THESIS

on

THE MILLING QUALITIES OF WHEAT

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PREFACE

A science is made by assembling and arranging individual facts in proper and logical order. In the preparation of this thesis the writer claims no originality of his own, beyond the arrangement of material, and wording of subject matter. The work is mostly the compilation of original researches published in this and other countries; and nothing has been written that lacks authenticity and genuineness in the milling qualities of wheat.

Whereas a tremendous investigational campaign has been launched to determine the exact milling qualities of the different classes of wheat, of the different varieties within each class, and of different individual kernels within each variety; and whereas the noble and splendid results have been obtained, as is evident from the accompanying pages, our ignorance is not yet inconsiderable in this line of work.

C O N T E N T S.

A Bird's Eyeview of the History of the Milling Process

The conception of milling quality has been changing with the evolutionary developements of milling process. The first method adopted by man consisted in crushing the berry, thus reducing it completely to a more or less powder form. In other words, the percentage of crushed berries, irrespective of their milling, chemical, nutritive or baking values, was the sole determining factor of milling quality. Bread made from such a meal shall obviously contain all the nutrients of original wheat and shall be coarse in texture, dark in color and strong in flavor.

Up to the middle of the last century the best milling consisted in grinding the wheat in a set of stones and the fine flour was obtained by sifting through bolts or sieves. As fine grinding would reduce a considerable portion of outer coatings to a fine powder, only soft wheats, which would readily crush the starchy interior of the grain without powdering the germ and outer layers, were employed in making the first grades of flour. This flour is not very desirable because it is relatively low in ash and protein, and rich in carbohydrates.

Hence a new process, which passed the wheat through successive sets of rollers set nearer and nearer together as the milling proceeds, came into prominence. Flour from each set of rolls is removed by sifting and the unreduced portions are passed on to the next set. While modern flour mills may differ from each other in details, they are all principally the same in that the bran is separated from the endosperm; that the endosperm is reduced to flour by repeated crushing; and that the flour is separated by means of bolting machines. The bran is also passed through seccessive rolls and bolting machines, until it is as thoroughly cleaned out from the adhering flour as practicable for the kind of flour to be made, or until the cost of reduction does not justify its further cleaning. The number of intermediate products depends upon the size of a mill, the number of stands or rolls, the number of bolts, and the special market demands. The finished products will also vary in different mills, but in general consist of:

First Patent Second Patent First Clear Grade	In most mills these are united into "straights" and "standard patents" flours used for bread.

Second Clear Grade:- used for low grade bread.

Red dog:- used for low grade bread and cattle feed.

Shorts or Middlings Bran	Frequently sold together as mixed feed for cattle, under the trade name of "Mill Run".

The process from start to finish is under the control of a miller; and he can make almost any separation or blends out of these separations, to supply the market demands. For instance, in the demands for breakfast foods, it has been found profitable by some millers to separate middlings and germ in the granular state and sell them under a variety of fancy names at almost a fabulous price.

Several grades of flour are produced. The different mills fix their own standards, which are largely determined by the demand of the trade of the individual mills. It is, rather, an unfortunate condition that there is no established standard universally recognized in flour work. Such terms as "straight", "patents", "shorts" etc. are used in very loose sense and have very little or no significance at all.

In the northwestern tier of states, the terms, "Baker's Flour, " "Patents," "Pastry Flour", and "Export Flour", convey more or less definite meanings, based on the percentage of gluten content, as follows:

A "Baker's Flour" contains about 35 percent of moist gluten. This flour is too strong for a housewife to use, since it requires a machine power to knead. Hence for the housewife, "Patent Flour" which contains from 25 percent to 30 percent, moist gluten and which needs comparatively less kneading power, is sold.

Any low grade flour which contains not over 24 percent, moist gluten is designated as "Pastry Flour".

Export Flour is a low grade flour, sold very generally to the foreign markets. The percentage and purity of the gluten content in this flour is not fixed.

THE WHEAT KERNEL.

Of all the food products which our beneficent nature has placed at our disposal, wheat easily ranks first. It is true that rice forms the staple food for a much larger proportion of the human race, yet it needs no argument to prove the superiority of wheat over that cereal. The superiority is due not only to the intrinsic food value of the wheat kernel but also to the vast number and variety of products which are being derived from it. Not this alone, but the nutritive ingredients are so proportioned in the wheat kernel that it can be called almost as perfect a balanced ration for man as any single food can be, except milk. The requirements of modern civilization, with the revolutionizing industrial and mechanical developments have led to the rigid analysis of wheat grain structure, here as well as elsewhere.

The wheat kernel may be divided into three distinct parts: embryo, endosperm, and bran.

The Embryo is an essential part of the seed, which when planted will develope into a new plant. Chemical analysis will show that the embryo or germ is not only rich in oils and mineral constituents, but in nitrogenous matter as well. It is about 6% by weight of the entire grain. In spite of all this germ is not included in the flour, firstly because it imparts a dark and un-inviting color, and secondly because the oils become rancid, especially when stored for a long time.

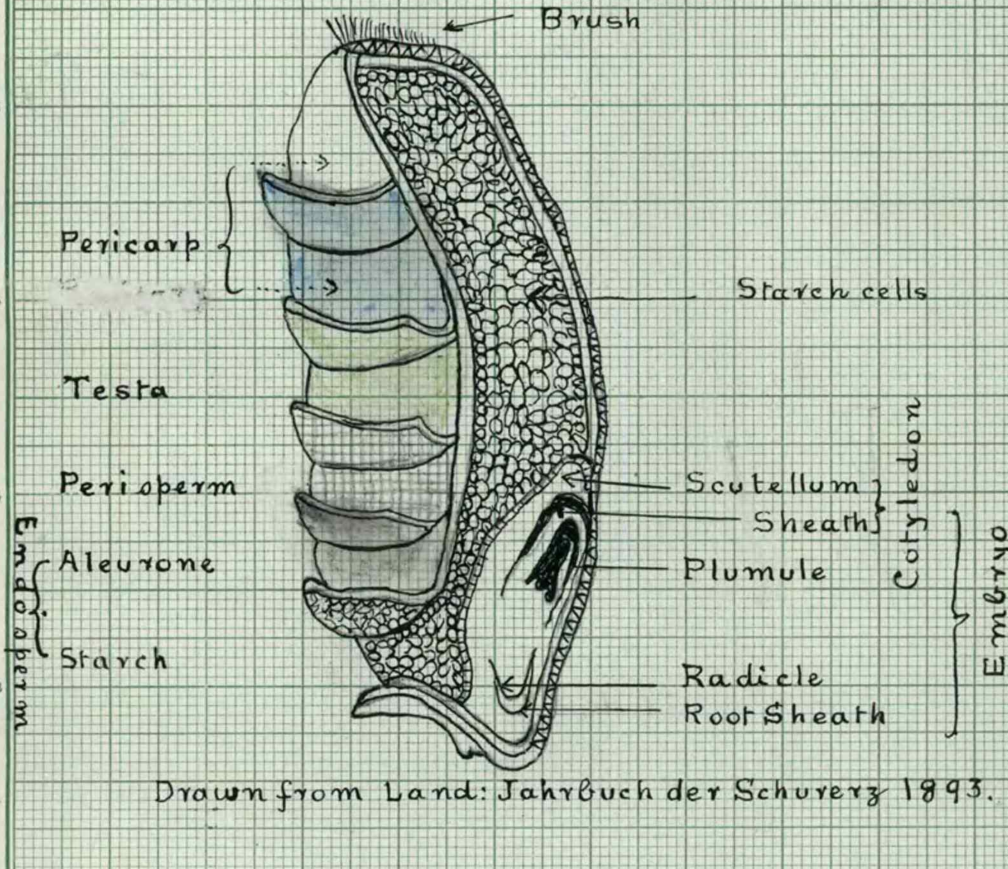
The embryo contains a cotyledon, a protective sheath enveloping the plumule (rudimentary stems and leaves) and a radicle (rudimentary root) enveloped in the root sheath.

The accompanying diagram shows a section through a grain of wheat. The different layers, composing the outer portion being folded back separately, reveal distinctly each and every part of embryo, endosperm and bran.

<u>The Endosperm</u> is over 80% of the wheat kernel by weight, out of which from 70 to 75% is recovered as flour. It is designed by nature to serve as the only food for the young plant during its process of germination and subsequent early growth. It contains all the starch and gluten of the wheat. True gluten, should be remembered, is found only in wheat and gives this grain its pre-eminence over the other cereals.

The outer part of the endosperm is distinctly different from the inner one. The interior of the grain consists mainly of large oblong or rectangular cells filled with starch granules of different sizes, thru which runs a more or less irregular band of gluten cells. The outer squarish cells are filled with a granular form of protein called aleurone. No matter how valuable this aleurone may be, it should not be confused with gluten itself, which is confined only in the interior of the endosperm.

STRUCTURE OF WHEAT KERNEL



Drawn from Land: Jahrbuch der Schurerz 1893.

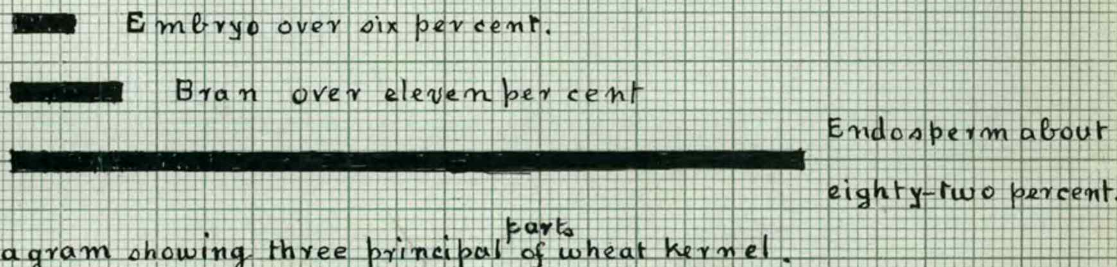


Diagram showing three principal parts of wheat kernel.

In the process of manufacture a miller rejects the aleurone layer as waste product. The center of the endosperm is richer in starch and poorer in gluten. From the center outward the proportion of gluten gradually increases and reaches its maximum immediately beneath the aleurone layer.

The Perisperm protects the gluten layer. Immediately above the perisperm are the testa and pericap,which constitute the skin of the grain. The testa is a fibrous covering containing yellow or reddish pigmentation or color of the grain . Surrounding the testa lies pericarp, which consists of two layers of cellulose. A pecularity about these layers, is that in the outer one the cells are arranged vertically and in the lower longitudinally.

The scutellum divides the endosperm from the embryo. It is a cellular membrane, peculiar to the graminaceae alone. It contains certain ferments to digest starch, gluten, etc. of the endosperm to such assimilable forms as glucose for the use of embryo.

The word bran as usually termed is indefinite and perhaps incorrect, because it is construed to mean "the whole grain minus the flour". Properly speaking bran constitutes three layers, as can distinctly be seen in an immature turgid kernel. The uppermost two celled layer, the pericarp, which bears a small tuft of hair technically known as brush. The intermediate layer is called perisperm and the last one is aleurone.

These three layers collapse and adhere so tenaciously to one another that their separation is practically impossible.

As ordained by nature, bran protects the germ and endosperm. It is the richest part of the kernel in protein and ash, and it constitutes over eleven percent of the bran by weight.

MILLING YIELD

Since flour is the most valuable mill product the wheats which have the higher percentages of flour are more valuable than those of which lower percentages are obtained. In order to have a fair conception of the possible difference in flour yields, expressed in terms of dollars and cents, the following table is quoted from the Minnesota Bulletin 131:

Value of mill products from one bushel of wheat with flour at $5.25 per barrel and mixed feed at $25.00 per ton.

Flour percent	Feed percent	Loss percent	Total Value
60	38	2	1.252
65	33	2	1.295
70	28	2	1.338
75	23	2	1.381

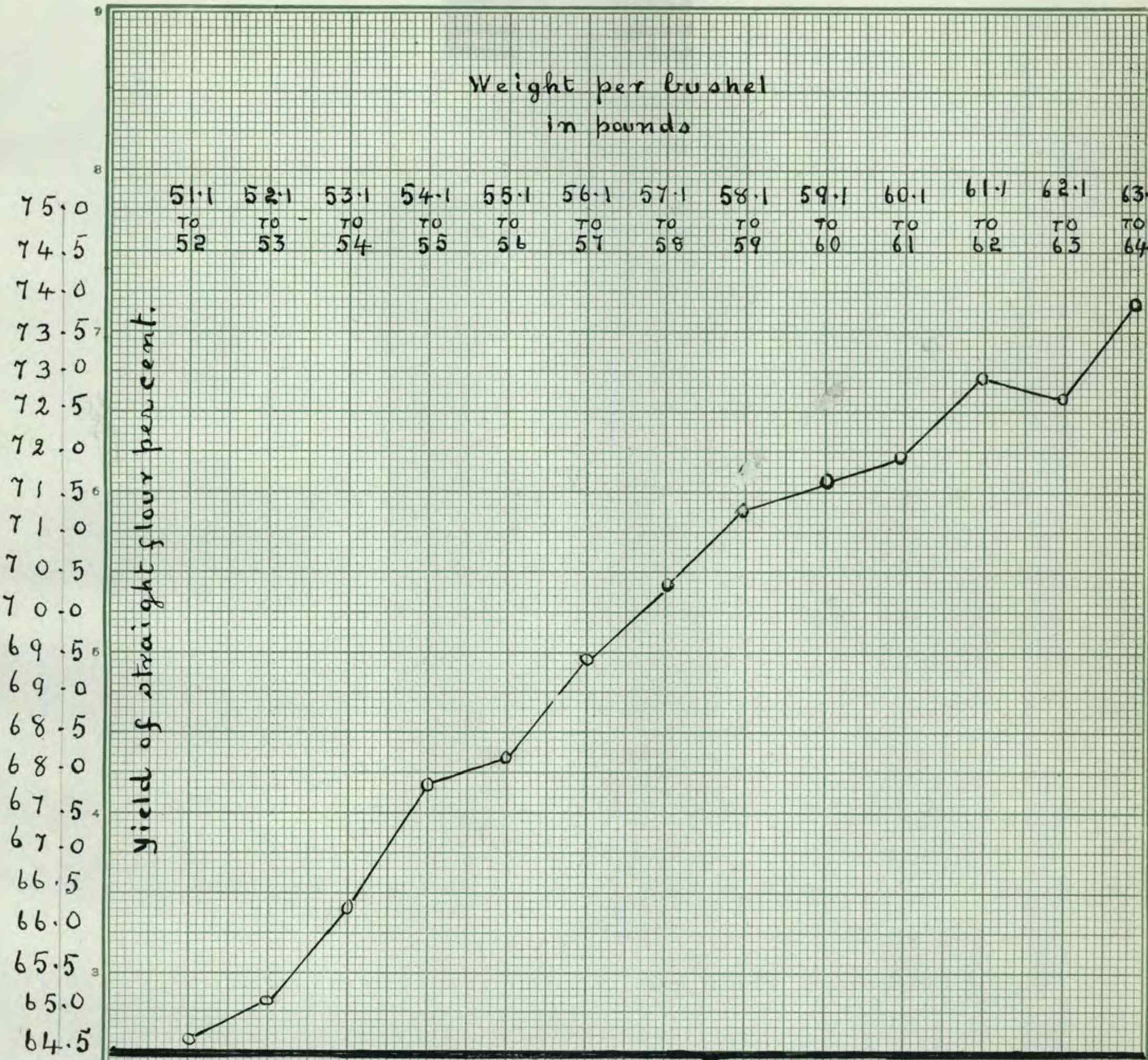
From this table it is clear that the wheat which yielded 75 per centum total flour is worth over $0.13 per bushel more to the miller than that which gave 60 percent. Whereas an amateur miller is apt to under-value the importance of this table, thinking it an extreme case of very seldom occurrence, an expert miller on the other hand, regards it as a question of failure and success and studies very seriously the causes affecting such differences.

The milling yield is closely associated with certain pphysical features of the kernel, especially the size of grain, thickness of bran, test weight per bushel, hardness of kernel, yellow berry and sprouted grains.

Relation of size of kernel to flour yield:-

The size of kernel has an important bearing upon the milling value of wheat especially as between the samples of the same variety, other things being equal. For instance of two wheats, otherwise of equal value for milling purposes, the one whose grains are larger will give the larger yield of flour. Millers very generally recognize this by screening out the smallest grains. Further, we might expect this to be a prima facie evidence, that there is bound to be larger percentage of bran upon the smaller grains of the same variety.

Test weight per bushel:- The value of the "weight per bushel" of grain as a measure of quality has the sanction of antiquity in the history of civilized man. With a very few unusual exceptions, the ratio between the test weight per bushel of wheat and theflour yield obtained therefrom, is the same. For the confirmation of this statement, a diagram from U. S. D. A. Bulletin 557, is shown on the accompanying sheet of paper. The direct relationship between weight per bushel of wheat and flour yield is so evident from this graphic picture that no further explanation is needed.



Graphic diagram showing the relation between the milling yield and wheight per bushel as indicated by the results of milling tests with samples of hard spring and hard winter winter wheat representing the crops of 1911 and 1912.

The weight of measured bushel of grain is dependent upon the shape, uniformity, and the moisture content of the kernels.

<u>The Shape</u>:- The shriveled, the shrunken, or the damaged kernels, due to their unsoundness, unripeness or careless handling, give low flour yields, because of the low proportion of endosperm to bran and germ.

<u>The Uniformity</u>:- A variety of wheat is considered uniform in bulk, if it contains the so called unseparable impurities, not more than the limit set forth by U. S. Grain Standard Act for number one wheat of that variety. In spite of our best cleaning and scouring of wheat before milling, a certain percentage of weed seeds, dirt, chaff, and other foreign grains find their way to the grinding rolls unseparated. Experience and experiment have both shown that the impurities when ground with wheat result in the lowering of flour yield.

<u>The Moisture Content</u>:- Grain is almost always composed of dry matter and water, even when it is thoroughly sun-dried. The proportion of dry matter in wheat varies with the season of the year, the section of the country in which it is grown,

and the way this crop is handled and stored. The water contained in any product has no feeding value at all. Five car-loads of wheat with twenty percent water, for example, will produce just exactly the same amount of flour as four carloads with no moisture. In short, there is a direct relation between milling yield and the moisture content of wheat; and in general, the yield varies inversely with the moisture content. May it be emphasized in passing that a low moisture content is characteristic of arid farm grains. This is an item of great value to a grain dealer, since it gives to arid farm grain a higher intrinsic value. A difference of 1% in moisture can not be ignored in the purchase of a large quantity of grain.

Hardness of the Kernel:-It is generally held that the hardness of a grain is indicative of superior milling quality and weight per bushel, particularly if the test be applied with in a variety. This test is usually given in the purchase of grain by biting of several kernels, but it is doubtful if an exact idea of relative hardness of the berries can thus be established. Of course, it would be possible to differentiate durum varieties from the white wheats of the west, but not from a lot of Australian to another of the same variety.

So an apparatus has been designed to determine quantitatively, in terms of mean crushing point of kernels, different degrees of hardness in wheat. This apparatus is of such a nature as to measure the weight used in crushing the berries. For accurate results such a device is dependable.

Quantitative estimates of hardness in any given pure strain of wheat will vary somewhat with the season and locality, but in general, soft wheats crush under a pressure of 6,000 grams, semi-hard ones under 9,000 grams, and hard wheats under 12,000 grams.

A third method for the determination of the hardness of the grain is by Specific Gravity method. Since there is a marked correlation between the hardness of grains and their specific gravity, more investigations need be made, and the exact degree of hardness with its corresponding specific gravity be properly tabulated to warrent its general use.

The range of specific gravity of both soft and hard wheats are as follows:

Soft Wheat ranges between	1.2619	and 1.4133
Hard " " "	1.4152	" 1.5027

<u>Yellow berry</u>:- By the term yellow berry is meant the appearance in wheat of grains of light yellow color, which are opaque, soft and starchy. This character may be found from a small fraction to generally one-half of a kernel, while the remainder of the kernel will be hard, flinty, and

translucent, or it may be that this character is found throughout the kernel.

The question, as to what causes such a character in our bread wheat, engaged the attention of several investigators, both in this country and abroad, and their unfortunate findings ended in condemning each other's results. The writer after a long and serious study, considers the undermention discussion and causes to be the only rational ones:

Hackel in his work on "True Grasses ", writes: "If that the albuminoids so fill up the intervals between the starch grains that the latter seem to be imbedded in cement, the albumen appears translucent and the fruit is called corneous; but if the union is less intricate there remain numerous small air cavities and the albumen is opaque and the fruit is meally. Both conditions may occur in the same variety of wheat and they seem to be occassioned by differences in climate and soil."

Yellow berry is not due to over-ripeness, nor to improper and protracted exposure after cutting, nor a heritable tendency in wheat, nor an action of fungi as it has been claimed by different authorities. "Yellow berry", says Professor Hyslop, is almost under the control of the grower, and the means to impede its recurrence are:

The judicious use of nitrogenous fertilizers, thorough cultivation and proper crop rotation in which clover and possibly other legumes precede the wheat. The only thing uncontrolable is climate.

On the Kansas Experiment Station the weight of Yellow berries, their specific gravity and nitrogen contents were compared with flinty kernels. Its average results are given below:

	Yellow Berries 100 grains	Flinty Berries 100 grains
Average weight	2.696 grams	2.740 grams
Average specific gravity	1.304 "	1.336 "
Average nitrogen percent	2.38 "	2.79 "

This table explains the seriousness of "Yellow Berry" character, affecting sadly the bank-books of wheat raisers. It makes bread wheat poor in protein content, and probably in starch as well, since it lowers the specific gravity and absolute weight per bushel. A sharp discrimination is made in the market against a sample containing a high percentage of yellow berries. From the milling stand-point this is justifiable, owing to the variation between the yellow and hard beries; but from baking stand-point a wide variation does not seem to exist.

The Nebraska Station reports that the yellow berry in hard winter wheat alone causes an annual loss to the wheat raisers of that state of from one-half to one million dollars.

Sprouted Grains:- The increased milling loss is associated with the stage of germination, but the baking tests show a slight improvement in volume and texture of loaf with the time up to and including the second day, after which a distinct reverse follows. In many cases the germination may perform favorable functions in the baking, but this germination should not go so far as to offset the milling qualities of the wheat.

Flour obtained entirely from a germinated wheat is seldom found in the market. A small percentage of sprouted wheat is mixed with sound one. It has been proven by the Kansas Station that the damage upon the milling and baking quality of wheat and flour from germinated grain has been overexaggerated. In their trial, 25% of sprouted wheat was mixed with 75% of sound grain and very little deleterious effect on the quality of flour was noticeable. It would be entirely safe to mix as much as 10% of the sprouted kernels, without very much impairing the quality of wheat, provided the germination is not too far gone.

Whereas the germinated wheat can thus be used, it does not mean that the loss is too trivial to take precautions against. A grain subjected to heat and moisture incurs a decided loss of starches, gluten and fats, commensurate with the degree of hydrolysis it has undergone. The diastase, for example, will decompose starches; lipasse, fats; and the proteolytic enzymes nitrogenous compounds. Furthermore the flours obtained from such wheats slightly darken the color of the loaf, and increase the bran content at the expense of the flour.

This statement is very well substantiated by the report made in Washington Bulletin 144, where the bran and shorts increased from 23.35% to 59.65% and the flour decreased from 74.15% to 31.60%, according as the germination proceeded on and on.

MILLING QUALITY OF WHEAT

The term "milling quality" has a varied meaning, and in speaking of wheat of high milling quality two millers may have very different standards in mind. The baker desires what is technically called a strong flour, and produces a large loaf of bread of good physical texture and one that does not dry out readily. The cracker-maker prefers the flour of low strength, and the macoroni man wants the flour of higher nitrogen percent, than is available in our common bread flour. The miller, on the other hand, is interested in a wheat which yields a greater percentage of flour of good appearance. It might happen, that a sample of wheat of excellent milling quality might yield flour unsatisfactory to the consumer, and on the other hand a poor, somewhat shrivelled sample of wheat, might give a small yield of flour possessing admirable baking qualities. Strictly speaking the term "Quality" should signify the suitability for the use intended, such as, "wheat of high macoroni quality"; "of high baking quality", or of "high milling quality".

There are several factors, entering into the determination of milling quality of wheat, as noted below:

1. Chemical Composition
2. Acidity
3. Color
    - Bleaching
        - Artificial
        - Natural

Soundness of Wheat

Impurities

Varietal Differences

4. Moisture

5. Aging

6. The Method of Farming

Dry Farming

Irrigation Farming

7. Uniformity

CHEMICAL COMPOSITION

Themilling and baking value of wheat has been one which has attracted the attention of chemists both in this country and abroad for many years, but up to the present time its complete solution has baffled their skill. While this is true, some advance has, undoubtedly been made and certain factors, which unquestionably have a bearing upon the quality as related to milling and baking, have been determined. Nevertheless, it must be admitted that we are still far from intimate understanding of the true relations of these factors.

The general composition of wheat does not differ materially from that of other organic bodies, in that it is made up of several different groups of constituents, viz., water, crude protein, fats, and carbohydrates. A graphical picture of the chemical constituents of wheat is arranged in its logical order below:

- Wheat
  - Water
  - Dry Matter
    - Organic
      - Nitrogenous
        - Proteids
          - Gliadin
          - Glutenin
        - Non-proteids
          - Edestin
          - Leucosin
          - Amides
      - Non Nitrogenous
        - Fats or Ether Extracts
        - Carbohydrates
          - Nitrogen
          - Free Extracts
          - Crude Fiber
    - Mineral

<u>Water:</u>- The moisture percent refers to the amount of hygroscopic water. Under ordinary conditions there is from 5 to 14 per centum moisture present in wheat. This water has no more food value than that taken from a well or a stream. An excess of moisture say over thirteen percent, in the freshly milled sample is undesirable because it causes fermentation.

<u>Dry matter</u>:-If the moisture is excluded from a grain, what is left is "Dry Matter", which is partly organic and partly inorganic or mineral in its composition.

The organic matter is further divided into nitrogenous and non-nitrogenous matter. Of all the material composing a food stuff the nitrogenous matter is most important. It embraces both proteids and non-proteids, which, however, are usually separated but classed together as protein. The nitrogenous compounds of wheat consist principally of proteids of which the recognized five ones are: globulin, albumen, proteose, gliadin, and glutenin.

A globulin is soluble in saline solutions and not coagulable at a temperature below 100 degrees C. This constitutes 0.6 - 0.7 per centum of the grain.

An albumen is coagulable at 52 degrees C. and it differs from animal albumen in several important particulars. It constitutes from 0.3 to 0.4 per centum of the kernel.

A proteose, which is extracted from wheat by dilute saline solutions after removing the globulin, constitutes from 0.2 to 0.4 per centum of the kernel.

A gliadin is a proteid body, soluble in dilute alcohol and forms nearly one-half of the total proteid matter of the kernel. It is a glue like body of wheat which binds the flour particles and enables the dough to expand where the gas is generated by the action of yeasts or by the chemicals.

A glutenin is insoluble in water, dilute saline solutions, and dilute alcohol, and together with gliadin forms nearly the entire proteid content of the wheat kernel.

Chemist divides the proteids into two general classes, viz., gluten and non-gluten proteids.

A gluten is a mixture of gliadin and glutenin. Crude gluten can be obtained either from a wheat meal or flour by simply washing out the starch and water soluble portions. A good gluten has a light yellow color, is tenacious and elastic, while the poor gluten is dark in color, sticky to handle. The bread making value of a flour, in a large measure, depends upon the amount and quality of gluten and proportion of gliadin which the gluten contains. Either an excess or scant amount of gliadin may cause a flour to be of a poor bread making qualities. The best grades of hard wheat flour contain from 56 to 58 percent of proteids in the form of gliadin.

In the literature on milling and baking qualities of flour, the expression "gliadin numbers" is very frequently met, meaning thereby the percentage of gliadin in gluten. The gliadin numbers of 60, for instance, means 60 per centum of the gluten is gliadin and the remaining 40 percent is glutenin.

Fat:- It is generally known to the chemist as "Ether Extract", because in addition to the fats it also contains all of the ether soluble materials in the kernel. The determination is made by extracting a moist free sample of wheat with pure ether. The fat of wheat is not a very important constituent in determining its value.

Carbohydrates:- These compounds are usually separated into crude fiber and nitrogen free extracts. The former is a mixture of cellulose and similar substances which remain after successive boilings of carbohydrates with a weak acid and a weak alkali. It is found principally in the bran. Carefully conducted experiments show that the woody fiber has but little nutritive value. The nitrogen-free-extracts are composed of a number of substances, but the sugars and starches are the main ones.

Starch is the most important of the carbohydrates of the wheat and constitutes from 54 to 59 per cent. of the kernel. It is, of course, of great importance as the principle food stuff in bread.

Sugars, such as, sucrose and maltose, are other compounds which are present in wheat in but small quantities. In sound wheat, if sugar be present, it should be in the form of cane sugar. Should, however, the sugar be in the form of maltose, it would indicate a partial hydrolysis of starch and would be objectionable.

Other constituents, in the category of organic matter, are of so little value, that there discussion is intentionally omitted.

It seems proper, to reproduce verbatim the relation between the soluble and insoluble carbohydrates as given in the Division of Chemistry Bulletin 13, U. S. D. A.

"From the analysis given in this paper and the best available results of other experiments, the proportion of insoluble to soluble carbohydrates in the air dried wheat are as follows:

Insoluble Carbohydrates

Starch	54.0	to	59.0%
Free Pentosans	3.5	to	4.5%
Lignin and its allies	2.0	to	2.5%
Cellulose	1.6	to	2.1%
Total	61.1	to	68.1%

Soluble Carbohydrates

Invertose	.027%
Sucrose	.330%
Dextrin	.160%
Total	.517

Mineral Matter:- The mineral matter of plants is expressed by the term "ash". It is the residue left after burning the organic matter to perfect whiteness.

Analysis of ash reveals an important group of salts, such as K_4 PO_4 (potassium phosphate) and other salts of calcium and magnasium which contain elements essential to the physiological functions of human body. Since commercial wheat flour contains far less percentage of these salts (being removed with bran) than the amount present in the original wheat grain, objections have been raised against the use of such flours, where as the whole wheat flour has been lauded because of its higher percentage of phosphate. While there is unmistakable ground for these objections, yet many of the attacks on the white flour are unwarrented and nothing short of criminal. This argument is over done, when we say that white flour has an assurance of purity and superiority.

The ash content of a flour depends on the several factors, such as the kind of wheat, the kind of soil that produces it, and the handling of wheat before milling.

As a rule, hard flinty kernels give a higher percentage of ash than yellow soft-ones from the same kind of wheat. The mills that possess superior facilities for cleaning, are able to produce from the same kind of wheat a flour with lower ash content than ones whose equipment is lacking in this respect. The larger portion of ash of the wheat kernel is found in the outer portions termed bran and shorts, consequently, cleaner the separation of the outer bran coats from the inner floury portions the lower will be the ash content.

An elaborate discussion on the further analysis of the ash elements is beyond the scope of this thesis, but a fair idea as to their percentages of these elements can be obtained from the following figures:

Fe.....0.004 to 0.012	SiO_2....0.006 to 0.0116
Ca.....0.029 to 0.050	Mn from a trace to0.007
K..... 0.340 to 0.439	Mg 0.116 to 0.162
Cl from trace to 0.192	Na from a trace to0.025
P..... 0.261 t0 0.418	S 0.093 to 0.189
Colorado Bulletin 219	N 2.074 to 3.008

A C I D I T Y

Wheat is almost always acid in reaction. This acidity indicates the amount of water soluble phosphates and amino acids, which, of course, can be neutralized by an alkali. Acidity may also be due either to lack of complete maturity of the wheat or to unsoundness caused by fermentation, as in wet or sprouted grains.

Wheat grown in warm dry countries have very few immature or musty kernels, and consequently are less subject to fermentation.

Acidity is expressed in percentages of grams at a certain degree of temperature. One cubic centimeter of 20/N solution of potassium hydroxide (KOH) is chemically equivalent to .0045 grams lactic acid. The choosing of lactic acid and 20/N solution of (KOH) potassium hydroxide is arbitrary. The acidity varies with the commercial grade of flour and its temperature, as follows:

	Room temperature	40° C
Short Patent	0.088 percent.	0.128
Long Patent	0.105 "	0.163
Straight	0.112 "	0.166

It has been found out that higher the temperature the greater is the acidity, till the temperature rises to 40° C., where the acidity is at its maximum. (".) Further increase in temperature results in the decline of that acidity.

A high acidity in wheat does not necessarily mean a corresponding acidity in the flour obtained therefrom, because the portions of the wheat kernel, next to bran and germ, are the only ones that possess high acidity value. So it stands to reason that the acidity in a flour grade rises according as these portions are incorporated into it.

The Color:- The color is the best indicator of flour quality. The housewife and likewise the baker prefer a flour decidedly white in color. Whereas an expert miller or baker may tell the commercial value of a flour by a mere glance on it, an amateur, on the other hand, believes this a game of hit or miss. Hence the use of tintometer is ("") recommended for the latter person.

("). Preconceived notions lead us to errors. The writer believes, that at the time when these experiments were being conducted, the authors, in working out correlation table, must have been under the wrong impression that the temperature alone is the determining factor, when, in fact, time has just as much part to play in, For example, if the acidity value, for shorts, is 0.128 grams at 40° C. it will certainly decline if unlimited time is given for this temperature to act.

("") "A few words on the use of tintometer may not be amiss here. This instrument is so arranged that a tray each of two different colored flours is placed in the field at one and the same time. The color of any opaque object such as flour is due to the light which it reflects, and when the reflections from these flours are thrown in the same field, different coloring will be observed. This instrument is also furnished with a series of red, blue and yellow colored standard glasses to match any color in question. Further these glasses in three different colors are graduated, shading from the lightest perceptible tint to a more pronounced one".

Color is expressed on an empirical scale ranging from 50 to 100 or above. The whiter the color the higher the color score. The following table, reproduced verbatim from the North Dakota Bulletin 89, shows the commercial or mill system of color scoring.

Mill System	System Described
1	102-105
1	100
1	99
1.5	98
1.5	97
1.5	96
2.	95
2.	94
2.5	91
3	88
3.5	85
4.	82
4.5	79
5.	76
5.5	73
6	70
6.5	67
7.	64
7.5	61
8	57
8.5	50

Color of wheat flour is one of the most important factors to determine its commercial value. For several years artificial bleaching has been resorted to, as a means of securing the desired color, but the use of sound grain, proper cleaning and washing machinery, and a modern milling system will enable any expert miller to produce flour sufficiently white in color.

<u>The Artificial Bleaching</u>:- The matter of bleaching to improve flour color, though does effect favorably the commercial value of a flour, is after all a sentimental question. The bleaching is not practiced to a very great extent in this country. The principle involved in bleaching process is to subject the flour to the action of some oxidizing agent, such as passing an electric current and air in an agitator, where the flour is exposed. The air will be exhausted and charged with an abnormal high percentage of nitrous acid or nitrites. This chemical is physiologically harmful to our body system but is forced on us, by a profiteer, never-the-less.

The color of bread, made out of bleached flour, is whiter, but its odor is slightly pungent. One thing that goes against the baker more than anything else is that the absorptive power of bleached flour is reduced, approximately, from 69.5% to 60%. In face of these dangers, it is unwise, on the part of a miller, to stoop to a vile practice of bleaching flour for color.

Natural Bleaching:- It is well known to the millers and bakers that flour, when stored from four to eight months, undergoes certain enzymatic changes, resulting in slight bleaching and improving of flour and bread. This flour will always be lighter in color and produce bigger loaves than the one freshly milled.

In order to secure the full advantage, resulting from the curing of flour by storage, the flour must be well milled and the wheat from which it is derived must be thoroughly cleaned. If not, the flour is very likely to become unsound through fermentation. The bleaching of flour then is a natural process of aging and curing.

Although the natural bleaching is whole-heartedly advocated, the interest on the investment, plus the storage charges should not be over-looked. In other words the natural bleaching of flour is feasible only when the storage charges and the interest on the money invested do not counter-balance the gain made in bleaching process.

Soundness of Wheat:- The matter of unsoundness in wheat, has already been referred to, as leading to heating, fermenting and actually charring or burning, and no further need be said on this topic beyond that it is in no wise less important a matter of miller's concern, than any other mentioned heretofore.

Impurities:- Wheat as milled contains several kinds of so called inseparable impurities, such as rye, corn cockle, kinghead, and wild vetch. Because of their similarity in size, shape, specific gravity, to the wheat kernels, are not removed from the wheat by the grain cleaning machinery in general use. It has been proved that the presence of these impurities injuriously effect the quality of flour. To have better understanding of the relative importance of these impurities the following table from U. S. D. A. Bulletin 328 can be quoted.

Milling and baking tests of clean wheat and of wheat containing different percentages of rye, corncockle, kinghead and hairy vetch.

Sample	Milling yield: Bran	Shorts	Flour	Water Absorption	Volume of loaf	Score: Texture	Color	Quantity of wheat for a bbl. of flour: Bushels	lbs.	Crumb
Clean wheat (check)	12.5	14.7	71.4	58.0	2,510	94	96	4	34	Creamy
Wheat plus 2% rye	11.9	15.9	71.2	57.4	2,433	93	94	4	35	"
Wheat with 3% rye	12.3	16.1	70.7	57.3	2,440	91	93	4	37	Slightly gray
Wheat with 1% corncockle	14.8	13.6	70.0	58.1	2,500	93	95	4	40	Creamy gray
Wheat with 2% corncockle	16.0	12.9	69.7	57.4	2,470	90	90	4	41	Gray
" " 3% " "	15.7	12.9	70.4	57.7	2,220	86	87	4	38	Very gray
Wheat with 1% Kinghead	13.0	15.3	70.2	57.8	2,445	93	88	4	39	Very gray
" " 2% "	13.9	15.7	69.4	57.8	2,450	92	83	4	42	" "
" " 3% "	14.3	16.8	67.6	57.9	2,400	89	79	4	50	" "
" " 1% hairy vetch	14.1	14.4	69.7	57.9	2,115	88	92	4	41	Creamy
" " 2% vetch	13.2	12.9	71.2	57.8	2,015	83	90	4	35	Yellow
" " 3% hairy vetch	12.8	14.6	71.2	58.2	1,940	78	85	4	35	"

In general, the table shows that the presence of two per centum or more of any of these impurities in wheat when milled has a deleterious effect both on milling and baking qualities of the wheat.

The presence of rye in wheat is less objectionable than that of corn cockle, kinghead, or vetch seed, but when it exceeds two per cent. in amount it lowers the quality of bread.

Corn cockle seems to have exceedingly injurious effects on the volume, color, and texture of loaf, etc., when present in amounts of three percent. or more, it reduces the water absorptive power of the flour. Furthermore it contains poisonous element known as saponin or sopotoxin, the presence of which is very undesirable in bread.

Kinghead when present in appreciable amounts materially lowers the flour yield, and imparts pronouncedly dirty color to the bread crumb.

Vetch seeds in wheat reduces the size of the loaf and give to the bread a yellowish tinge and disagreeable vetchy flavor.

Varietal differences:- There is very little difference between the flour colors obtained from different varieties of wheat, the only exceptions are found in durum wheat flour which is pronouncedly creamy, and forly-fold which is predominatingly white.

M O I S T U R E

Excess of water may mean an expensive transportation, loss through evaporation, bin burning and moulding, or it may mean an ideal milling and baking when properly distributed and controlled. It is reported that whole cargoes often spoil enroute from this country. Therefore the relation of moisture to wheat kernel should be critically studied.

<u>Relation of size of kernel to its moisture capacity</u>:

It should be remembered here that the well developed kernels have the higher moisture content, than poorly developed ones. The North Dakota Station conducted experiments to determine the relative moisture percentages in different sizes of kernels, and their average findings are graphically shown as follows:

<u>0 1 2 3 4 5 6 7 8 9 10 11 12 13 14</u>

L A R G E

M E D I U M

S M A L L

Moisture percentages

Diagram showing average percentage of moisture capacity incidental to the different sizes of shrivelled kernels.

Water absorbing capacity of wheat under different temperatures

At all the temperatures water is absorbed rapdily at first and less readily as the maximum of water absorbing capacity is approached. Absorption is much more rapid at higher temperatures than at comparatively lower ones. Individual samples reach their maximum capacity at different times. To have a proper conception of influence of different temperatures on the rate and quantity of water absorbed by wheat the reader is referred to the undermentioned tables:

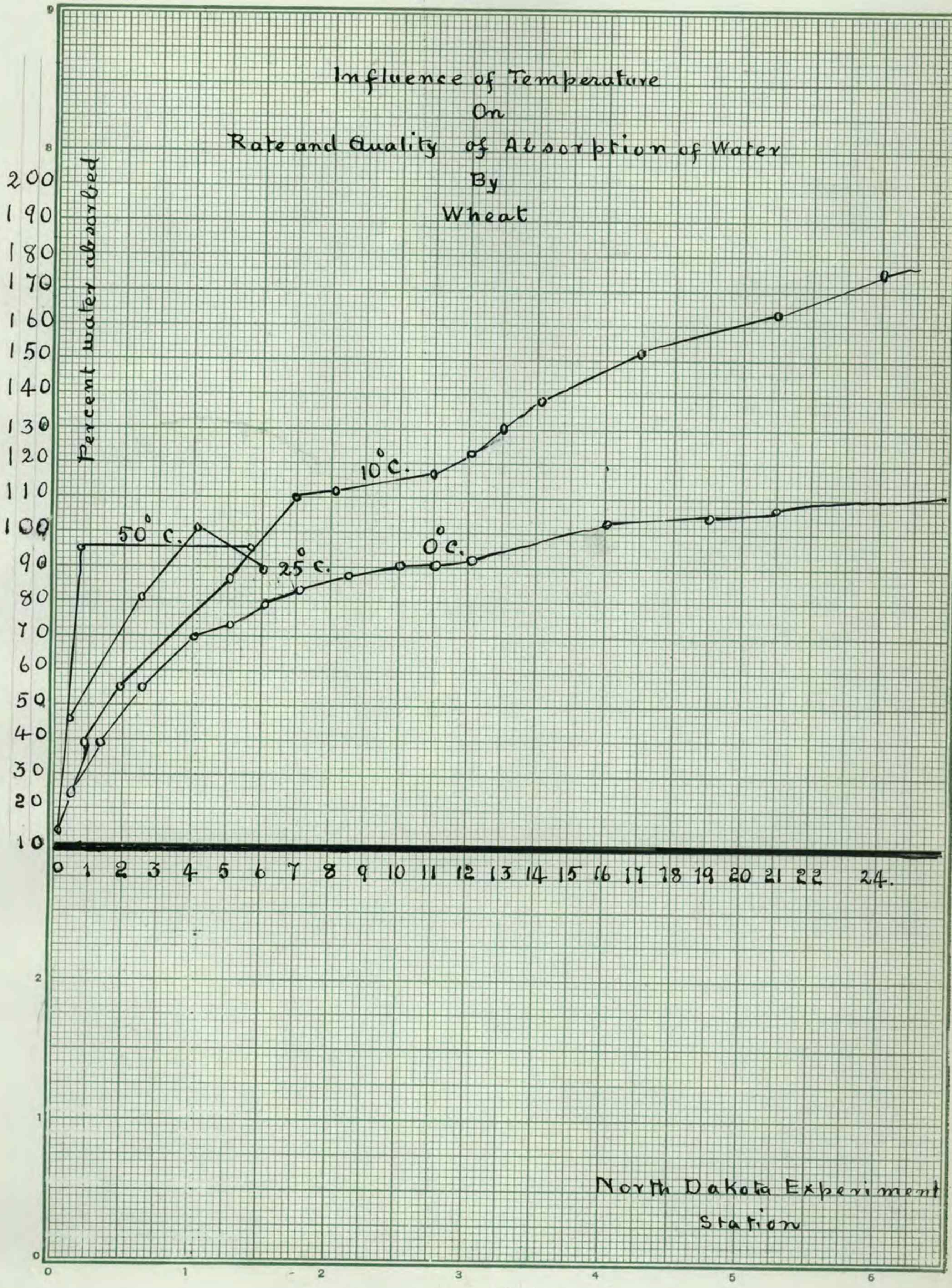
Zero degree C.			10° C.			25°C.			50°C.		
Time		Absorption	Time		Absorption	Time		Absorption	Time		Absorption
Days	Hours	Water %	Days	Hours	Water %	Days	Hours	Water %	Days	Hours	Water %
0	0	14.91	0	0	14.91	0	0	14.91	0	0	14.89
0	4.5	30.02	0	2.25	24.45	.0	.67	29.74	0	3.75	65.86
0	22.7	49.58	1	8.50	62.95	0	4.92	50.04	0	5.50	73.79
1	9.8	57.15	1	21.75	61.29	0	21.83	70.21	0	6.75	80.35
2	7.58	65.93	2	9.42	73.21	1	6.83	81.15	0	15.10	93.85
3	.33	69.56	3	6.67	84.53	2	.67	89.66	0	23.0	94.33
4	23.6	78.93	4	22.33	98.82	3	.42	97.61	1	5.25	93.41
5	23	83.19	5	23.58	100.42	4	22.17	91.66	4	23.25	94.3
7	23	87.61	7	21.92	110.76						
9	3.42	90.63	8	22.00	116.18						
10	.50	90.95	10	242	123						
11	23.75	95.71	11	23.6	130.46						
12	23.00	96.87	13	3.25	136.36						
15	.25	99.13	14	22.6	146.24						
18	6.92	103.4	17	0	154.65						
20	22.2	103.9	20	6	167.90						
25	6.67	106.2	25	5.75	197.04						

It would be fundamentally important to note that after the maximum moisture capacity of wheat is approached at 50° C. it is almost uniformally maintained for sometime, but that at 25° C. a speedy decline begins immediately after the maximum is reached. The former temperature is high enough to protect the wheat kernel from decomposition, while at the latter such a decomposition does take place, leading to early putrefaction. At 10° C. especially when assisted by aeration the setback due to decomposition is not experienced but in its stead an increase in water absorbing power caused by the vital processes and growth occurs. The rudimentary plant (seedling) having a relatively high proportion of water, increases the absorptive power of the kernel.

Further, on account of the growth and bacterial activities within and without the kernel, considerable heat is evolved, which under favorable conditions might cause the grain to mold, bin burn, or putrefy.

At 0° C. the absorption though slow but steady was noticed and as much moisture is absorbed at 50° C. in an hour as in a full day at 0° C. (see diagram on next page).

It should be borne in mind that wheat when heated in the presence of moisture gets useless for milling purposes. One of the important facts in connection with these wet wheats is the actual loss in dry matter. The North Dakota Station reports that the samples of wheat under water at a temperature of 25° C. lost 23.4 per cent. of their dry matter in 5 days, those kept at 0° C., but for the same length of time, lost only


Influence of Temperature
On
Rate and Quality of Absorption of Water
By
Wheat
Percent water absorbed
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
10° C.
50° C.
25° C.
0° C.
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 24.
North Dakota Experiment
Station

5.5 per cent.

Of all the samples, under experiment, those kept at 0^{o} C. were the only ones satisfactory for high grade milling and their germinating qualities were perfectly intact. It follows from this experiment that the wet wheat should either be cooled or its moisture be removed to lessen or eliminate the danger of heating.

Water absorbing capacity of sprouted wheat:-

Sprouted wheat is little more open than the natural one, absorbing water more readily, but it has much lower absorbtive capacity than the unsprouted grain.

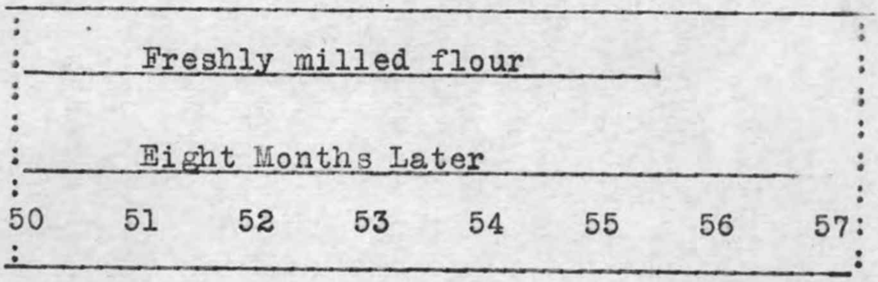
Pressure and water absorption of wheat:- The North Dakota Station immersed the wheat in water to note the height of liquid from time to time. Although the wheat swelled but the height of the liquid remaind constant, proving thereby that water occupies practically the same space within the kernel as it does without it. Since no change was observed in the height of "wheat immersed in water," pressure upon it would be without effect.

The above mentioned deduction holds true only when the wheat is immersed in water, in which case the inter-space of wheat kernels is occupied by water; but in our storage bins the pressure inhibits water absorbing power of the grain.

In another trial, two samples of wheat under different pressures were exposed to water at 25° C. for 3 hours. The one under the greater pressure contained 26.8 per cent. moisture and the other had 28 per cent. The check wheat, that is, one not subjected to artificial pressure, under the same temperature had a moisture content of 40 per cent.

Mixing wheat of different moisture content:- An experiment carried on by the Office of Grain Standardization wherein 1898 bushels of western white wheat of 9.7% moisture were mixed with 1126 bushels of an eastern red winter testing 15.1% moisture. After three days the white wheat showed 12.2 per cent. and the red 12.9 percent. moisture. After seven days the red wheat tested 12.5 per cent. and the white 12. Two deductions can be made from this experiment, (1) that the wheats of different moisture content, when mixed, lend themselves to osmatic pressure to equilize that moisture content; and (2) that the moisture exchanges are fairly rapid where differences are great.

Water absorption of flour:- The absorptive capacity of flour and starch and hydrolized starch is highest at 0° C., and it gradually decreases with increasing temperature. But all other conditions being equal, the freshly milled flour is weaker in water absorbing power than the stored one from the same sample of wheat.



Water absorbing power of flour before and after storage. The figures show the percentages absorbed.

The average absorption immediately after milling, as shown in the graphic diagram, is about 55.63 per cent. and after eight months amounts to 56.85, an increase of 1.22 per cent. This would mean much to the baker when translated into loaves of bread.

Water absorbing capacity of gluten:- The proportion of water in the gluten when thoroughly sun-dried amounts on the average to about 180° per cent. of the gluten dried to constant weight at 100° C. The proportion of water in the gluten is still higher on higher temperature or with more water at its disposal.

Aging:- When wheat undergoes sweating in a bin or stack, the temperature rises and the grain feels moist to the touch. During a normal sweating process the moisture is increased and the milling value of the wheat is benefitted. But the greater degree of heat generated is extremely harmful, because it results in stack, or bin, burning.

At the Kansas Experiment Station artificial heat and moisture were applied to a new wheat, corresponding, in an extent and an amount, to the natural sweating and similar improvements in milling and baking qualities, with this artificial treatment, were obtained.

The interval that should elapse, between the time the wheat is moistened and heated and the time that it is milled, depends on the hardness of the wheat, and the amount of water added. If the wheat is of good quality and normal moisture content, artificial sweating is of no avail but if the moisture content isbadly needed longer tempering would be beneficial. A miller, in latter case, should have facilities enough at his command to temper and control the heat and moisture.

Methods of Farming: Very interesting results of great economic importance have been obtained by the untiring labor of the Utah Experiment Station, concerning the milling and baking values of wheat grown under dry and irrigation farmings. The brief discussion of its findings with original tabulated data is presented below:

Dry Farming:- In all cases under trial, the grain was stored for nine months after harvesting, before it was milled. The milling was done under uniform conditions. From the Table 1V, under the caption of "Soft Winter Varieties", will be noted a uniformly low yield of flour, a high percentage of protein and dry gluten content, and a low percentage of moisture in wheat, bran, and shorts.

Table V shows the effect of irrigation on the wheat and flour qualities against the dry farming system. The application of irrigation water gives a plumper grain of heavy weight per 100 kernels. Irrigation seems to have no effect on the moisture content of wheat and its products; but there is a perfect negative correlation between the amount of water applied and the protein content of the wheat and its milled products. The wheat that received 25 inches of irrigation water was 1.5% less in protein contents of the grain than the one produced under dry farming condition. This sets the price of dry farmed wheat considerably higher than irrigated one.

Table lV. Study of Soft Winter Varieties Under Dry Farming

Varieties	Composition of Wheat Varieties per cent.: Weight of 100 Kernels	per cent. Flour	Bran	per cent. shorts	Moisture	Protein	Composition of Flour.: Moisture	Protein	Wet Gluten	Dry Gluten	Ash %
Gold Coin	3.390	72.54	16.63	10.03	8.40	12.40	10.69	11.99	30.20	10.69	0.542
Currel	2.796	66.93	26.46	.98	8.16	17.14	9.29	14.52	42.87	14.79	0.502
Kofod	3.213	66.32	22.75	9.48	7.77	16.78	10.05	15.34	47.67	15.73	0.596
Oklahoma 1784	3.208	66.23	24.27	8.81	7.08	16.77	9.91	14.62	47.04	15.02	0.513
Zimmerman 2907	2.502	68.20	26.39	6.38	8.39	16.02	10.00	13.61	39.08	12.60	0.490
Blue stem 3000	3.094	69.04	24.14	5.42	7.68	16.00	10.18	14.60	35.25	12.70	0.446
Japanese 1787	2.994	68.91	23.88	7.52	8.17	15.87	9.65	13.79	39.41	12.72	0.586
Salt Lake Club	3.042	67.46	26.65	6.70	8.32	15.66	9.98	12.57	36.88	13.02	0.508
California Gem	2.617	66.66	27.17	6.37	8.03	15.39	8.89	13.02	39.33	13.57	0.613
White Club 2999	2.711	69.12	24.27	5.01	7.77	15.20	9.25	12.93	33.22	11.48	0.495
Deihli'o Med.	3.068	67.94	26.32	5.85	7.85	14.86	9.13	13.96	36.79	13.92	0.474
Jap. Velvet Chaff	3.387	66.11	25.74	6.34	7.33	14.84	9.43	14.36	41.78	13.58	0.524
Australian 3019	3.455	68.90	25.75	5.61	8.16	14.16	9.36	11.94	29.68	11.40	0.469
Average	3.170	67.90	25.24	6.68	8.00	15.62	9.56	13.86	38.17	12.95	0.507

Table V. Comparative Study of Irrigated

Composition of irrigated and non-irrigated varieties								Composition of Flour				
Varieties	Irri-gation	weight of 100 kernels	per cent of flour	percent of bran	per cent of shorts	moisture content	protein content	moisture	protein	wet gluten	dry gluten	ash
New Zealand	25	4.735	72.00	22.93	5.13	8.00	12.68	10.01	10.50	29.48	10.11	0.451
" "	15	4.624	72.37	22.14	4.67	8.46	12.71	10.53	10.92	30.80	10.19	0.446
" "	0	3.673	72.07	22.27	4.87	8.39	16.20	10.11	13.65	32.34	11.98	0.443
Minn. 163	25	3.518	71.13	22.71	6.68	8.41	13.59	10.78	12.00	31.45	11.35	0.457
Minn. 163	15	3.509	71.41	23.21	7.49	8.76	13.57	10.24	11.75	35.95	11.09	0.394
	0	3.067	70.43	21.71	7.24	8.69	16.48	10.42	14.73	36.95	14.66	0.391
" "	25	4.537	70.03	22.37	7.04	8.32	13.62	10.45	12.10	31.49	11.05	0.559
Kofod	15	4.589	72.18	21.40	7.44	8.45	13.44	10.54	12.03	28.08	10.38	0.476
"	0	4.202	70.92	21.49	7.68	8.77	13.41	10.88	10.63	26.06	9.95	0....
"												
Whittington	25	4.728	66.67	20.58	12.18	8.85	14.70	10.53	13.56	31.80	11.79	0 .760
"	15	5.277	66.01	21.18	11.36	8.44	15.42	10.38	14.31	33.85	12.28	0.796
"	0	4.298	66.79	28.47	4.59	8.40	15.41	11.16	14.07	39.65	13.60	0.708
Egyptian Spr	25	4.732	63.17	25.15	11.04	8.84	13.02	10.33	11.48	25.87	10.30	0.698
" "	15	4.113	68.18	24.51	6.71	8.84	13.62	10.30	11.23	28.02	9.71	0.564
" "	0	4.274	66.58	28.02	5.16	8.55	14.26	9.54	12.37	32.77	10.58	0.707
Kubanka	25	4.863	62.68	25.95	11.47	8.83	14.17	10.14	13.71	33.82	12.54	0.769
"	15	4.359	65.58	23.03	11.60	8.43	14.88	10.68	14.90	37.14	12.47	0.614
"	0	3.350	64.73	22.86	11.92	8.22	15.26	10.81	14.91	37.14	14.06	0.770
White Club	25	3.191	68.17	25.27	5.87	8.23	13.25	10.00	9.81	25.28	9.36	0.466
" "	15	3.647	69.00	23.17	7.62	7.89	12.79	9.47	10.10	21.42	9.32	0.462
" "	0	2.816	67.81	26.17	5.75	8.11	14.34	9.13	12.06	31.94	10.92	0.503
Pellissier	25	3.220	67.80	23.53	9.82	8.31	16.54	10.14	16.21	46.97	15.73	0.607
"	15	3.428	68.01	23.72	9.56	8.64	16.20	10.01	15.50	43.04	14.59	0.581
"	0	3.829	64,93	25.96	9.62	8.32	18.11	10.58	15.95	47.82	16.08	0.558
Average	15	4.065	69.24	22.94	8.10	8.50	14.35	10.41	12.92	32.55	11 .63	0.544
"	25	4.008	68.08	23.39	8.52	8.46	14.00	10.41	12.63	34.05	11.71	0.578
"	0	3.569	67.88	24.75	7.11	8.44	15.45	10.43	13.62	35.18	12.58	0.552

Uniformity:- The question of uniformity is perhaps the hardest one which confronts a miller. To obtain prices and unslacking demand from the baker and the housewife a mill must have a reputation for consistent quality of flour. In spite of the multitudes of varieties, both new and old, which are liable to appear, the mill has to keep the various grades of flour up to a certain standard.

In attacking this problem, the miller's business ability, to keep the expenses down, and his technical knowledge, to make proper mixtures are called into play. A good miller should always have a tabulated sheet of flour strengths to go by, and in figuring out the strength of his mixture, he should follow the Lancashire millers' method, an example of which is reproduced below:

Suppose we are selling to a baker a flour of 67.2 strength number and in order to meet his demand we arrange our mixture of

Wheats	Strength No.	On parts taken
48 parts No. 1 Manitoba	88	4224
30 parts Plate	53	1590
22 parts English	40	880
100		6,694

Then our theoratical number= 6,694 ÷ 100 or 66.94.

Since the difference between the strength of our theoratical mixture and the one set by trade grade as 67.2 is but slight, the flour expected from such a mixture would be fairly good.

CHEMICAL COMPOSITION OF DIFFERENT MILL STREAMS AND THEIR EXPLANATIONS.

Explanation of terms:- The first break flour is made by the first break rolls. Bran, dust and any other impurity such as crease dirt clinging to the wheat kernels thus gets into this flour. This is the reason, why the first break flour is decidedly inferior to most of the subsequent ones. The second and third break flours are obtained largely from the interior of the wheat kernel, but its quality is injured in color by the presence of bran powder. The fourth break flour comes from the portion of wheat kernel next to the bran; and it is nearly like the flours from the sixth and seventh middlings, since it is literally shaved off from the bran.

One purpose of making breaks is to take off the coarsest part of bran. In so doing, some flour is produced, but a greater portion of the interior of the wheat kernel is left in a granular condition. These grains of endosperm are of various grades and sizes and these are known as "middlings".

The process of obtaining flour from these middlings consists of a series of crushing operations known as "reductions", and because of the purity of the middlings the finest grades of flours are produced. The middlings are never hundred per cent. pure, because as the wheat kernel is broken in the break rolls, larger or smaller pieces of bran are also broken off, which remain sticking to the endosperm particles. If it were not for these bran particles the middlings could at once be reduced to flour. Each time the middlings are reduced, some flour is produced leaving behind the remaining middlings richer in bran. Thus the seventh or eighth middlings are nothing but "low grade" or feed.

Description of mill stream flours from a five break mill in Kansas.

First break flour;

Second break flour;

Third break flour ;

Fourth break flour ;

Short Patent flour, 65 per cent. This flour is obtained from first, second, and third middlings.

Long Patent flour, 80 per cent. This flour is obtained from first, second, third, fourth, fifth, sixth, and seventh middlings; and also second and third break flour.

First clear flour 33 per cent. Contains first, second, third, and fourth break flours; fourth, fifth, sixth, seventh and eighth middlings.

Second clear 18 per cent. contains first and fourth break flours; flours from eighth middlings and from reels and dust sweeping.

Low Grade flour, 1½ to 2 per cent., obtained from the tail end of the mill.

Chemical Composition of Flours from Different Mill Streams; Percentages Based on Air Dry Samples.

Mill Streams	Moisture	Ash	Protein	Gluten Wet	Gluten Dry	Amino Compounds	Acid	Water Soluble Phosphorous	Phosphorous Total	Phosphorous % of total soluble Phos.
Whole Wheat	11.48	1.97	12.77			.456	.399	.159	.430	35.81
First Break	11.65	.61	11.57	32.9	11.1	.240	.200	.073	.144	50.69
Second Break	11.77	.54	11.57	31.9	10.9	.185	.157	.060	.119	50.42
Third Break	11.78	.59	13.68	40.9	13.8	.185	.170	.058	.116	50.00
Fourth Break	11.49	.75	15.88	44.9	15.3	.237	.240	.093	.175	52.90
Short Patent 65%	11.20	.41	11.09	29.8	10.3	.171	.107	.026	.090	28.89
Long Patent 80%	9.70	.51	12.29	36.3	12.1	.194	.127	.037	.106	34.90
Straight 98%	9.58	.49	12.08	37.0	12.2	.166	.137	.039	.109	35.77
Fourth and Fifth Middlings	10.52	.59	12.89	38.5	12.5	.240	.182	.059	.135	43.70
Sixth and Seventh Middlings	9.89	.83	13.08	38.9	12.1	.291	.271	.093	.196	47.45
Eighth Middling	10.18	1.44	15.39	36.2	13.5	.533	.504	.193	.324	59.71
First Clear 33%	11.14	.71	13.00	36.1	12.1	.254	.212	.085	.162	52.47
Second Clear 18%	9.73	.88	14.31	39.6	13.4	.311	.300	.105	.315	33.41
Low Grade 1½ to 2%	10.27	1.55	15.34	47.3	12.8	.579	.453	.200	.364	54.95

Kansas Bulletin 202.

Moisture:- An interesting point to note in this connection is that the moisture content of the second, third, fourth breaks, first patent, and first clear is higher than one in the rest of the streams. This leads us to the conclusion that very little water added in tempering penetrated farther than the bran coatings.

Ash:- The short patent has the lowest percentage of ash, while the low grade has the highest. The ash content is lowest in those streams which come from the interior of the wheat kernel, while the reverse is true when the streams are taken from those portions next to the bran.

Protein:- Protein includes all the nitrogenous compounds in the wheat flour. It is calculated by multiplying the percentage of nitrogen with 5.7. The factor "5.7" is used for wheat products instead of "6.25" the factor used for most feeding stuffs. This is because the average percentage of nitrogen in nitrogenous compounds of most feeding stuffs is 16, while in wheat and wheat products it is nearly 17.6.

The protein content follows almost the same law of variation as the ash. With the exception of first and second breaks, and short patent and straight flours, all these streams are higher in protein content than the wheat itself.

Gluten:- The short patent flour has the smallest amount of gluten in regard to quantity, but this is one of the best in quality.

The Amino Compounds:-There is a close relationship between the amino compounds and the acidity. With the exception of long patent flour, the acidity and the amino compounds vary almost in the same proportion.

Phosphorous:- The wheat has the highest percentage of phosphorous; and the phosphorous content increases gradually from the interior of the kernel toward the outer coatings of bran.

To our terminology, as explained heretofore, must be added the following terms, because they are met very widely in the milling literature.

Graham:- Strictly speaking, graham is simply a wheat meal; that is, the entire grain ground to a powder, without bolting or sifting. When thus prepared it has the same ingredients as the wheat itself. Such a flour is coarse and off colored.

The Entire Wheat:-The term "entire wheat" would suggest a flour practically identical with the graham. This flour, in fact, is made by first decorticating the grain and grinding the remainder. In this method only a small portion of the kernel is rejected.

A Whole Wheat:-This flour is made by including with the patent grades the middlings and the low grade flours with considerable amount of germ.

The terms "soft" and "granular" occur very frequently, the former refers to the soft wheat flour, which is smooth and velvety to feel, and the latter to the hard wheat flour which feels gritty and heavy.

MILLING TESTS BY GRADES.

The North Dakota State Law, enacted in 1905, makes it the duty of Experiment Station to conduct experiments and determine the comparative milling values of different grades of wheat..........In accordance with this law the experiments were undertaken to determine the comparative milling values of different grades of wheat, without any regard to its varieties. The findings of the Experiment Station are tabulated below:

Flour Averages by Grades

Products	Grade 1	Grade 2	Grade 3	Grade 4
Flour %	70.12	69.20	69.41	67.33
Bran %	10.11	11.50	12.12	12.25
Shorts %	16.42	16.51	14.92	16.50

Per cent. Protein in Wheat and Flour

Wheat	14.41	13.25	15.69	14.76
Flour	13.25	12.95	14.32	13.88

Value of Wheat by Grade Per Bushel.

Dollars	1.06	1.01	0.98	0.96

The superiority of 'grade 1' over 'grade 2', and that of 'grade 2' over 'grade 3', and of 'grade 3', over 'grade 4' is quite obvious from this table.

The investigations on this line have not been on a sufficient scope to establish any definite conclusion, but it is very interesting to note how the wheat grades correspond to the flour grades obtained from them.

CLASSES OF WHEAT FROM MILLER'S STANDPOINT.

The variety and market value of wheat determine, in a large measure, the classes to which a certain type of wheat belongs. Certain groups of varieties enter into the production of certain types of milling products, and as such are placed in a class. We have five recognized classes of wheat, as follows:

Class 1. Hard Red Spring, includes Marquis, Red Fife, Minnesota 169, Red Huston, Chul , Preston and similar other varieties. This class of wheat is largely grown in North Dakota and Minnesota.

Class 2. Durum or Macaroni wheat includes numerous varieties such as Romanow, Kubanka, Nicaragua, Mohamed Ben Bachir, Richi and others. Durum wheat is grown in principally the same territory as Hard Red Spring wheat, and to a limited extent in the Southern Great Plains areas, and Intermountain, and Pacific Coast States.

Class 3. Hard Red Winter wheat includes Turkey Red, Crimean, Kharkov, Beloglina etc. This class of wheat is chiefly grown in Nebraska, Kansas, parts of Oklahoma, Montana, and other adjoining states.

Class 4. Soft Red Winter wheat includes Jones Winter Fife, Kinney, Red Russian, Marvelous, Red hybrid and several other varieties. This class is mainly grown in sections east of the Mississippi River and in the State of Missouri.

Class 5. Common White wheat includes all white varieties of common wheat except Sonora variety whether winter or spring grown. Since only a limited amount of work has been done on this class of wheat, its proper value from a milling standpoint is not exactly known. It is grown comparatively to a very small extent in some of the Eastern States and more generally in the inter Mountain and Pacific Coast States.

Dr. Duvel, in order to find out the milling qualities of these five classes of wheat, conducted a very extensive experiment, lasting for five years from 1908 to 1913 inclusive. The results of his findings, supplemented with those of others are tabulated below:

Comparative Study of Several Classes of Wheat Made by Dr. Duvel and Many Other Distinguished American Investigators.

Classes of Wheat	Test Weight per Bushel	Average yield of flour per cent.	Bran and Short	Loss in Milling	Color	Moisture	Crude Protein	Loaf Volume per 340 Grams of Flour	Texture scored in per cent.	Water absorbed in a loaf per cent.
	lbs									
Soft Red Winter	61.4	69.7	27.1	3.2	96.2	11.9	10.6	1,965	91.9	52.4
Durum	62.8	70.3	28.8	0.8	90.2	12.5	14.3	2,070	90.7	55.7
Hard Red Winter	62.1	72.0	26.4	1.6	95.3	12.1	12.1	2,219	93.5	55.2
Hard Red Spring	60.2	70.2	27.8	2.0	96.4	13.1	12.9	2,421	94.8	55.7
Common Soft White	60.1	70.0	27.0	3.0	98.0	11.8		1,907		51.7
Common Hard White	60.3	70.8	26.7	1.5	98.1	12.9				

Note! The test weight of Hard Red Winter is exceptionally high in this experiment.

In average flour yield the hard red winter wheat is about two per centum higher than the other classes, between which only small differences are noted. The poor showing of soft red winter and soft white wheats is probably due, in part, to the mechanical losses always incidental to soft flaky nature of flour which remains clinging to the spouts, and part to the losses through evaporation. The opposite is evidently true of durum wheat, which is hard and brittle and is reduced to very coarse granular flour, which is, too heavy to hang. Besides this, less water is used in tempering soft textured wheat than hard wheat, owing to its tendency of flaking or flattening out of the particles of endosperm in grinding process in excess of moisture.

The comparison of color shown in the table does not tell the whole story, as there are variations in color that cannot be expressed by a score, but in general, all classes of wheat score alike with the only exception of Durum which must have been more creamy to average so low as 90.2.

Of all these classes of wheat, under consideration, Durum is the highest in crude-protein contents; Hard Red Spring, second; Hard Red Winter, third; and Soft Red Winter, fourth. The two remaining classes are not so very important from milling standpoint and their data are not available.

Hard Red Winter and Hard Red Spring wheats have average volumes of 2,219 and 2,421 cubic centimeters respectively. This crowns these two classes of wheat with enviable and unsurpassable success. But in the strength of flour the Spring wheat leads the hard winter by a good margin.

In the matter of texture, the several classes of wheat stand pretty near in the same order as they do in loaf volume, except that Soft Red Winter has a slight advantage over Durum wheat.

In the matter of water absorption Durum and Hard Red Spring stand abreast, Hard Red Winter slightly lags behind, and the rest have no place in the competition.

In conclusion it may be said, that in this comparison acre-yield was not taken into consideration and that the results obtained herein cannot necessarily represent all the wheat growing districts alike. In some sections, the order of precedence may be invariably either, Hard Red Winter first, Durum second, and Hard Red Spring third, or exactly the reverse of it, or the Durum wheat might be out of question all together.

REMARKS ON SOME OF THE LEADING AMERICAN WHEATS.

In selecting the most profitable wheat to grow it is seldom possible to satisfy both the farmer and the miller. A wheat of poor milling quality may be a prolific yielder, and for that reason is very profitable to the producer. A grower should select a variety which is most remunerative from a business stand point, irrespective of miller's preference. A miller, on the other hand, should not be sadly disappointed at grower's selfish attitude, because there will always be enough good milling wheat coming to be mixed with poor one. The U. S. Grain Standardization is conducive to the production of better milling wheats, for it insures premium prices for such grain. And the dry farming sections of the globe, where the grain is to be seeded thinly, have no other recourse left but to select the best milling wheat adapted to their particular environment.

It cannot be over emphasized here, that in choosing the best variety of wheat the locality in which it is grown must be considered. No single variety is the best for all the sections of a country and much less for the entire world. The Canada Experiment Station reports, that the percentage of crude protein in Defiance is 8.06 in Del Norte, and 14.92 in Fort Collins; that in Marquis it is 16% in Fort Collins, and 14.6 in Grand Junction Collins; and that in Turkey Red, it is 13.13 in Fruita, and 8.22 in Lojora. Examples can be piled on examples, if that were the object in view. The writer is strongly impressed that the conception of high milling value of any variety is vague and illusive, unless a particular locality goes with it. Consequently the values of the wheat varieties discussed hereunder should be considered as relative rather than absolute.

CRIMEAN WHEATS.

The Turkey Red:- The term 'Turkey' is a misnomer, since the origin of this variety is in Southern Russia, near Crimea. It is a hard red winter wheat and is most widely grown on the surface of our planet—the earth. It outyields most wheats and tests generally very high. It may be called a standard wheat, since it produces a considerable amount of flour of high baking and market value. It is considered the best variety in the foreign market, even though it is subject to yellow berry. It is very susceptible to climatic changes and does not give best results when grown outside of the dry warm climates.

The Kharkov and the Malakof and the Kan Red varieties are also Crimean wheats. They are perfectly like the Turkey Red in all physical structure, so much so that they cannot be distinguished from one another when mixed up in a pile. Both of these varieties are perfectly at home where the Turkey succeeds.

The Kharkov is more hardy than the Turkey, and considerably better adapted than the latter in the northern climates.

It commands the same prices on the market as Turkey Red and it is equally valuable for milling purposes.

Marqui s Wheat:- Is a Canadian hybrid between Calcutta Hard Red and Fife. It has been demonstrated at Ottawa, Canada, that this hybrid is of high bread-making strength and color. It is so early as to escape rust and it yields 50% more than Fife. Carleton remarks, "For northern localities in Canada, Marquis wheat is chiefly valuable for its earliness, strength of straw, heavy bushel weight, fine appearance of the kernel and excellent baking strength".

Marquis wheat is excellent wheat for dry lands. It possesses a first-class milling value. It is equal to or slightly superior to similar samples of Fife, Bluestem, and Preston Spring wheats, because it yields higher percentage of flour than any of these three.

Value of Marquis in humid zones. Wherever possible winter wheat should be grown. Fife, Bluestem, and Preston should not be discarded under the mere impression of their infalliable inferiority to Marquis. All of them should be given a uniform trial and the best one chosen.

Value in semi-arid zone: If winter varieties cannot be economically grown, durum wheat should be given the second choice and Marquis the third.

In arid Zones: Marquis has no place.

<u>In irrigated zones</u>:- Soft wheats, such as Defiance, Bluestem, Little Club, and Dicklow generally out-yield Marquis, but in cold irrigated sections, as that of California, Marquis does remarkably good.

<u>Bluestem</u>:- Is another standard hard red spring wheat of some sections. This is to be differentiated from the Pacific Bluestem, which is an Australian wheat. Bluestem always commands a premium of two to three cents a bushel over the club varieties. It contains a high per cent. of gluten and when milled gives a strong flour of superior white color. It is a deservedly popular wheat with some millers.

<u>Durum Varieties</u>:- This class of wheat is adapted to soils rich in nitrogenous matter and slightly alkaline in nature. It is a spring wheat and is unsurpassed by any other variety in hot dry and humid climates. Its kernels are translucent, vitreous and very generally of amber color. The chief uses of this class in the U. S. A. are the manufacture of a coarse granular flour called "semolina", the bread making flour and the puffed wheat. The class, as a whole, has a very limited use for cereal breakfast foods. From semolina, the edible pastes, such as macaroni and spagetti are made.

Experiments bear out the results that the best varieties of durum, such as Kubanka, and Arnautka, are just as good in flour yield as our best bread wheats, although it is low in high grade of flour. The average percentage of shorts is about

12.89, which is much higher than what can be obtained from common wheats. The hardness of durum wheat increases the cost of milling about 15 cents per barrel, but the flour is more valuable, because it contains more crude protein, the best muscle-building material. The flour is condemned by the baker because of its yellow color, and its sticky and less expansive-dough; but it possesses a good nutty taste, sweet flavor, great strength and water absorbing power.

Taking all the merits and demerits into consideration it should be admitted that the durum wheat is not given its due credit in this country. Eighty per cent. of the best bread consumed in Russia is made from durum wheats; and the durum wheat is sold at a premium price over hard wheats of that country. Durum flour is of great value in blending with both hard and soft wheats and a successful blend will do away with the characteristic stickiness of the dough, lighten the color, and increase the volume of loaf.

The Utah Experiment Station compares the common bread wheat and durum as follows:

	Grams weight 100 kernels	Water %	Flour %	Bran %	Shorts %	Protein %
Common Wheat	3.0417	8.46	53.21	35.11	10.91	16.76
Durum	3.7258	8.89	50.23	31.97	17.27	17.14

General belief of Utah Station, North Dakota, Nebraska Canada Experimental Farm, Onterio Agriculture College, and the Bureau of Plant Industry is that durum wheats have proved themselves drought resistant and rust resistant and they will ultimately become the leading spring type of grain in dry land agriculture. Another remarkable quality of Durum wheat is that it will resist rust even when the rain falls during the growing season.

Dawson Golden Chaff:- is one of the highest yielding varieties of America . It is low in crude protein, but the quality of the gluten is excellent. It compares favorably well with Turkey Red in hardness of the kernels and percentage flour yield obtained therefrom.

Fife:- Is an early hard red spring variety which yields remarkably well in South Dakota and its suburbs. It compares with bluestem as follows:

	Yield Bu.	Protein % (x6.25)	Test Weight	Bran %	Shorts %	Flour %
Bluestem	13.9	18.56	60.5	5.4	11.4	71.5
Fife	13.2	18.37	63.0	6.7	13.3	69.6

Fife is little inferior, in milling value, to Bluestem. Due to the fact that it contáns 1.9% more shorts and 1.9% less straight flour. It is sold for about 3 cents per bushel less than bluestem. Since it has recently been officially admitted as one of the Northern Hard Spring wheats, on the Minneapolis and Chicago markets, this price difference is liable todisappear.

Fultz:- Fultz, Fulcaster, Poole, Michigan Amber etc., are Mediterranean wheats. They are soft red winter varieties and do best in localities of 30 inches rainfall or over.

Fultz, an awnless, variety was originally selected from bearded Lancaster. Today it is one of the most widely known wheats. This variety is rather early and possesses a semi hard kernel of good market quality. It can be called a general purpose type because it is grown all over the country and abroad.

<u>Fulcaster</u>:- Is also one of the most popular soft red winter wheats of the Eastern United States, ranking easily next to fultz. It is very generally grown on the areas, lying between Pennsylvania and Oklahoma. It is the heaviest yielding varieties for the common prairie of Illinois. The results, obtained at the Kentucky Experiment Station, comparing Fulcaster with other leading varieties of that section are tabulated below:

Awnless Wheats	Milling Quality	Yield per acre in Bu.	Test Weight
Fultz	92.2%	34.5	60.0
Extra Early Oakley	92.2%	32.3	58.7
Harvest King	94.2%	31.9	59.7
Awned Wheats			
Kansas Mortgage Lifter	94.5%	32.1	59.9
Fulcaster	95.5	31.9	60.4
Lancaster Red	94.2%	31.3	60.4

<u>Sonora</u>:- Sonora's prevalence is explained by its earliness and suitability to dry climates. Inspite of its

being sold at a discount, and inspite of its flour being of poor color, it continues not only to be grown but to constitute the bulk of the grain in dry regions of California, Utah, Colorado, and Arizona. The following table, reproduced from California Bulletin 212 explains the importance of Sonora with other leading varieties of that section:

	Gluten%	Crude Protein %	No. of Kernels in 10 grams.	Water %	Ash %
Propo	8.23	10.68			
Club	8.19	9.35	405	12.28	2.11
Australian	8.29	9.89	341	11.59	2.12
Bluestem	8.12	10.18	366	12.18	2.02
Sonora	8.14	9.71	442	12.12	2.08

On the basis of protein content the varieties stand in the following order: Propo, Bluestem, Australian, Sonora, and Little Club. California wheats are all low in protein content and ash.

Poole:- Poole is a very popular variety of Ohio, it is the third highest yielding variety of that state, but stands first in milling and baking tests.

Club:- Club wheat shows fine looking kernels, which produce dark unattractive colored flour, decidedly wanting in strength. Little Club has a very good name with California millers. In foreign markets it is called "dwarf wheat". As its name implies, it possesses a small stalk with a small head, but plenty of grain. Flour obtained from such wheats is relatively high in fiber and low in ash and ether extracts as compared with hard winter wheats. Such wheats are good for making crackers and other starchy breakfast foods.

Defiance:- Is a prolific yielder. It is a soft wheat, grown mostly in the East. This variety when grown in the West, would be poor in milling value.

SOME PROMISING AUSTRALIAN WHEATS

Pacific Bluestem:- Should not be confounded with the Bluestem as grown in the Dakotas and Minnesota. It has different names in different places: in California it is popularly known as white Australian and in Central Washington as White Elliot. It was introduced into the United States by the coast millers about thirty-five years ago. And it is one of the leading spring wheats of the Pacific Northwest.

Although it is soft to semi-hard white wheat it is considered a good milling variety. It is a heavy yielder under certain conditions, especially in California, both as irrigated and dry farmed wheat. But one drawback which makes Early Baart to replace Pacific Bluestem in the drier spring wheat sections of Oregon and Washington is its late maturing habit.

In the year of 1916, U. S. D. A. started a trial of 69 varieties of Australian wheats, at the Sherman County

Branch Station, Moro, Oregon. Their trial shows that there are at least three wheats, Bobs, (") Federation, and Hard Federation, of outstanding merits.

Bobs:- A pure-line selection of this spring variety has been carefully tested at the upper mentioned station for about seven years consectively. Its average yield per acre exceeds slightly that of Early Baart, and exceeds 4.6 bushels that of Pacific Bluestem. The Bureau of Chemistry of the U. S. D. A. reports that the average milling value of Bobs has proven its superiority over the Oregon-grown Marquis.

Marquis is generally regarded as one of the very best milling wheats grown commercially in this country. For the entire period of the trial the average yield of Bobs has exceeded that of Marquis for the same length of period, by 3.5 bushels per acre. Now since it matures earlier than Marquis, and slightly earlier than Early Baart, it should be considered a wheat of great future promise.

The Bulletin 22 of the Department of Agriculture of Victoria, Australia, makes a rather curious report, on the origin of Bobs, as follows: "This interesting wheat was produced in 1896 and is really a hybrid—being a cross between Nepaul barley and Early Lambrigg Wheat ("")...It is a popular variety in New South Wales, and it has given very satisfactory yields in dry as well as in cool, moist districts."

(") The trial of Bobs was started in 1911.

("") A hybrid between barley and wheat has never been accomplished by other plant breeders. Whether the Australians succeeded in that is questionable.

It is considered as one of the best milling wheats of Australia; its grain is hard and translucent; and it yields a flour of high strength. The flour of this wheat is very highly prized for blending purposes.

Federation wheat is, without qustion, the most popular and prolific variety of wheat in New South Wales. It was produced by the late Mr. Farrar, from a composite cross between Purple Straw and Yandilla. Yandilla is already a cross between Improved Fife and Etewah. It has a short, upright, stiff straw, unaffected by some of the most violent wind storms. It is a variety, as regarded in its original home, of maximal grain and of minimal straw. Federation is a soft, white plump variety, which yields a good percentage of creamy yellow flour. It is lower in flour strength than Bobs.

Hard Federation: Is a selection from Federation. As its name signifies, it is a hard-horny variety of superior milling qualities. It matures earlier than Federation and consequently may prove to be a better dry-land wheat. At Moro in 1918 and 1919, the Hard Federation spring wheat exceeded theaverage yield of Pacific Bluestem seven bushel per acre, and of Early Baart and Marquis six bushels per acre. This variety in general, is better than Federation.

A word of warning about Australian wheat should be sounded here: Two destructive diseases, "Flagsmut" and

"Take-All", to which these Australian wheats are badly susceptible, have recently been discovered in Indiana and Illinois. Hence these wheats should be bought either through the State College or through the U. S. Department of Agriculture.

Early Baart:- As its name indicates, it is an early maturing spring white wheat of Australian or more properly of Dutch origin. The kernels are large, white and soft to semi-hard in texture. The straw is not so stiff as that of Pacific Bluestem and it is therefore likely to lodge. It is not winter hardy and should never be sown in fall. The O. A. C. Bulletin 144 reports that Early Baart is supplanting the Pacific Bluestem on dry soils of Columbia Basin; that it is superior to the Bluestem in early maturing and milling qualities; that it sells on the Portland market as number one Bluestem; and that it can be strongly recommended for the Columbia Basin.

Forty fold:- Is also known as Gold Coin. From the standpoint of total acreage and yield it ranks next to the Turkey Red in certain sections of the northwest. It is a white kerneled, semi-hard and easily shattering variety of winter wheat. It is a remarkably good yielder in certain wheat growing districts of this country, but shatters easily and is of poor milling quality.

Jones Fife:- Is a composite hybrid of Fultz, Mediterranean, and Russian Velvet. It possesses amber colored, from soft to semi-hard, grain. Wheats previously grown in the north-eastern states, due to the nature of soil and climates, were inclined to be soft and starchy. This hybrid has proven quite an improvement over the old soft wheats. Jones Fife shatters badly and is poorer in milling qualities than Little Club.

Dicklow:- Has attained popularity in the irrigated districts of Southern Idaho mainly, and in Colorado, and Utah partly. It is a white, beardless, spring wheat, grown both in irrigated and non-irrigated sections of Idaho. Irrigated wheat, according to Idaho Bulletin 72, excels the dry-farmed one by approximately six bushels an acre, but drops in crude protein content a little less than two per cent. Where Marquis is good in cold irrigated sections, Dicklow is good in warm irrigated lands. The coast-millers regard this variety, a wheat of intermediate value between Fortyfold and Bluestem, viz, a little superior to the former and inferior to the latter.

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