, and 10 received the same treatment with water for the same length of time as portions 3, 4, 5, and 6, but instead of drying on the floor, these portions were placed in the electric oven at a temperature of 100° C. to 120° C. until all the added water was driven off and the berries were hard and brittle. The wheat was then placed in muslin bags and

TABLE 63.—Milling data. Water and heat experiment.

Serial number	Portion number	TREATMENT.	Per cent moisture	Tempering water	Amount scouring dust	Per cent total flour	Per cent patent flour	Per cent break flour	Per cent tailings flour	Per cent bran	Per cent shorts	Per cent dust	Pounds total flour per bushel
42	1	No treatment	10.62	60	26	75.80	55.94	8.56	11.29	17.74	5 44	1.01	45.48
43	2	Heat alone	9.19	60	26	73.69	53.80	9.39	10.41	18.43	7.02	0.85	44.21
44	3	Water 2 days	11.00	50	14	75.48	51.95	9.78	13.69	13.59	9.69	1.23	45.28
45	4	Water 4 days	11.24	60	22	75.21	55.26	8.98	10.95	18.80	4.64	1.34	45.13
46	5	Water 8 days	10.47	60	28	75.13	52.32	9.49	13.31	17.75	5.88	1.23	45.08
47	6	Water 12 days	10.69	60	25	76.84	54.86	8 54	13.43	16.54	5.59	1.02	46.10
48	7	Water 2 days + heat	9.19	80	30	73.53	56.44	7.99	8.59	15.88	9.59	0.99	44.12
49	8	Water 4 days + heat	8.67	90	30	76.16	54.04	7.67	14.44	15.25	7.67	0.91	45.69
50	9	Water 8 days + heat	8.22	110	28	73.63	53.53	6.56	13.53	18.40	7.06	1.00	44.11
51	10	Water 12 days + heat	7.48	110	38	74.44	54.12	6.52	13.81	17.16	7.40	0.98	44.66

TABLE 64.—Baking tests. Water and heat experiment.

Serial number	Portion number	TREATMENT.	Per cent moisture in flour	Water absorbed by 30 grams, cubic centimeters	Percentage of absorption	Water used for loaf, cubic centimeters	Total water in materials	Per cent total water	Total materials, grams	Weight of dough, grams	Dough left in kneader	Time for rising	Loss in baking	Weight of baked loaf, hot	Rise in expansion case, millimeters	Rise in oven, millimeters	Net rise in oven	Volume of loaf, cubic centimeters
42	1	No treatment	11.90	16.0	53.3	181	220	40.15	548	536	12	1:19	13	522	5	33	28	1,290
43	2	Heat alone	10.32	19.0	63.3	215	250	42.95	582	570	12	1:34	18	550	0	0	0	650
44	3	Water 2 days	11.48	16.0	53.3	181	220	40.14	548	587	11	1:32	15	521	5	31	26	1,290
45	4	Water 4 days	11.73	16.0	53.3	181	220											
46	5	Water 8 days	10.73	16.0	53.3	181	217	39.59	548	533	15	1:41	13	519	5	35	30	1,305
47	6	Water 12 days	11.92	15.5	51.6	176	216	39.77	543	531	12	1:52	13	517	5	26	21	1,227
48	7	Water 2 days + heat	10.65	18.5	61.6	210	246	42.63	577	561	16	1:49	17	542				
49	8	Water 4 days + heat	10.43	18.5	61.6	210	245											
50	9	Water 8 days + heat	10.10	19.5	65.0	221	250	42.51	588	577	11	1:38	17	559	2			870
51	10	Water 12 days + heat	10 58	18.5	61.6	210	248	42.98	577	563	14	1:57	17	545	6			930

hung up where the wheat would assume an air-dry condition.

These different portions were next milled. The milling data are found in table 63. All the samples which were subjected to heat are low in moisture. From this is seems that if the wheat has once been deprived of its hygroscopic water it will not again take up from the air an amount sufficient to equal its original water content. Because these wheats were drier it was necessary to use a larger amount of tempering water. The per cent of milling products shows nothing to correspond with the different treatments received. It should be remembered that had these wheats been ground for the purpose of producing commercial flour, these per cents of flour would not have been obtained, especially with those subjected to the heat treatment. These wheats were so brittle that much bran powder found its way into the flour, especially the tailings. As these tests were to be comparative it was sought to make the per cents of the mill products as much alike as possible.

BAKING TESTS.

These data are summarized in table 64. The tests were made on the patent flour. The flour from the portions subjected to heat is lower in moisture notwithstanding that more water was used for tempering. These flours have also the greatest percentage of absorption and the most total water in materials. The baking qualities of those flours subjected to water alone differed very little from the normal. The length of time for the water treatment made no appreciable difference. From this it should not be concluded that wheat is not injured by moisture. It must be remembered that this wheat received the best of treatment after it was removed from the Mason jar. The experiment shows, however, that water by itself does not injure the wheat. The injury comes from chemical changes brought about by the presence of water. The most common is that of germination. Water-soaked wheat is also injured by the heat usually generated. Wheat can be water-soaked for a short time without any material injury to the milling and baking qualities if the temperature is low and the wheat is subsequently thoroughly dried without any heating.

The flour from all the wheats subjected to heat was ruined for all baking purposes. The flour would soak up a larger amount of water than the normal flour, but the dough lacked

that elastic consistency present in normal dough. The dough worked up like cake dough. It was brittle and had almost no power to retain the gas generated by the yeast. The length of time made no material difference, as would be expected from the result on those treated with water alone. The bread was heavy and hard. Eight of these loaves are shown in plates 24 and 25. The normal loaves are the ones subjected to the water treatment alone. The loaves to the right of the normal


4 2   4 3   4 4   4 8
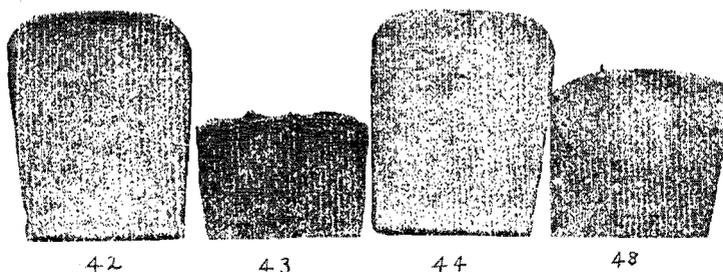
PLATE 24. Loaves showing effect of moisture and heat on wheat. See text for description.

loaves received the heat treatment in addition to the water treatment. The numbers below refer to the serial number.

MOISTURE AND PROTEIN CONTENT.

The data for moisture and protein are found in tables 65 and 66. These show the same general relations as have been noted in previous tables. The products from the wheat subjected to heat are as a rule lower in moisture than the other. The somewhat higher percentages for the portions both moistened and heated are due to the smaller moisture content.

RELATION OF GLIADIN AND PROTEIN.

These data are found in table 67. The difference in gliadin percentages of the portions treated with water alone are so small that they can be accounted for by differences in the samples. The very low percentages of gliadin in the heated samples are striking. The lowest is in portion 2. This also had the poorest baking qualities. Of the other four, No. 10 has the highest per cent. This had also a little more rising power than the rest. That No. 2 should be so much lower than the rest was due to the more prolonged action of higher temperature. The others were moist, and so the temperature was not above steam heat for the larger portion of the time the

wheat was in the oven. Evidently heat at the temperature used renders a large portion of the gliadin insoluble in 70 per cent by volume alcohol, and at the same time the baking qualities of the flour are destroyed.

There is very little difference between the patent and break flours. As in the other samples noted, the tailings flour is much lower in the gliadin per cent of protein.
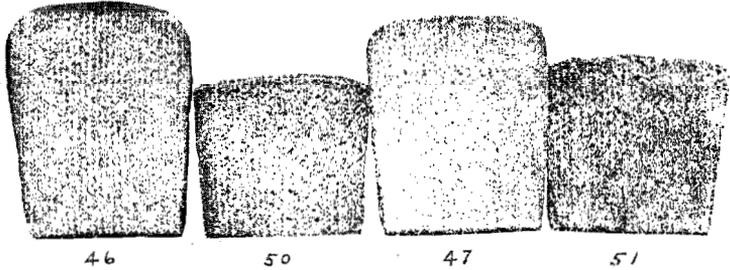

PLATE 25.   Loaves showing effect of moisture and heat on wheat.   See text for description.

TABLE 65.—Heat and water experiment. Moisture content.

Serial number.	Portion number.	TREATMENT.	Wheat.	Patent flour.	Break flour.	Tailings flour.	Shorts.	Bran.
42	1	No treatment...............	10.62	11.60	12.04	10.00	8.55	8.45
43	2	Heat alone	9.19	10.32	10.72	9.26	8.11	8.03
44	3	Water 2 days..............	11.00	11.48	11.83	9.98	7.73	8.89
45	4	Water 4 days..............	11.24	11.73	12.06	9.44	7.73	8.97
46	5	Water 8 days..............	10.47	10.73	10.74	9.38	7.54	8.84
47	6	Water 12 days.............	10 69	11.92	11.63	10.09	8.49	9.45
48	7	Water 2 days + heat.......	9.19	10.65	10.99	9.28	8.34	9.05
49	8	Water 4 days + heat.......	8.67	10.43	10.73	8.85	7.74	8.35
50	9	Water 8 days + heat.......	8.22	10.10	10.72	8.58	7.50	7.91
51	10	Water 12 days + heat.......	7.48	10.53	11.02	9.28	8.36	8.55

TABLE 66.—Heat and water experiment. Protein content.

Serial number.	Portion number.	TREATMENT.	Wheat.	Patent flour.	Break flour.	Tailings flour.	Shorts.	Bran.
42	1	No treatment	13.11	11.12	13.82	15.87	17.65	15.84
43	2	Heat alone	13.14	11.06	13.14	16.16	17.98	16.78
44	3	Water 2 days............	12.99	11.06	13.87	16.24	17.98	15 68
45	4	Water 4 days...........	12.91	10.97	13.19	16.04	19.18	16.47
46	5	Water 8 days...........	13.18	11.12	13.26	16.39	17.90	16.53
47	6	Water 12 days..........	12.97	11.06	13 36	15.99	....	16.13
48	7	Water 2 days + heat....	13.37	11.34	14.07	16.93	17.27	16.84
49	8	Water 4 days + heat....	13.02	11.31	14.36	15.47	17.58	16.73
50	9	Water 8 days + heat....	13.51	11.26	13.99	15.36	17.87	17.31
51	10	Water 12 days + heat...	13.62	11.34	13.96	15.80	17.72	17.10

TABLE 67.—Water and heat experiment.   Relation of gliadin and protein.

Serial number	Portion number	TREATMENT.	Patent flour.			Break flour.			Tailings flour.		
			Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.	Per cent protein.	Per cent gliadin.	Per cent gliadin in protein.
42	1	No treatment	11.12	6.28	56.47	13.32	7.72	57.95	15.87	7.34	46.25
43	2	Heat alone	11.06	1.34	12.11	13.14	1.84	14.00	16.10	1.80	11.18
44	3	Water 2 days	11.06	6.35	57.54	13.37	7.08	52.95	16.24	7.51	46.24
45	4	Water 4 days	10.97	6.32	57.60	13.19	7.52	57.01	16.04	7.88	49.12
46	5	Water 8 days	11.12	6.41	57.64	13.26	7.04	53.09	16.39	4.78	29.16
47	6	Water 12 days	11.06	6.24	56.41	13.36	7.40	55.38	15.99	6.72	42.02
48	7	Water 2 days + heat	11.34	3.84	33.86	14.07	4.67	33.19	16.93	4.55	26.87
49	8	Water 4 days + heat	11.31	3.78	33.42	14.36	4.64	32.31	15.47	3.96	25.59
50	9	Water 8 days + heat	11.26	2.24	28.77	13.99	4.14	36.74	15.36	3.44	22.33
51	10	Water 12 days + heat	11.34	4.13	36.41	13.96	5.04	36.10	15.30	4.56	29.80

SUMMARY.

The scope of this extensive bulletin is shown in the table of contents, and the work described involves thousands of data that can scarcely be usefully summarized.   The investigations of two years or more are included, most of which have been upon wheat of the crops of 1906 and 1907.   The general line of effort has been an attempt to trace, if possible, connections between the chemical composition of wheats and flours and their milling and baking qualities.   In this connection much attention has been given to the control of the milling and baking tests so as to improve them in respect to the uniformity of their results, in order that tests may be more comparable. At best such tests can never possess a high degree of accuracy when compared with chemical tests, but it is believed that some progress has been made.

The work shows that the baking results are influenced very greatly by a large number of details, and that while the gliadin-protein ratio may be of some importance its effect may be entirely offset by the influence of other agencies.   The special baking experiments recorded show how easily results may be modified by variations in the amount of water or yeast used, differences in the extent of the rising, in the working of the dough, in the fineness of the flour, in the initial temperature of baking, etc.

The effect of germination of wheat on the baking qualities of the flour which it may yield was shown to be pronounced but not of the character that might have been anticipated. Slight germination injured the bread but very little.   The effect of heat upon the bread-making power of wheat was very marked.   Moist wheat dried at 100°C. to 120° C. was ruined for this purpose.

The bulletin contains detailed analyses of about sixty wheats, with milling tests of the same and baking tests on the flours produced.   The baking tests in many cases include comparisons of patent, break and tailings flour from the same grinding.