4-1905

Macaroni Wheat: Its Milling and Chemical Characteristics and its Adaptation for Making Bread and Macoroni

J.H. Shepard
South Dakota Agricultural College

BULLETIN 92 APRIL, 1905

South Dakota Agricultural College Experiment Station

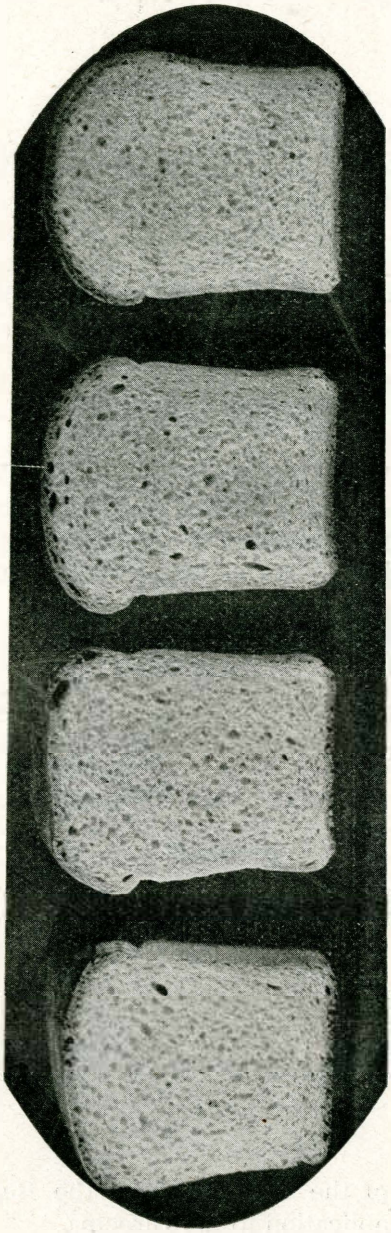
Macaroni Wheat

Its Milling and Chemical Characteristics

Macaroni Bread

Macaroni

Industrial Uses



Baker's Test

Sponge Test

Gluten and its Distribution

Department of Chemistry

GOVERNING BOARD

BOARD OF REGENTS

Hon. I. W. Goodner, President ..... Pierre, S. D.
Hon. F. A. Spafford ..... Flandreau, S. D.
Hon. R. M. Slocum ..... Herreid, S. D.
Hon. A. W. Burtt ..... Huron, S. D.
Hon. M. F. Greeley ..... Gary, S. D.
Hon. I. D. Aldrich (Secretary of Regents) .... Big Stone, S. D.

STATION COUNCIL

R. M. Slocum ..... Regent Member
M. F. Greeley ..... Regent Member
James Chalmers, President of the College.
James W. Wilson, Director and Professor of Animal Husbandry.
E. C. Chilcott, Vice-Director ..... Agronomist
James H. Shepard ..... Chemist
N. E. Hansen ..... Horticulturist
W. A. Wheeler ..... Botanist and Entomologist
E. L. Moore ..... Veterinarian and Zoologist
R. A. Larson ..... Secretary and Accountant

ASSISTANTS

A. B. Holm ..... Soil Physics
H. G. Skinner ..... Animal Husbandry
Frank Norton ..... Chemistry
A. E. Koch ..... Chemistry
William West ..... Agronomy
Adolph Morlock ..... Horticulture
T. B. Kelly ..... Stenographer

Any farmer of the state can have the Bulletins of this Station free upon application to the Director.

MACARONI WHEAT.

Its Milling and Chemical Characteristics and Its Adaptation for Making Bread and Macaroni.

DEPARTMENT OF CHEMISTRY, JAMES H. SHEPARD, CHEMIST.

This Bulletin is a continuation of the work reported in Bulletin No. 82 of this Station. But the work has assumed a wider scope in order to throw more light upon the various industrial uses for which Macaroni wheat is adapted.

Of late much controversy has arisen concerning the Macaroni wheat industry. Many and conflicting reports have been circulated in the daily press and in trade journals. It is true that many statements have been prompted by prejudice and adverse trade interests. But in all the discussions the fact that there are many kinds of Macaroni wheat, each with its own peculiarities, has been lightly passed over or ignored entirely.

The most acrimonious of these discussions have centered around the value of Macaroni wheat for bread making, and its milling value. By some it has been claimed that the flour yield is so low that there is no profit in milling it. Others have contended that the flour yield is greater than for spring bread wheats. Some contend that it is most difficult to mill while others have reported that they have experienced no difficulty in this respect. Some declare that the flour is so yellow that bakers and the general trade decline to buy it while others find no difficulty in this respect. Some claim that the bread is of

poor flavor and of bad color, while others report exactly contrary conditions.

Is it not possible that these conflicting reports, barring those which emanate from some who are financially interested in decrying Macroni wheat, arise from observers who are looking at the same shield, it is true, but from different sides? Is it not possible that one side of the shield may be of gold and the other of silver? Is it not possible that all the conflicting reports are true and that each one has reported what he has actually seen?

In order to throw as much light as possible upon the whole subject, the same investigations reported in Bulletin 82 have been repeated for another year and in addition the baker's sponge test and actual baking tests have been made with each variety, while exact colorimetric determinations have been made on the flour, semolina, bread and macaroni. In the baking tests the loaf weight, texture and volume have been determined and in the case of the macaronis made each has been cooked and tested for texture and flavor. Consequently the work covered by this bulletin embraces an investigation into the merits of each variety of Macaroni wheat now known in this country. And if one has a desire to verify each of the conflicting statements that he may have seen, it is suggested that a close perusal of the data obtained will reveal the fact that almost anything might be true if one only had the right kind of Macaroni wheat to work with. In other words, the different varieties of Macaroni wheat as grown with us vary most markedly from one another in their essential characteristics. Now take this fact together with an other fact, viz.: that many varieties of Macaroni wheat are now in general cultivation, and that these varieties are difficult to differentiate from one another by their general appearance and even by their mode of growth, and it will be very easy to account for the different estimates which have been placed upon the merits of Macaroni wheat. Of course it must be remembered that in all these discussions any Durum wheat, regardless of its variety, has been taken as a type for all Durum wheats, and by this type all have been judged.

In order to exhibit the various facts in as compact a form as may be, the results obtained have been arranged in tabulated

form so far as possible. In these tables are shown the percentages of mill products and moisture, the crude protein and its distribution, the gluten and the baker's sponge test, the baking and the macaroni test, the color of the flour, bread and macaroni, and the nitrogen content of the whole wheat as grown in this state from year to year.

Since the wheat plats at the home Station were all destroyed by hail in 1893, these investigations have been carried out on samples of the different varieties of Macaroni wheat grown at the Highmore Range Station. The samples, therefore, furnish the best basis for comparison. All varieties were good, as will appear from the grades given in the milling table.

The different varieties have been divided into three divisions: the Northern or Russian wheats, the Southern or Mediterranean wheats, and the Miscellaneous wheats coming from widely separated sources.

In order to have a basis for comparison, the different varieties of bread wheats have been carried through the same investigations. These bread wheats are represented by the very best varieties obtainable. Consequently the tests are all made upon first class samples of the individual varieties investigated.

In selecting a new wheat that is best adapted to any region several important factors must be taken into consideration. In the first place it must be a good yielder and resistant to the unfavorable climatic conditions of that region, and also to the prevailing diseases which tend toward crop failure. In the Great Plains region drouth and hot winds are to be reckoned with. In certain years rust and smut ruin the more tender wheats. As a rule the macaroni wheats are strongly resistant to these adverse crop conditions and it now remains to select from the available Durums such as give the best results when used for the trade demands.

The uses of the Macaroni wheats are more extended than those of the wheats used for bread-making alone. It is an undisputed fact that the bread wheats make an indifferent macaroni. Nothing but a good macaroni wheat can be successfully used for that purpose. Then again some of the macaroni wheats make elegant bread, bread that is scarcely equalled by the best of the bread wheats. It is also true that some of the

macaroni wheats make indifferent macaroni and very unattractive bread. As a rule the products from macaroni wheat are richer in protein or muscle-building material than any of the bread wheats, but in order to satisfy the American trade demand a rigid course of selection must be resorted to in choosing the macaroni wheat which will prove most satisfactory.

The demand at present is for a Durum wheat that will make good macaroni, an attractive flour, and a bread that is satisfactory in loaf, color and flavor. This is much to ask of one variety of wheat but our work leads us to believe that the problem is capable of a satisfactory solution. The key to success lies in choosing only the best kind or kinds for cultivation. After that the best localities for growing this best kind to perfection must be carefully determined.

It is now well known that the Macaroni wheats are preeminently dry weather wheats. This leads to the inevitable conclusion that the dryest parts of our country are the natural habitats of these new wheats and it is to those localities we must look for our supply of the highest grade of Macaroni wheat.

Since hail destroyed our home plats this Bulletin deals only with Durum wheats grown in the dryest region this state affords. An inspection of the milling table will show these to be of excellent quality.

Origin of Varieties

A. Bread Wheats

Blue Stem, Minnesota No. 169. This is one of the very best varities of the Blue Stem wheats. It was originated by Professor Hayes of the Minnesota Station. The sample tested was grown by Gottfried Stengel, Milbank, South Dakota.

Fife. This sample was grown by the North Dakota Station. It was sent to this Station by Professor J. H. Sheppard, but the name of variety was not given. It was a fine sample of Fife wheat.

Turkey Red. This is a winter variety of wheat grown by this Station. The seed originally came from Kansas.

No, 1514, White Eared Spring. This is a Russian spring bread wheat. The seed was obtained in exchange at the Paris Exposition of 1900. Sample tested was grown by this Station.

No. 1517, Ghirka Spring. This is also a Russian spring bread wheat, coming from the Grodno Government, Russia. The original seed was obtained in exchange at the Paris Exposition of 1900. The sample tested was grown by this Station.

B. Northern or Russian Macaroni Wheats.

No. 5639, Kubanka. This is probably the best of all the varieties of the Durum wheats for the Great Plains Region. The seed was originally selected by Mr. Carleton. The original importation was sent directly to the writer for propagation. It came from the Uralsk territory. When everything has been taken into consideration, and especially its bread-making qualities and delicately flavored macaroni, it is an ideal wheat for the farmers of the Northwest.

No. 1354, Kubanka. The original seed was obtained from the district of Novo-Uzhensk, Samara Government, in the winter of 1898. This variety is decidedly inferior to the 5639.

No. 1516, Kubanka. The original seed was also from the Samara Government, Russia. It was obtained in exchange at the Paris Exposition of 1900. The berries of this wheat are small and they are not typical of the Kubankas. It is much inferior to the No. 5639 in flour yield.

No. 1541, Kubanka. The original seed came from the Astrachan Government, Russia. This variety is inferior in the quality of its bread and macaroni.

No. 8212, Kubanka. This No. was bought in the open market of the Uralsk and was distributed directly to the farmers of the Northwest. It is a close second to the No. 5639. It falls off in the texture and quality of its bread.

No. 8213, Kubanka. This No. has the same history as the preceding but was of a later importation. It is somewhat inferior to the 8212.

No. 1431, Arnautka. The original seed was grown in the region North of the Sea of Azov, and was obtained at Berdiansk, Russia.

No. 1537, Arnautka. The original seed also came from Berdiansk, Russia. This is the principal variety from that region.

No. 5643, Gharnovka. The original seed was selected by Mr. Carleton in 1900. It came from the vicinity of Tagenrog, Don Territory. Supposed to be adapted to the most arid portions of the Great Plains.

No. 5646, Gharnovka. Original seed came from the same locality as the preceding. This variety may be sown late in Autumn south of the 35th parallel. These two varieties are the best of the Tagenrog wheats.

No. 1546, Gharnovka. This wheat also came from Tagenrog. The 5646 is the best of the three as grown with us.

No. 5642, Yellow Gharnovka. The original seed was selected by Mr. Carleton at Ambrocievka, twenty miles north of Tagenrog. The grains of this wheat are yellowish and transparent. It is also supposed to be adapted to the most arid parts of the Great Plains. It gives a low flour yield.

No. 8230, Yellow Gharnovka. Has the same origin as the preceding but is of a later importation. Low flour yield, but both Yellow Gharnovkas make excellent macaroni. The texture and quality of the bread is fair.

No. 5644, Velvet Don. The original seed was selected by Mr. Carleton at Ambrocievka in 1900. It is distinguished by having white chaff and black beards. It gives a low flour yield and the bread is only of fair quality with a dark color.

No. 5645, Black Don. The same history as the preceding. Has black chaff and black beards. It is no better than the Velvet Don.

No. 8232, Black Don. Same as preceding but of later importation.

No. 1350, Pererodka. The original seed came from the Orsk district, Orenberg Government. Said to have been identical with the Kubanka originally, but much changed owing to different soil and climatic conditions where grown in Russia. Flour yield low but quality of bread and macaroni excellent.

No. 1515 Pererodka. From Simbirsk, Russia. The original seed was obtained in exchange at the Paris Exposition of 1900. This No. is a close second to the Kubanka No. 5639 in the yield of flour and the quality of bread and macaroni.

No. 5800, Beloturka. The original seed came from Vilmorin, Andrieux et Cie., Paris, but probably it originated earlier in Russia. It is one of the best known Russian macaroni wheats, and is commonly grown in the North Caucasus and the Southern Volga region.

No. 1513. Beloturka. The original seed was obtained in exchange at the Paris Exposition of 1900. The grain came from Russia. Both these give good flour yields. The bread is of medium quality and the macaroni excellent.

No. 5351, Berdiansk. This variety came direct from Marseilles, France, but it is of Russian origin, being shipped from Berdiansk. Its variety is unknown. It is much inferior to several varieties previously described.

No. 5352, Novo Rossisk. The original seed came from Novo Rossisk, Russia, but the variety is unknown. The flour yield is low but the bread and macaroni are of good quality.

No. 5355, Tagenrog. The original seed came from Tagenrog, Russia, but the variety is unknown. The flour yield is low but the bread and macaroni are of good quality.

No. 1508, Spring Wheat (macaroni). The original seed came from Hungary and was obtained in excharge at the Paris Exposition of 1900. The flour yield is low and the bread of only fair quality. The macaroni is of good quality.

No. 1540, Chernokoloska. The original seed came from the Poltava Station in the Don territory, Russia. The flour yield is low and bread of fair quality only, but the macaroni is of good flavor and texture.

C. Southern or Mediterranean Wheats.

No. 5353, Algerian. Original seed received direct from Marseilles, France. No varietal name is given. Like all of the Southern wheats it is much inferior to the best Russian.

No. 5380, Pellissier. One of the best wheats grown in Algeria. But as compared with the best Russian varieties the flour yield is low, the bread only fair and the macaroni of good quality and flavor.

No. 7785, Pellissier. The original seed came from Algeria. Rather better bread than the preceding, otherwise about the same.

No. 5492, Medeah. The original seed came from Algeria where it is a standard variety. It is probably the best wheat grown there and has proven a desirable kind in some other countries. But as grown with us it is hard to mill, the flour yield is low, the bread of poor quality and the macaroni is fair.

No. 7579, Medeah. Same source and value as the preceding.

No. 7581, Kahla. This variety also came from Algeria. Its value when grown with us is about the same as the Medeah.

No. 7794, Kahla. Same source and value as preceding.

No. 1428, Egyptian. From Samara government. With us no better than the preceding.

Nos. 1428, 1481, 1509, 1510, Ble dur. These are Algerian wheats of undetermined variety. They offer small inducements for use in the Great Plains region.

No. 7578, Marouni. This is also an Algerian wheat of little promise.

No. 7792, Adjini. This is another Algerian wheat and is one of the poorest varieties.

No. 7792, Mahmoudi. This wheat also comes from Algeria and is no better than the preceding.

No. 7793, Mohamed ben Bachis. Another Algerian wheat and with us is one of the poorest varieties.

No. 7795, Richi. This is an Algerian wheat of only average quality.

No. 9130, Saragolla. The original seed came from Italy. It is there one of the most highly prized varieties used for making macaroni on account of its superior flavor. With us the flour yield is low and the bread is of medium quality. But the macaroni is excellent.

D. Miscellaneous Macaroni Wheats.

No. 5354, Argentine. The original seed came from Argentina through Marseilles. No name was assigned but it is probably Candeal, a good variety grown in Argentina.

No. 1377, Realli Forte. The origin of this seed is unknown, but it was received through Jos. Torre & Bro., New Orleans, La. It is a very poor variety.

No. 1492, Nicaraugua. The original seed was obtained from J. B. Simpson, Dallas, Texas. It gives a low flour yield, but the bread and macaroni are of good quality.

No. 1493, Wild Goose. This seed was obtained from the Hougen Milling Co., North Wood, North Dakota. It also gives a low flour yield but the bread and macaroni are of good quality.

In order to meet the present conditions of the home market in this country, it is evident that the Durum wheat which will give a large yield of flour and also make both bread and macaroni of high quality is the best wheat for every interest concerned.

Note—The numbers preceding the names are the Seed and Plant Introduction numbers of the U. S. Dept. of Agriculture.

The Milling Qualities of the Macaroni Wheats.

In the Milling Table which follows, data are given for five samples of bread wheats. These are given for the purpose of comparison. It matters not how far the results obtained in our small reduction plant may differ from those obtained in actual practice in our large roller mills, all samples were treated alike and the results are strictly comparable. The flour reported is straight flour as each sample was ground to a finish The flour was of sufficient fineness to pass a No. 12 Shindler silk seive. The bran was taken from a No. 20 wire gauze and a No. 30 common gauze. In finishing the shorts were taken from a No. 64 XX Shindler silk and the No. 12, the 30 gauze having been exchanged for the 64. It will be noticed that four seives were used in the bolter. In each case the products were finished separately thus avoiding as much as possible any unnecessary reduction of either the bran or shorts. By following this method a very good quality of flour was obtained.

The second column gives the names of the varieties milled. The two samples of Russian bread wheats were most excellent kinds. If they were only more rust resistant they would be desirable wheats to grow in the more humid parts of the semi-arid regions. As rust resisters, however, they are not superior to our fifes and blue stems, if the season of 1904 is any criterion.

In regard to the names assigned to the different varieties of the macaroni wheat it is but just to say that they do not have much significance. We all know how many strains of blue stem wheat are to be obtained at any market center, and how much likelihood there would be of obtaining the same strain twice were a buyer unacquainted with our growers to buy blue stem wheat making his selections one or two years apart on the Chicago open market. It is just this condition which prevails with the macaroni wheats. Take for instance the Kubanka variety. Two or three separate importations have been made, some of which have been bought on the open market and it is altogether unlikely that the same strain has been obtained each time. But most fortunately each importation has been assigned a number by means of which it may be identified. It may be

advisable to assign new names to the variety which proves to be the best for general use.

The third column gives the yield per acre in bushels obtained on the Station plats at Highmore.

The fourth column gives the number of pounds per bushel as tested with a Fairbanks grader.

In the fifth column the letters refer to the condition of the grain as to plumpness. P signifies plump, S shrunken, SS slightly shrunken, etc.

In the sixth column the letters refer to the ease of reduction. Thus E means easy, M medium and H signifies hard to reduce. The bread wheats are compared with one another and the same is true of the Durums. But when a comparison as between the bread wheats and the Durums is desired the letter M in a bread wheat is about equivalent to E of the Durums.

The quality of the semolina is given on a scale of 100, Kubanka 5639 being taken as the standard.

The next few columns under Mill Products need little explanation. A weighed quantity of wheat, 500 grams or 1.1 pounds was weighed, tempered and milled. Each product was weighed and its percentage calculated. The error column shows how nearly the work approximated 100 per cent. If the minus sign precedes the error it indicates that much loss; if the plus sign is used it indicates a gain above 100 per cent. This gain occurs through the absorption of water by the wheat while tempering.

The color columns indicate the shades as determined by a Lovibond Tintometer. This will be explained further on when discussing the color table.

The semolina corresponds to the purified middlings obtained in the regular course of reduction as practiced by our commercial roller mills. In this work all reductions were made on the corrugated rolls. The semolina was taken from a No. 10 Shindler silk which allowed all the fine flour to pass through. The semolina itself passed a No. 64 XX Shindler silk. No attempt was made to determine the semolina quantitatively as it was not possible to carry the sifting far enough to make a complete separation. I tried this but small particles of bran

were thus carried through. A middlings purifier would be necessary to make a quantitative separation of the semolina.

The moisture determinations are also self explanatory.

It is plain that so far as these tests are concerned that Kubanka 5639 is the best wheat milled, the bread wheats not excepted. It yields a greater per cent. of flour than any other. The color is not much different from the best blue stem flour while a casual glance at the photographs on the title page will show that it makes a better loaf of bread than any other. We have yet to find the person who does not prefer the Kubanka bread to any other.

The Russian macaroni wheats as a whole give better results than the others although there is a wide difference among the samples milled. Some are as good as the 5639 in some respects, but none are so good in all the milling characteristics.

The milling table follows :

MILLING AND MOISTURE TABLE.

Sample						Mill Products				Color of Flour		Semolina			Per Cent. Moisture			
Laboratory No.	Name	Yield—bu. p'r acre	Grade—lbs. per bu.	Condition	Reduction	Per Cent. Bran	Per Cent. Shorts	Per Cent. Flour	Per Cent. Error	Yellow	Orange	Color Yellow	Color Orange	Quality	Wheat	Bran	Shorts	Flour
	Bread Wheats—																	
...	Blue Stem Minn. No. 169.	....	57.9	P	E	22.26	8.80	68.40	— .54	.20	.05	.30	.15	80	8.03	8.76	8.33	8.68
...	Fife- from No. Dak. Exp. Station..	....	59	P	M	20.04	12.60	68.00	+ .64	.20	.05	.15	.20	90	13.56	14.36	13.32	13.95
...	Turkey Red—Winter Wheat.....	....	62.5	P	M	21.20	12	66	— .80	.10	.15	.20	.20	85	11.78	11.66	12.35	12.68
133	1514 White Eared Spring.....	....	59.9	P	E	20.20	9.80	69.40	— .60	.18	.02	.20	.15	80	10.71	10.79	10.71	11.07
136	1517 Ghirka Spring.....	....	60	P	E	18.32	9.60	71	—1.08	.20	...	.15	.20	80	10.70	9.97	8.84	10.26
	Average.....	....	59.9	....	....	20.40	10.56	68.56	— .48	.18	.05	.20	.18	83	10.96	11.11	10.71	11.33
	North'n or Russian Mac. Wheats—																	
48	5639 Kubanka	15.2	62	P	E	8.02	15.34	76.80	+ .16	.28	.02	.40	.30	100	8.06	7.76	7.83	8.34
69	1354 Kubanka	12.8	62.5	P	E	15.80	16.54	68.14	+ .48	.28	.02	.35	.30	98	8.43	9.32	9.03	9.54
135	1516 Kubanka	10.7	62.9	P	M	15.90	19.30	64.40	— .40	.27	.18	.40	.35	90	8.56	8.54	8.35	8.83
141	1541 Kubanka	10	62.5	P	M	14.70	15.02	69.36	— .92	.23	.12	.45	.35	90	8.29	8.17	7.85	8.61
154	8212 Kubanka	16.7	63.1	P	M	13	14.44	72.44	— .12	.22	.08	.35	.35	100	8.59	8.50	8.08	8.66
155	8213 Kubanka	13.5	62.6	P	M	18.10	18 80	63.10	.00	.25	.15	.40	.30	100	8.67	9.71	9.15	9.69
78	1431 Arnautka.....	19.3	62.8	P	M	14.40	14.30	72.30	+1.	.30	.15	.35	.40	90	9.05	9.09	8.72	9.41
139	1537 Arnautka.....	16.2	62.9	P	M	13.90	14.60	72.30	+ .80	27	.18	.35	.40	90	9.04	9.46	9.42	9.60
61	5643 Gharnovka.....	15.5	61.9	S.S.	M	18.06	19.30	63.40	+ .76	.22	.18	.14	.46	92	9.07	9.54	9.22	9.50
63	5646 Gharnovka.....	14.7	62	S.S.	M	13.70	15.56	70.34	— .40	25	.15	.30	.40	95	9.11	9.22	8.91	9.54
142	1546 Gharnovka.....	16	61.6	S.S.	M	17.10	16.36	66.74	+ .10	.22	.18	.20	.45	95	9.20	9.31	9.58	9.56
60	5642 Yellow Gharnovka.....	18.7	61	S.S.	M	18	21.24	60	— .76	.31	.14	.35	.40	98	9.25	9.58	9.12	9 79
156	8230 Yellow Gharnovka.....	19.2	63	P	M	17.30	18.20	63.84	— .66	.25	.10	.40	.30	100	9.04	9.19	8.72	9.44
49	5644 Velvet Don.....	18.8	61.2	P	H	23.70	21	54.50	— .80	.25	.20	.30	.40	95	8.72	8.52	7.97	8.70
62	5645 Black Don.....	16.5	62	P	H	20.08	19.30	60.84	+ 22	.28	.12	.40	.35	92	9.35	9.78	9.40	9.89
158	8232 Black Don.....	11.7	61	P	H	20.70	16.40	63.80	+ .90	.24	.16	.30	.30	98	9.48	10.02	9.89	10.14
67	1350 Pererodka.....	15.9	62.5	P	E	18.98	14.58	67.40	+ .96	25	.10	.35	.30	100	9.91	10.73	10.10	11.06
134	1515 Pererodka.....	16.3	62.5	P	E	12.68	14.82	72.30	— .20	.20	.10	.40	.20	100	9.18	9.77	9.25	9.77

MILLING AND MOISTURE TABLE.—Concluded.

Sample						Mill Products				Color of Flour		Semolina			Per Cent. Moisture			
Laboratory No.	NAME	Yield—bu. p'r acre	Grade—lbs per bu.	Condition	Reduction	Per Cent. Bran	Per Cent. Shorts	Per Cent. Flour	Per Cent. Error	Yellow	Orange	Color Yellow	Color Orange	Quality	Wheat	Bran	Shorts	Flour
65	5800 Beloturka	12	62.8	P	M	13.98	13.36	71.86	— .80	.27	.13	.40	.30	98	9.41	10.16	9.62	10.21
132	1513 Beloturka	14	62.8	P	M	17.60	12.22	70.20	+ .02	.28	.12	.30	.35	10	9 39	10.20	9.73	10.20
53	5351 Berdiansk	15.8	60.5	P	H	17.30	16.80	65.40	— .50	.27	.18	...	.60	90	9.71	10.59	10.16	10.51
54	5352 Novo Rossisk	13.6	61.8	P	H	19.10	17.10	63	— .80	.25	.10	.30	.35	95	10.06	10.49	10.28	10.32
57	5355 Tagenrog	18.5	61.9	P	H	20	20	61.10	+1.10	.20	.20	.35	.40	95	10.29	11.30	11.88	11.27
128	1508 Spring Wheat (Macaroni)	16.5	63	P	H	17.70	16.64	66.52	+ .86	.25	.15	.30	.45	90	10.29	10 74	10.93	10.87
140	1540 Chernokoloska	12.8	61.5	P	H	22.90	14	63.60	+ .50	.15	.35	.35	.40	95	10.18	10.73	10.26	10.90
	Average	15.2	62.2	....	....	16.90	16.63	66.55	+ .08	.25	.14	.33	.37	95	9.21	9.62	9.31	9.77
	South'n or Mediterranean Mac. w't																	
55	5353 Algerian	13.7	59.5	S. S.	H	22.50	16.30	59.90	—1.30	.25	.20	.20	.40	92	10.36	10.11	9.71	10.23
58	5380 Pellissier	17.8	61	P	H	21.10	19.20	60.50	+ .80	.25	.15	.20	.40	95	10.57	11.71	10.84	11.56
149	7785 Pellissier	20.2	59.2	S. S.	H	21.34	20.10	58.84	+ .28	.23	.12	.15	.40	95	10.46	11.29	10.92	11.40
59	5492 Medeah	12	59.2	P	H	26.50	16	56.60	— .90	.15	.25	.25	40	95	10.70	11.52	11.71	11.44
146	7579 Medeah	14	57.5	P	H	25.60	20.50	54.34	+ .44	.20	.20	.20	.40	90	11.09	12.61	12.19	12.57
148	7581 Kahla	11.3	59	P	E	22.80	15.80	61.10	— .30	.25	.20	20	.40	98	10.84	11.64	11.40	11.73
152	7794 Kahla	9	58.5	S. S.	M	24.10	19.50	56.30	— .10	.20	.20	.20	.45	95	10.86	11.29	11.24	11.50
77	1428 Egyptian	18.8	63.1	P	M	20.50	12.66	65.30	—1.54	.25	.20	.40	.40	95	10 65	10.31	9.30	10.44
112	1481 Ble dur	16.5	61.8	P	H	32.30	18.56	50.40	+1 26	.25	.20	.20	.45	98	10.93	11.31	10.83	11.71
129	1509 Ble dur	16	63	P	H	25.50	17.50	56.10	— .90	.25	.20	.25	.35	100	10.53	10.75	10.37	10.77
130	1510 Ble dur	17.2	62.5	P	H	21.46	20.10	57.84	— .60	.20	.25	.30	.40	95	10.48	10.55	10.12	10.64
145	7578 Marouni	11.7	59 5	S. S	M	20.36	20.44	60.20	+1	20	.30	25	.50	92	10.62	11.08	10.97	11.20
147	7580 Adjini	10.7	57.1	S. S.	H	27.76	23	49.80	+ .56	.20	.25	.30	.30	96	10.94	11.82	11.66	11.83
150	7792 Mahmoudi	14.2	60.1	S. S.	H	25.20	24.10	50.80	+ .10	.20	.25	.25	.40	95	11.20	11.45	11.33	11.41
151	7793 Mohamed ben Bachis	11.8	60.5	S. S.	H	31.20	21.36	47.44	.00	.20	.25	.30	.40	95	10.97	11.49	11.11	11.67
153	7795 Richi	12	57 5	S. S.	H	31.14	21	48.10	+ .24	.20	.25	.20	.35	100	11.13	12 06	11.85	12.35
162	9130 Saragolla	11.2	57	S. S.	M	26.70	17.84	55.92	+ .46	.20	.20	.35	.40	95	11.59	12.41	12.01	12.34

	Average	15.2	59.8	....	....	25.06	19.06	55.85	—	.03	.22	.22	.25	.40	95	10.82	11.38	11.03	11.46
	Miscellaneous Macaroni Wheats																		
56	5354 Argentine	17	60	P	E	22.92	17.60	59.44	—	.04	.20	.15	.20	.30	98	11.61	12.04	11.16	11.95
75	1377 Realli Forte	16	60	P	H	28.24	21.26	50.90	+	.40	.22	.18	.20	.30	90	11.93	12.23	12.19	12 61
122	1492 Nicaraugua	18.8	62.5	P	H	21.70	23.70	54.94	+	.34	.20	.15	.30	.30	100	11.64	12 22	12.13	12.25
123	1493 Wild Goose	17.8	62.2	P	M	20.84	22.50	55.26	—	1.40	.25	.15	.35	.30	100	11.67	11.37	11.19	11.60
	Average	17.7	61.2	....	....	23.42	21.27	54.14	—	.17	.22	.16	.26	.30	97	11.71	11.97	11.67	12.10
	Average of macaroni wheats	15	61.2	....	....	20.48	17.93	61.60	+	.01	.24	.17	.29	.35	95	10.02	10.47	10.15	10.60

The Crude Protein and its Distribution.

The next table gives the crude protein and its distribution among the mill products. Bread and macaroni are valued according to the amount of crude protein or muscle building nutrients they carry. They are not an economical source for starch or the carbohydrates.

It will be seen that macaroni wheats as a whole are richer in protein than the bread wheats. Among the macaroni wheats the Mediterranean wheats carry the larger percentage of protein in the whole wheat but this does not indicate they are therefore capable of yielding a richer flour. This factor depends upon the distribution of the protein. It is evident that what protein is stored up in the bran and shorts does not enrich the flour. A whole wheat may carry a large percentage of protein and it may carry its protein so distributed that a large per cent. of it is lost in the bran and shorts.

The Kubanka, 5639 is again the best wheat milled in this respect. Its flour carries the highest per cent. of protein save one, the Beloturka; but it excels the Beloturka in the saving of its protein in the flour; or in other words the Beloturka loses more of its protein in the bran and shorts.

A careful study of this table reveals many interesting and useful facts. The first four columns show the percentages of crude protein in the whole wheat and in its mill products. The next four show how many pounds of protein 100 pounds of the whole wheat or of its mill products carry. The last four columns show what becomes of the crude protein in a wheat after it is milled. It shows whether a wheat is an economical one to grow and mill for flour production.

In case the wheat is wanted for stock feeding it does not matter so very much where the protein is located, whether it is in the bran, shorts or flour. In that case the amount of protein in the whole wheat is a better criterion. This table therefore would enable one to select a wheat for feeding purposes as well as for milling.

It is evident that the best wheat for milling is the one that gives the largest per cent. of protein in the flour; and the most economical one to grow and mill is the one that puts the greatest percentage of its total protein in the flour.

The table follows :

CRUDE PROTEIN AND ITS DISTRIBUTION.

N. × 5.7 = CRUDE PROTEIN.

Laboratory Number	Sample Name	Per Cent. Crude Protein				Pounds Protein in 100 lbs. Wheat and in Mill Products Therefrom					Per Cent. Distribution Between Mill Products of Total Protein in Wheat			
		Whole Wheat	Bran	Shorts	Flour	Whole Wheat	Bran	Shorts	Flour	Error	Bran	Shorts	Flour	Error
	Bread Wheats—													
...	Blue Stem, Minnesota No. 169	13.11	14.25	14.08	12.37	13.11	3.19	1.25	8.44	—0.23	24.35	9.57	64.35	—1.73
...	Fife, from North Dakota Experiment Station	12.71	14.71	12.65	11.97	12.71	2.96	1.60	8.15	0.00	23.32	12.56	64.12	0.00
51	Turkey Red, winter wheat	12.14	13.91	12.60	11.23	12.14	2.96	1.54	7.41	—0.23	24.41	12.68	61.03	—1.88
133	1514 White Eared Spring	14.82	17.10	16.19	13.17	14.82	3.48	1.60	9.12	—0.62	23.46	10.77	61.54	—4.23
136	1517 Ghirka Spring	15.62	18.30	17.27	14.54	15.62	3.36	1.65	10.32	—0.29	21.53	10.58	66.42	—1.47
	Average	13.68	15.65	14.56	12.66	13.68	3.19	1.53	8.69	—0.27	23.42	11.23	63.49	—1.86
	Northern or Russian Macaroni Wheats—													
48	5639 Kubanka	14.65	12.77	13.91	14.42	14.65	1.03	2.11	11.06	—0.45	7.00	14.40	75.49	—3.11
69	1354 Kubanka	14.71	15.16	13.91	14.42	14.71	2.39	2.28	9.80	—0.24	16.28	15.50	66.67	—1.55
135	1516 Kubanka	15.11	15.42	14.54	14.93	15.11	2.45	2.62	9.63	—0.41	16.23	17.36	63.77	—2.64
141	1541 Kubanka	15.22	15.33	14.99	14.93	15.22	2.28	2.28	10.37	—0.29	14.98	14.98	68.16	—1.88
154	8212 Kubanka	14.54	14.54	14.08	14.25	14.54	1.88	2.05	10.32	—0.29	12.90	14.12	70.94	—2.04
155	8213 Kubanka	15.28	14.82	14.42	14.82	15.28	2.68	2.74	9.35	—0.51	17.54	17.91	61.19	—3.36
78	1 31 Arnautka	14.65	14.7	14.31	14.42	14.65	2.11	2.00	10.37	—0.12	14.40	14.01	70.82	—0.77
139	1537 Arnautka	15.11	14.59	14.82	14.82	15.11	2.05	2.17	10.72	—0.17	13.58	14.34	70.94	—1.14
61	5643 Gharnovka	15.33	15.96	15.11	15.16	15.33	2.91	2.91	9.63	+0.12	18.96	18.96	62.83	+0.75
63	5646 Gharnovka	15.39	14.88	15.05	15.28	15.39	2.05	2.34	10.77	—0.23	13.33	15.18	70.00	—1.49
142	1546 Gharnovka	16.70	16.70	16.07	16.13	16.70	2.85	2.62	10.77	—0.46	17.06	15.70	64.51	—2.73
60	5642 Yellow Gharnovka	14.31	14.59	13.91	13.62	14.31	2.62	2.96	8.15	0.58	18.33	20.72	56.97	—3.98
156	8230 Yellow Gharnovka	13.74	13.74	13.51	13.22	13.74	2.39	2.45	8.44	—0.46	17.38	17.84	61.41	—3.32
49	5644 Velvet Don	14.31	14.93	13.91	13.91	14.31	3.53	2.91	7.58	—0.29	24.70	20.32	52.99	—1.99

CRUDE PROTEIN AND ITS DISTRIBUTION—Concluded.

N. × 5.7 = CRUDE PROTEIN.

Laboratory Number	Sample Name	Per Cent. Crude Protein				Pounds Protein in 100 lbs. Wheat and in Mill Products Therefrom					Per Cent. Distribution Between Mill Products of Total Protein in Wheat			
		Whole Wheat	Bran	Shorts	Flour	Whole Wheat	Bran	Shorts	Flour	Error	Bran	Shorts	Flour	Error
62	5645 Black Don	15.56	15.85	15.56	14.71	15.56	3.19	3.02	8.95	—0.40	20.51	19.41	57.51	—2.57
158	8233 Black Don	16.53	16.70	15.79	15.73	16.53	3.48	2.57	10.03	—0.45	21.03	15.52	60.69	—2.76
67	1350 Pererodka	14.14	14.48	14.31	14.19	14.14	2.74	2.11	9.58	+0.29	19.35	14.92	67.74	+2.01
134	1515 Pererodka	14.82	15.05	15.50	14.08	14.82	1.88	2.28	10.20	—0.46	12.46	15.38	68.85	—3.31
65	5800 Beloturka	15.62	15.05	15.39	14.65	15.62	2.11	2.05	11.17	—0.29	13.50	13.14	71.53	—1.83
132	1513 Beloturka	15.50	15.50	15.39	14.59	15.50	2.74	1.88	10.26	—0.62	17.65	12.13	66.18	—4.04
53	5351 Berdiansk	15.68	16.25	15.00	14.93	15.68	2.79	2.51	9.75	—0.63	17.82	16.00	62.18	—4.00
54	5352 Novo Rossisk	15.50	14.82	15.96	15.45	15.50	2.85	2.74	9.75	—0.16	18.38	17.65	62.87	—1.10
57	5355 Tagenrog	16.47	15.85	15.79	15.50	16.47	3.19	3.14	9.46	—0.68	19.38	19.05	57.44	—4.15
128	1503 Spring Wheat (macaroni)	15.56	16.07	15.96	14.88	15.56	2.85	2.68	9.92	—0.11	18.32	17.22	63.74	—0.72
140	1540 Chernokoloska	15.39	16.02	15.28	14.76	15.39	3.65	2.17	9.41	—0.16	23.70	14.07	61.11	—1.12
	Average	15.19	15.19	14.90	14.71	15.19	2.59	2.46	9.82	—0.32	16.9.	16.23	64.66	—2.12
	Southern or Mediterranean Macaroni Wheats													
55	5353 Algerian	16.53	17.10	16.36	16.36	16.53	3.88	2.68	9.80	—0.17	23.45	16.21	59.31	—1.03
58	5380 Pellissier	16.36	16.53	15.90	15.56	16.36	3.48	3.08	9.41	—0.39	21.25	18.75	57.49	—2.51
149	7785 Pellissier	16.53	17.16	16.07	15.62	16.53	3.65	3.25	9.18	—0.45	22.07	19.66	55.52	—2.75
59	5492 Medeah	15.33	16.25	15.45	14.67	15.33	4.33	2.45	8.27	—0.28	28.25	15.99	53.90	—1.86
146	7579 Medeah	14.59	15.68	14.71	13.74	14.59	3.99	3.02	7.47	—0.11	27.3	20.70	51.17	—0.79
148	7581 Kahla	17.04	17.67	16.53	16.19	17.04	4.05	2.62	9.92	—0.45	23.75	15.38	58.19	—2.68
152	7794 Kahla	17.27	17.73	16.42	16.29	17.27	4.28	3.19	9.35	—0.45	24.75	18.48	54.13	—2.64
77	1428 Egyptian	14.71	15.11	14.71	13.85	14.71	3.08	2.00	9.06	—0.57	21.16	13.57	61.63	—3.64
112	1481 Ble dur	15.16	15.62	14.36	14.36	15.16	5.07	2.68	7.24	—0.17	33.43	17.67	47.74	—1.13

129	1509	Ble dur	15.05	15.22	14.54	14.48	15.05	3.88	2.57	8.09	—0.51	25.76	17.05	53.79	—3.40
130	1510	Ble dur	15.62	15.73	14.93	14.71	15.62	3.36	3.02	8.49	—0.75	21.53	19.34	54.38	—4.75
145	7578	Marouni	16.53	17.16	16.42	16.07	16.53	3.48	3.36	9.69	0.00	21.03	20.35	58.62	0.00
147	7580	Adjini	16.76	17.84	16.02	15.96	16.76	4.96	3.71	7.92	—0.17	29.59	22.11	47.28	—1.02
150	7792	Mahmoudi	15.79	16.87	15.45	15.28	15.79	4.28	3.71	7.75	—0.05	27.08	23.47	49.10	—0.35
151	7793	Mohamed ben Bachis	15.85	17.39	15.39	15.45	15.85	5.42	3.31	7.35	+0.23	34.17	20.86	46.40	+1.43
153	7795	Richi	17.90	18.07	16.76	16.64	17.90	5.64	3.53	7.98	—0.75	31.53	19.75	44.59	—4.13
162	9130	Saragolla	17.44	18.53	17.56	16.64	17.44	4.96	3.14	9.29	—0.05	28.43	17.97	53.27	—0.33
		Average	16.14	16.80	15.74	15.42	16.14	4.22	3.02	8.60	—0.30	26.15	18.67	53.32	—1.86
		Miscellaneous Macaroni Wheats—													
56	5354	Argentine	16.19	16.99	16.47	15.62	16.19	3.88	2.91	9.29	—0.11	23.94	17.96	57.39	—0.71
75	1377	Reali Forte	16.19	16.93	15.22	15.11	16.19	4.79	3.25	7.70	—0.45	29.58	20.07	47.54	—2.81
122	1492	Nicaraugua	15.28	16.07	15.68	14.54	15.28	3.48	3.71	7.98	—0.11	22.76	24.25	52.24	—0.75
123	1493	Wild Goose	15.68	16.19	16.13	14.65	15.68	3.36	3.65	8.09	—0.58	21.45	23.27	51.64	—3.64
		Average	15.84	16.55	15.88	14.98	15.84	3.88	3.38	8.27	—0.31	24.43	21.39	52.20	—1.98
		Average of macaroni wheats	15.60	15.90	15.29	15.00	15.60	3.30	2.75	9.24	—0.31	21.02	17.58	59.39	—2.01

Gluten and Baker's Sponge Test.

The next table concerns the wet and dry gluten in the flour and the Baker's sponge test. The wet and dry gluten factors are important since they throw much light upon the value of a flour for baking purposes.

The wet gluten was determined in the usual way by washing away the starch and soluble matter from a weighed quantity of flour, 10 grams, in a gentle stream of water.

After washing, the gluten was placed under water for an hour and then weighed.

This gave the wet gluten. This wet gluten was then dried at the temperature of boiling water and weighed again.

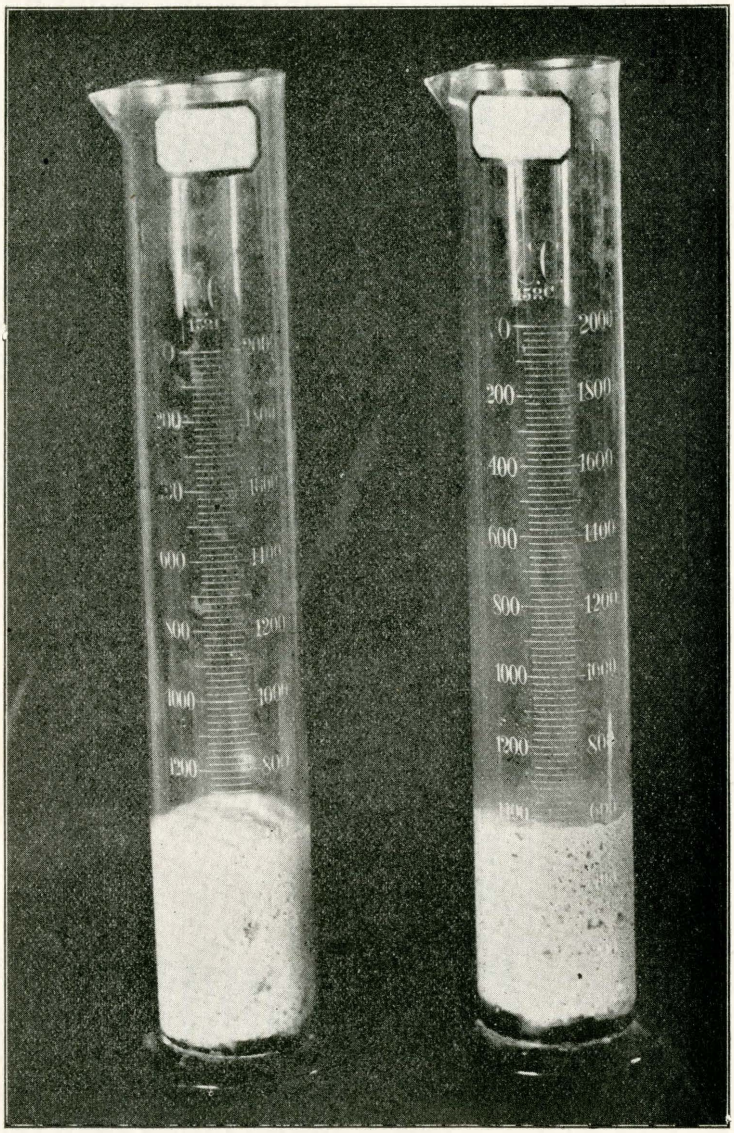
In the table the first column gives the per cent. of wet gluten and the second the per cent. of dry gluten. The third column gives the number of grams of water held by one gram dry gluten. As a rule the more water the gluten can hold the better the flour for baking purposes. The fourth column refers to the appearance and adhesiveness of the pure washed gluten.

The next seven columns are devoted to the Baker's Sponge test. This was executed as follows : Five grams of compressed yeast and five grams of sugar were thoroughly rubbed up with 60 c. c. of water. One hundred grams of flour were then added and then water was carefully run in from a burette until the dough was of such a consistency that it would not stick to the hands. The kneading was done in an earthenware dish by means of a spatula. The reading of the burette plus 60 c. c. gave the amount of water requird.

The dough was placed in a slightly oiled cylinder, (See Plate I, page 23,) which was then kept at 90 deg. F. until the dough reached its maximum height and broke. The volume was then read in cubic centimetres. The dough was then cut from the sides of the jar and allowed to rise a second time and this volume was also noted. Also the time for each rise was recorded. The last two columns under Baker's Sponge test are self explanatory. In comparing the bread wheats with the macaroni wheats it must not be forgotten that the macaroni wheats carry more gluten in the flour. It appears from the data that the bread wheat glutens are slightly superior gram for gram, but the greater quantity in the macaroni seems to offset this advantage. The sponge test is a more accurate test of the tenacity of the gluten than the loaf volume, owing to the greater accuracy obtainable in the rise and measurement. The

last column indicates the water capacity of the flours, and affords a good criterion for comparison.

PLATE I.



GLUTEN AND BAKER'S SPONGE TEST.

Laboratory Number	NAME	Gluten in Flour: Per Cent. Moist Gluten	Per Cent. Dry Gluten	Water Capacity—Gms water held by 1 gm Gluten	Quality	Baker's Sponge Test: Rise: Time-min'ts: First Rise	Second Rise	Average Time	Volume—C. C.: First Rise	Second Rise	Average Rise	Av. Rise for Each gm glut'n	Per Cent. Water Absorbed by flour	Per Cent. Water in Air Dry Flour	Gms. Water held by Dough from 100 Gms Flour
	Bread Wheats—														
	Blue Stem—Minn. No. 169	47.05	14.88	2.15	98	98	58	78	740	615	678	45.56	74	8.68	82.7
	Fife—from North Dakota Experiment Station	41.30	13.60	1.98	100	105	60	83	700	620	660	48.52	65	13.95	79
	Turkey Red—Winter Wheat	39.20	12.70	2.09	98	95	60	78	600	580	590	46.40	62	12.68	74.7
133	1514 White Eared Spring	47.75	15.20	2.12	95	95	60	78	660	650	655	43.09	65	11.07	76.1
136	1517 Ghirka Spring	55.05	17.75	2.10	92	100	65	83	680	670	675	38.02	66	10.26	76.3
	Average	45.99	14.82	2.10	97	99	61	80	676	627	652	44.00	66	11.33	77.4
	Northern or Russian Macaroni Wheats—														
48	5639 Kubanka	48.23	16.10	2.00	90	85	55	70	660	590	625	38.82	72	8.34	80.3
69	1354 Kubanka	51.95	17.70	1.94	90	80	55	68	710	610	660	37.29	74	9.54	83.5
135	1516 Kubanka	53.95	17.95	2.01	80	100	50	75	640	500	570	31.74	75	8.83	83.8
141	1541 Kubanka	53.55	17.78	2.01	85	83	60	72	670	570	620	34.87	72	8.61	80.6
154	8212 Kubanka	55.55	18.55	1.99	80	90	55	73	600	540	570	30.73	69	8.66	78.7
155	8213 Kubanka	58.08	18.73	2.10	85	90	50	70	670	580	625	33.36	73	9.69	82.7
78	1431 Arnautka	48.80	16.63	2.00	85	90	55	73	660	580	620	37.28	72	9.41	81.4
139	1537 Arnautka	50.70	16.90	2.00	85	95	55	75	680	560	620	36.69	73	9.60	82.6
61	5643 Gharnovka	54.65	17.40	2.14	90	85	65	75	720	690	705	40.52	72	9.50	81.5
63	5646 Gharnovka	52.43	17.53	1.99	85	90	55	73	650	600	625	35.65	72	9.54	81.5
142	1546 Gharnovka	57.75	18.90	2.06	85	90	50	70	720	600	660	34.92	73	9.56	82.6
60	5642 Yellow Gharnovka	48.80	16.45	1.97	82	75	60	68	600	530	565	34.35	69	9.79	78.8
156	8230 Yellow Gharnovka	46.70	15.80	1.96	83	80	55	68	600	540	570	36.08	68	9.44	77.4
49	5644 Velvet Don	43.20	14.83	1.91	70	75	45	60	500	420	460	31.02	70	8.70	78.7
62	5645 Black Don	46.68	15.40	2.03	80	70	45	58	600	500	550	35.71	66	9.89	75.9
158	8232 Black Don	55.50	18.10	2.07	80	80	50	65	620	560	590	32.59	66	10.14	76.1

67	1350	Pererodka	51.80	17.00	2.05	95	80	65	73	740	700	720	42.35	66	11.06	77.1
134	1515	Perorodka	51.55	16.55	2.12	85	85	50	68	650	560	605	36.56	62	9.77	71.8
65	5800	Beloturka	55.30	17.75	2.12	90	85	55	70	720	640	680	38.31	65	10.21	75.2
132	1513	Beloturka	55.90	18.70	1.99	85	95	60	78	730	620	675	36.09	66	10.20	76.2
53	5351	Berdiansk	50.25	16.60	2.03	80	60	40	50	540	520	530	31.92	63	10.51	73.5
54	5352	Novo Rossisk	57.85	18 50	2.13	88	70	45	58	700	620	660	35 68	63	10.32	73.3
57	5355	Tagenrog	61.28	19.45	2.15	85	80	50	65	700	600	650	33.42	63	11.27	74.3
128	1508	Spring Wheat Macaroni	55.60	17.75	2.13	85	85	50	68	700	560	630	35.49	63	10.87	73.9
140	1540	Chernokoloska	51.20	16.80	2.05	85	85	55	70	640	580	610	36.31	68	10.90	78.9
		Average	52.93	17.36	2.05	85	83	53	68	657	575	616	35.50	69	9.77	78.4
		Southern or Mediterranean Macaroni Wheats—														
55	5353	Algerian	54.05	18.40	1.94	68	70	45	58	560	530	545	29.62	70	10.23	80.2
58	5380	Pellissier	56.55	18.45	2.06	80	80	50	65	600	580	590	31.98	65	11.56	76.6
149	7785	Pellissier	53.40	17.30	2.09	80	80	50	65	575	550	563	32.54	68	11.40	79.4
59	5492	Medeah	53.95	17 20	2.13	80	75	45	60	600	520	560	32.56	66	11.44	77.4
146	7579	Medeah	52.05	16.90	2.14	80	70	45	58	580	480	530	31.36	64	12.57	76.6
148	7581	Kahla	60.85	19.30	2.15	80	90	45	68	640	540	590	39.56	64	11.73	75.7
152	7794	Kahla	59.05	18.90	2.12	80	80	45	63	600	510	555	29.35	65	11 50	76.5
77	1428	Egyptian	46.80	15.85	1.95	80	75	45	60	600	530	565	35.65	66	10.44	76.5
112	1481	Ble dur	50.85	16.80	2.03	75	80	45	63	580	480	530	31.55	68	11.71	79.7
129	1509	Ble dur	51.75	16.95	2.05	78	80	60	70	580	520	550	32.45	64	10.77	74.8
130	1510	Ble dur	52.15	17.25	2.02	80	80	60	70	630	550	590	34.20	60	10.64	70.6
145	7578	Maronni	59.05	19.25	2.06	78	80	50	65	570	530	550	28.57	62	11.20	73.2
147	7580	Adjini	58.25	19.60	1.97	75	75	55	65	620	580	600	30.61	63	11.83	74.8
150	7792	Mahmoudi	58 00	18.90	2.07	75	70	50	60	600	570	585	30.95	62	11.41	73.4
151	7793	Mohamed ben Bachis	56.90	18.85	2.02	75	75	45	60	590	560	575	30.50	62	11.67	73.7
153	7795	Richi	59.05	19.05	2.10	70	75	40	58	600	540	570	29.92	62	12.35	74.4
162	9130	Saragolla	58.10	19.50	1.98	80	80	50	65	600	600	600	30.77	66	12.34	78.4
		Average	55.34	18.13	2.05	78	77	49	63	595	540	568	31.31	64.5	11.46	76.0
		Miscellaneous Macaroni Wheat—														
56	5354	Argentine	56.20	18.60	2.02	85	80	50	65	670	600	635	34.14	62	11.95	74.0
75	1377	Reali Forte	49.25	17.20	1.86	70	75	40	58	580	500	540	31.39	63	12.61	75.6
122	1492	Nicaraugua	52.20	17.55	1.98	88	80	50	65	620	600	610	34.76	60	12.25	72.3
123	1493	Wild Goose	52.90	17.80	1.96	85	80	40	60	600	550	575	32.30	62	11.60	73.6
		Average	52.64	17.79	1.96	82	79	45	62	617	563	590	33.15	61.8	12.10	73.9
		Average of Macaroni Wheats	53.79	17.68	2.04	82	81	51	66	631	561	596	33.76	66.5	10.60	77.1

Bread and Macaroni.

The next table gives the bread and macaroni tests. The baking test was executed as follows: In each case the loaves were made exactly alike and the same amount of material was employed excepting the water, which was determined by the sponge test. For making one loaf there was used one cake of compressed yeast, Red Star brand, ten grams of sugar, five grams of salt, fifteen grams of Cottolene, and three hundred grams of flour.

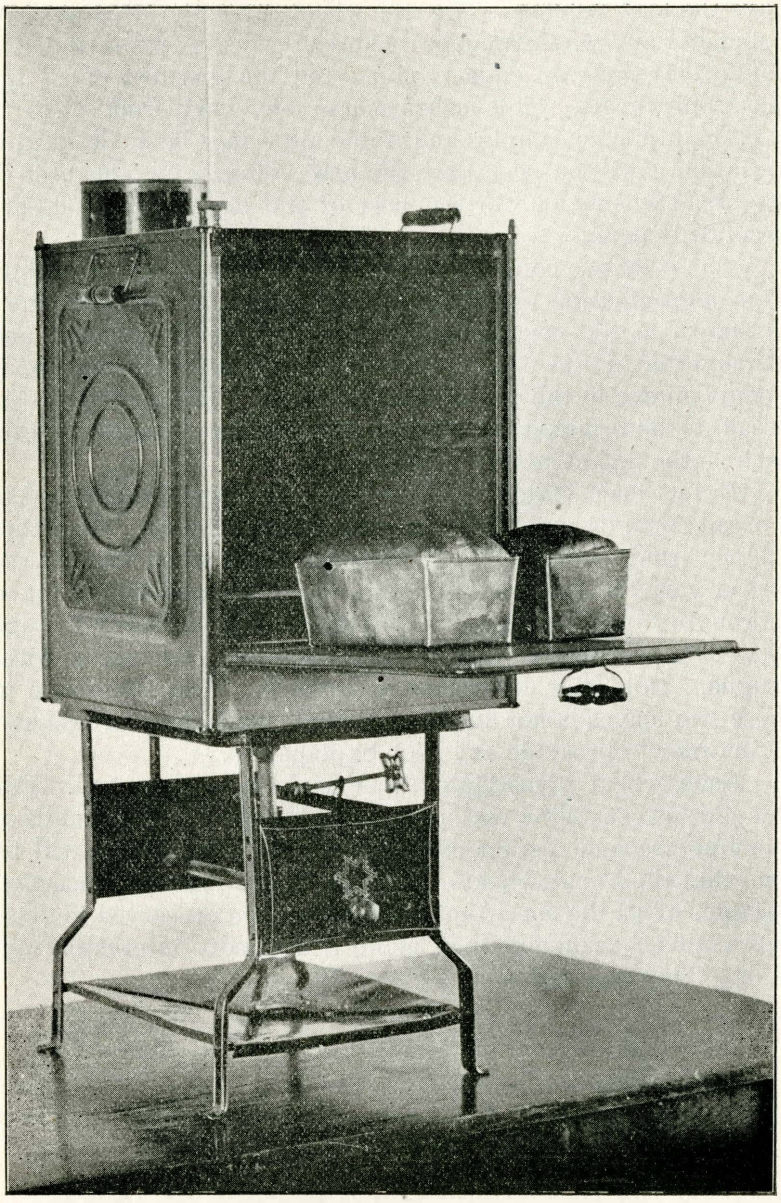
The compressed yeast, sugar and Cottolene were rubbed up in the lukewarm water, then the salt was added, after which sufficient flour was stirred in to make a smooth, stiff batter. This was then transferred to a glass mixing board and the remaining flour was kneaded in. The mixing and kneading continued for about thirty minutes, which left the dough smooth, light and soft as could be handled. It was now allowed to rise until its volume was doubled. It was now lightly kneaded, shaped and placed in a baking tin where the volume was allowed to double again. It was then placed in an oven at 240 degrees C. and baked forty-five minutes, using a somewhat lower temperature towards the last. The average temperature was about 200 deg. C.

The oven and tins used are shown in Plate II. (See Plate II, page 27.) It will be noticed that an ordinary gasoline stove was employed. But we had a thermometer inserted through the top of the oven. At the bottom an extra spreader consisting of a sheet of stove pipe iron was used. This prevented scorching, while the thermometer allowed the use of a proper temperature.

The first column in the baking test gives the weight of the baked loaf in grams. 500 grams is nearly equal to 1.1 pounds. The variations in loaf weight are due to the different quantities of water held by each flour. The heavier the loaf the better the baker likes the flour since it takes that much less flour to make the standard pound loaf. It will be noticed that all the Russian wheats averaged heavier than the bread wheats.

The next column gives the loaf volume. This was determined by placing the loaf in a tin of greater capacity than the volume of the loaf. This tin was then filled with granulated

PLATE II.



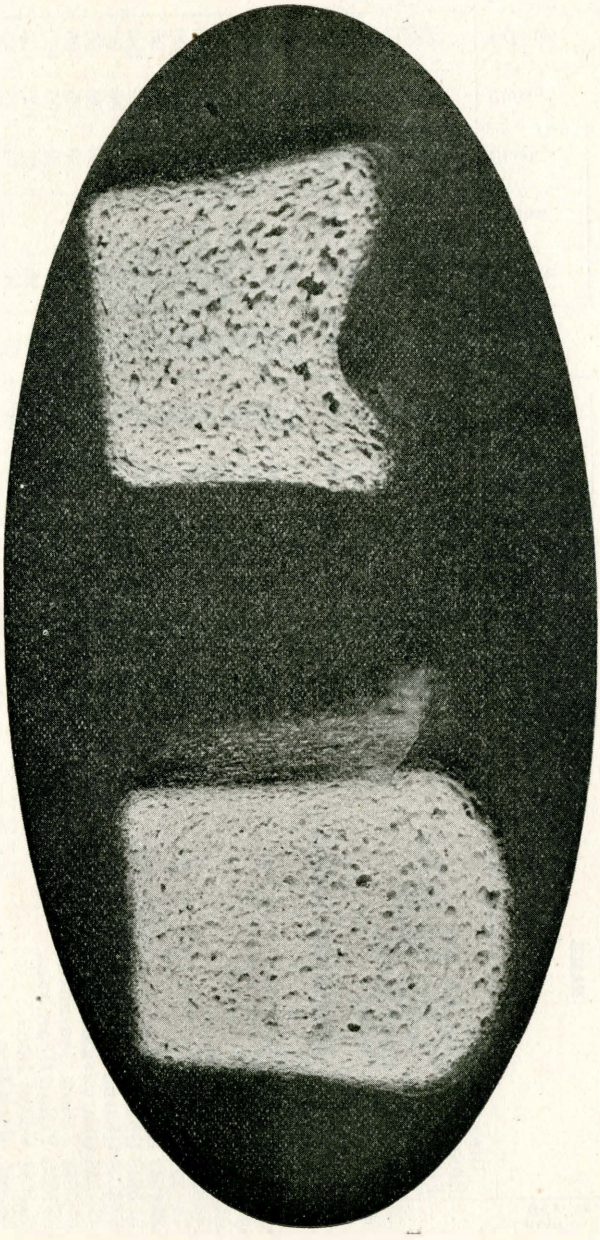
sugar, which was afterward measured in a graduated jar. Now the volume of the tin less the volume of the sugar employed gave the loaf volume. The fife wheat gave the greatest loaf volume of any wheat among the bread wheats, while the Kubanka 1354 gave an equal volume and the greatest of all the macaroni wheats. This measurement may vary from 20 to 25 c. c. on duplicate samples and if due allowance be made for this variation it will be seen that the loaf volumes for the best of the bread wheats and for the best of the Russian Durums are practically equal.

The next two columns give the color of the bread crumb. This determination will be explained farther on. The texture as shown in the next column is reckoned on the fineness and distribution of the gas cavities. The difference in texture is plainly shown in the cut on the title page. The quality of the bread is determined by taking into account several factors, such as the flavor, texture, color, etc.

It has been stated that the best macaroni wheat makes a bread equal or superior to the best bread wheats. Also that the macaroni wheats make a very poor bread when some of the poorer varieties are used. One baking illustrated this point so thoroughly that photographs were taken. (See Plate III, page 29.) The poor loaf is Realli Forte and the good one is Nicaraugua. Note the difference in texture. This difference in these two loaves is not due to accident. The tests were repeated in order to preclude any such explanation.

Each wheat investigated was made into macaroni. For this purpose semolina was used instead of flour. The details of manufacture and testing are given in Bulletin 82. It will be seen that the bread wheats make decidedly inferior macaroni. Samples of all the macaronis made have been preserved in glass jars at this Station and they make a decidedly interesting exhibit. The table follows.

PLATE III.



Sample		Baking Test						Macaroni Test					
		Loaf		Crumb				Color					
Laboratory No.	Name	Weight Grams	Volume C. C.	Color: Orange	Color: Yellow	Texture	Quality	Orange	Yellow	Black	Flavor	Texture	Quality
	Bread Wheats—												
...	Blue Stem Minn. No. 169.	460	1610	.15	.55	85	90	.70	.....	.50	60	80	75
...	Fife from No. Dak. Exp. Station...	442	1700	.20	.30	90	95	.50	.....	.40	60	85	80
...	Turkey Red—Winter Wheat.....	445	1650	.25	.35	85	90	.50	.20	.40	70	85	85
133	1514 White Eared Spring.....	442	1600	.05	.35	90	95	.50	.....	.40	70	85	85
136	1517 Ghirka Spring.....	440	1610	.10	.35	90	95	.50	.....	.40	70	85	85
	Average.....	447	1634	.15	.38	88	93	.54	.04	.42	66	84	82
	North'n or Russian Mac. Wheats—												
48	5639 Kubanka	460	1680	.25	.55	100	100	.90	.....	.40	100	100	100
69	1354 Kubanka	460	1700	.25	.50	100	100	.90	.....	.35	100	100	100
135	1516 Kubanka	470	1350	.30	.55	80	80	.90	.....	.50	90	90	90
141	1541 Kubanka	458	1510	.30	.40	85	90	1.00	.....	.50	100	90	95
154	8212 Kubanka	460	1540	.40	.40	90	95	1.00	.....	.30	100	100	100
155	8213 Kubanka	460	1550	.35	.45	90	95	.90	.....	.30	100	100	100
78	1431 Arnautka.....	470	1480	.40	.40	80	85	1.00	.....	.50	100	95	98
139	1537 Arnautka.....	465	1450	.42	.38	80	82	1.10	.....	.40	100	100	100
61	5643 Gharnovka.....	464	1480	.40	.35	80	80	1.10	.....	.50	80	90	85
63	5646 Gharnovka.....	470	1470	.38	.37	80	80	.85	.....	.50	90	95	93
142	1546 Gharnovka.....	460	1500	.40	.40	80	80	.80	.....	.50	85	95	90
60	5642 Yellow Gharnovka.....	448	1350	.35	.45	95	90	.95	.....	.40	100	100	100
156	8230 Yellow Gharnovka.....	454	1390	.40	.40	95	90	.95	.....	.40	100	100	100
49	5644 Velvet Don.....	460	1330	.40	.40	80	70	.80	.....	.70	75	85	80
62	5645 Black Don.....	455	1390	.40	.35	90	90	.90	.....	.50	95	95	95
158	8232 Black Don.....	456	1450	.40	.45	80	85	.85	.....	.65	95	85	90
67	1350 Pererodka.....	450	1500	.30	.35	100	100	.60	.....	.30	100	100	100
134	1515 Pererodka	440	1530	.30	.40	100	100	.60	.....	.35	100	100	100
65	5800 Beloturka.....	453	1610	.30	.65	90	95	.90	.....	.30	100	100	100

132	1513	Beloturka	440	1550	.35	.45	95	95	.90	.....	.30	100	100	100
53	5351	Berdiansk	458	1480	.35	.40	95	95	.90	.....	.40	100	95	98
54	5352	Novo Rossisk	430	1600	.35	.35	100	100	.90	.....	.30	100	100	100
57	5355	Tagenrog	448	1490	.20	.40	100	100	1.00	.....	.30	100	100	100
128	1508	Spring Wheat (Macaroni)	436	1500	.25	35	90	95	.90	.1	.40	100	100	100
140	1540	Chernokoloska	448	1470	.35	.40	95	90	.80	.2	.50	10.	100	100
		Average	455	1494	.34	.42	90	90	.90	.01	.42	96	97	96
		South'n or Mediterranean Mac. w't												
55	5353	Algerian	460	1500	.20	.45	90	90	.70	.10	.40	90	90	90
58	5380	Pellissier	443	1500	.20	.45	95	95	.90	.....	.40	100	100	100
149	7785	Pellissier	456	1515	.25	.35	100	100	.80	.10	.40	100	100	100
59	5492	Medeah	445	1420	.35	.40	70	75	.90	.10	.40	100	90	90
146	7579	Medeah	439	1380	.45	.40	70	70	.90	.10	.40	100	90	90
148	7581	Kahla	450	1450	.45	.35	85	85	.90	.....	.40	100	100	100
152	7794	Kahla	455	1480	.40	.35	90	90	.90	.....	.40	100	100	100
77	1428	Egyptian	445	1440	.45	.45	70	75	.90	.45	.30	100	95	98
112	1481	Ble dur	449	1250	.45	.40	50	60	1.00	....	.40	95	95	95
129	1509	Ble dur	437	1220	.45	.40	50	60	.90	.....	.40	100	95	98
130	1510	Ble dur	445	1260	.40	.45	50	90	.90	.....	.40	100	98	98
145	7578	Marouni	440	1570	.40	.40	100	95	.90	.....	.40	95	90	92
147	7580	Adjini	445	1630	.45	.35	80	85	.90	.....	.50	95	85	90
150	7792	Mahmoudi	430	1640	.35	.40	90	90	.80	....	.50	95	90	93
151	7793	Mohamed ben Bachis	429	1570	.45	.35	85	85	.90	.....	.40	95	95	95
153	7795	Richi	433	1580	.40	.40	90	95	.90	.....	.49	100	95	95
162	9130	Saragolla	452	1510	.40	.35	90	95	.80	.....	.40	100	100	100
		Average	444	1454	38	.39	80	82	.88	.05	.36	98	94	94
		Miscellaneous Macaroni Wheats—												
56	5354	Argentine	438	1430	.40	.35	85	85	.90	.....	.50	95	90	92
75	1377	Reali Forte	440	1180	.60	.30	40	50	.80	.....	.90	90	80	85
122	1492	Nicaraugua	430	1600	.30	.40	100	100	.80	.20	.30	100	100	100
123	1493	Wild Goose	434	1680	.30	.50	100	100	.80	.20	.30	100	100	100
		Average	435	1472	.40	.39	81	84	.83	.10	.50	96	93	94
		Average macaroni wheats	449	1477	.36	.41	85	87	.88	.03	.41	.97	95	96

Color Determinations.

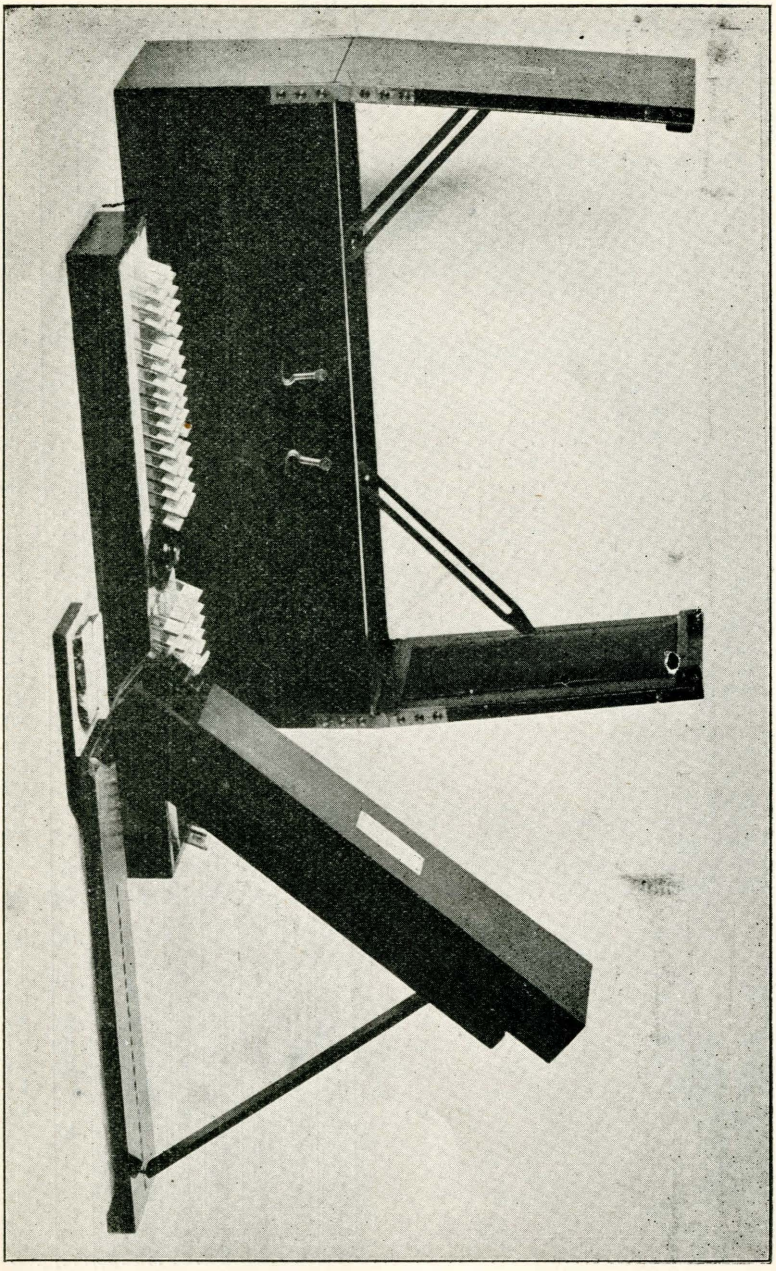
There has been much controversy over the color of macaroni flour and bread as compared with those from spring bread wheats. This fact called for a thorough investigation. In order to secure results that were standard and beyond controversy, a Lovibond Tintometer was purchased, (see Plate IV, page 33.) The color of the flour, bread crumb, semolina and macaroni were carefully determined for each variety of wheat.

This tintometer is so arranged that a tray of standard white and a tray of the flour, etc., under examination may be placed in the field at the same time. Now the color of any opaque object such as flour is due to the light or colors which it reflects. When the reflections from the standard white and from the flour are thrown into the same field a different coloring will be observed in the field of the instrument. Now a series of standard glasses are furnished with the instrument. These glasses are colored red, blue and yellow, the three primary colors. By means of these three colors any color can be matched. If therefore in the white field of the tintometer the proper colored glassed be introduced the color of the flour can be matched exactly and the whole field of the instrument will have the same color. The glasses in the different primary colors are graduated shading from the lightest perceptible tint to a more pronounced shade. A combination of the three primary colors on transmitted light will absorb all colors producing black.

It was found that the color of a flour depended largely upon its fineness. The finer the flour the lighter is its color. This may account for some contradictory statements concerning the color question. This fact is brought out strikingly by comparing the color of the flour with that of the coarser semolina.

The table which follows needs no further explanation :

PLATE 1V.



COLOR TABLE.

Laboratory No.	Sample — Name	Flour — Yellow	Flour — Orange	Bread — Yellow	Bread — Orange	Semolina — Yellow	Semolina — Orange	Macaroni — Black	Macaroni — Yellow	Macaroni — Orang
	Bread Wheats—									
...	Blue Stem, Minn. No. 169	.20	.05	.55	.15	.30	15	.50	...	.70
...	Fife, from North Dakota Exp. Station	.20	.05	.30	.20	.15	.20	.40	...	.50
...	Turkey Red, Winter Wheat	.10	.15	.35	.25	.20	.20	.40	...	.50
133	1514 White Eared Spring	.18	.02	.35	.05	.20	.15	.40	...	.50
136	1517 Ghirka Spring	.20	...	.35	.10	.15	.20	.40	...	.50
	Average	.18	.05	.38	.15	.20	.18	.42	.04	.54
	Northern or Russian Macaroni Wh'ts									
48	5639 Kubanka	.28	.02	.55	.25	.40	.30	.40	...	.90
69	1354 Kubanka	.28	.02	.50	.25	.35	.30	.35	...	.90
135	1516 Kubanka	.27	.18	.55	.30	.40	.35	.50	...	.90
141	1541 Kubanka	.23	.12	.40	.30	.45	.35	.50	...	1.00
154	8212 Kubanka	.22	.08	.40	.40	.35	.35	.30	...	1.00
155	8213 Kubanka	.25	.15	.45	.35	.40	.30	.30	...	.90
78	1431 Arnautka	.30	.15	.40	.40	.35	.40	.50	...	1.00
139	1537 Arnautka	.27	.18	.38	.43	.35	.40	.40	...	1.10
61	5643 Gharnovka	22	.18	.35	.40	14	.46	.50	...	1.10
63	5646 Gharnovka	.25	.15	.37	.38	.30	.40	.50	...	.85
142	1546 Gharnovka	.22	.18	.40	.40	.20	.45	.50	...	.80
60	5642 Yellow Gharnovka	.31	.14	.45	.35	.35	.40	.40	...	.95
156	8230 Yellow Gharnovka	.25	.10	.40	.40	.40	.30	.40	...	.95
49	5644 Velvet Don	.25	.20	.40	.40	.30	.40	.70	...	.80
62	5645 Black Don	.28	.12	35	.40	.40	.35	.50	...	.90
158	8232 Black Don	.24	.16	.45	.40	.30	.30	.65	...	.85
67	1350 Pererodka	.25	.10	.35	.30	.35	.30	.30	...	.60
134	1515 Pererodka	.20	.10	.40	.30	.40	.20	.35	...	.60
65	5800 Beloturka	.27	.13	.65	.30	.40	.30	.30	...	.90
132	1513 Beloturka	.28	.12	.45	.35	.30	.35	.30	...	.90
53	5351 Berdiansk	.27	.18	.40	.35	...	.60	.40	...	.90
54	5352 Novo Rossisk	.25	.10	.35	.35	.30	.35	.30	...	.90
75	5355 Tagenrog	.20	.20	.40	.20	.35	.40	.30	...	1.00
128	1508 Spring Wheat (macaroni)	.25	.15	.35	.25	.30	.45	.40	.10	.90
140	1540 Chernokoloska	.15	.35	.40	.35	.35	.40	.50	.20	.80
	Average	.25	.14	.42	.34	.33	.37	.42	.01	.90
	Southern or Mediterranean Mac. Whe'ts									
55	5353 Algerian	.25	.20	.45	.20	.20	.40	.40	.10	.70
58	5380 Pellissier	.25	.15	.45	.20	.20	.40	.40	...	.90
149	7785 Pellissier	.23	.12	.35	.25	.15	.40	.40	.10	.80
59	5492 Medeah	.15	125	.40	.35	.25	.40	.40	.10	.90
146	7579 Medeah	.20	.20	.40	.45	.20	.40	.40	.10	.90
148	7581 Kahla	.25	.20	.35	.45	.20	.40	.40	...	.90
152	7794 Kahla	.20	.20	.35	.40	.20	.45	.40	...	.90
77	1428 Egyptian	.25	.20	.45	.40	.40	.40	.30	.45	.90
112	1481 Ble dur	.25	.20	.40	.45	.20	.45	.40	...	1.00
129	1509 Ble dur	.25	.20	.40	.45	.25	.35	.40	...	.90
130	1510 Ble dur	.20	.25	.45	.40	.30	.40	.40	...	.90
145	7578 Marouni	.20	.30	.40	.40	.25	.50	.40	...	.90
147	7580 Adjini	.20	.25	.35	.45	.30	.30	.50	...	.90
160	7792 Mahmoudi	.20	.25	.40	.35	.25	.40	.50	...	.80

COLOR TABLE—Concluded.

Laboratory Number	Sample — Name	Flour		Bread		Semolina		Macaroni		
		Yellow	Orange	Yellow	Orange	Yellow	Orange	Black	Yellow	Orange
151	7793 Mohamed ben Bachis	.20	.25	.35	.45	.30	.40	.40	...	.90
153	7795 Richi	.20	.25	.40	.40	.20	.35	.40	...	.90
162	9130 Saragolla	.20	.20	.35	40	.35	.40	.40	..	.80
	Average	.22	.22	.39	.38	.25	.40	.36	.05	.88
	Miscellaneous Macaroni Wheats –									
56	5354 Argentine	.20	.15	35	.40	20	.30	.50	...	.80
75	1377 Reali Forte	.22	.18	.30	.60	.20	.30	.90	...	.80
122	1492 Nicaraugua	.20	.15	.40	.30	.30	.30	.30	.40	.80
123	1493 Wild Goose	.25	.15	.50	.30	.35	.30	.30	.20	.80
	Average	.22	.16	39	.40	.26	.30	.50	.10	.83
	Average of Macaroni Wheats	.24	.17	.41	.36	.29	.35	.41	.03	.88

The Effect of Soil and Climate on Total Protein.

The next table deals with the total protein in the whole wheat as grown from year to year in this state. The computations are made on the water free wheat.

It is of importance to know how the total protein will be affected by a change of habitat in the case of wheats. It must be remembered that these wheats have been brought from long distances. When such great changes of habitat are brought about it is quite possible that a change either toward diminution or increase will ensue. Therefore analyses have been made each year to note any changes that might occur. Where possible the original seed was also analyzed. The table which follows explains itself. We have nothing to fear so far as protein diminution is concerned. The Kubanka 5639 rather shows an increase. In studying the table it must not be forgotten that an unfavorable season tends to lower the protein content while a favorable season tends toward higher results.

The table follows:

SOIL AND CLIMATIC EFFECT ON PROTEIN.

Laboratory Number	Sample Name	Year Grown: Imported Seed	1901 Brookings	1901 Mellette	1902 Brookings	1902 Mellette	1903 Highmore
	Northern or Russian Macaroni Wheats						
48	5639 Kubanka	14.1	18.75	.....	13.97	14.36	15.90
69	1354 Kubanka	.....	19.72	19.89	.....	.....	16.07
135	1516 Kubanka	.....	.....	20.86	.....	.....	16.47
141	1541 Kubanka	.....	20.12	20.06	.....	.....	16.59
154	8212 Kubanka	15.28	.....	.....	12.65	17.90	15.90
155	8213 Kubanka	18.92	.....	.....	12.37	17.44	16.70
78	1431 Arnautka	.....	20.46	20.46	15.05	.....	16.13
139	1537 Arnautka	.....	18.87	21.89	13.85	.....	16.59
61	5643 Gharnovka	.....	18.35	20.24	12.14	17.21	16.87
63	5646 Gharnovka	.....	18.35	21.03	13.34	17.16	16.93
142	1546 Gharnovka	.....	20.86	21.72	.....	.....	18.41
60	5642 Yellow Gharnovka	.....	19.49	20.35	12.54	18.13	15.79
156	8232 Yellow Gharnovka	18.64	.....	.....	12.94	14.02	15.11
49	5644 Velvet Don	15.05	16.59	.....	13.79	14.71	15.68
62	5645 Black Don	.....	20.12	20.46	13.34	17.56	17.16
158	8232 Black Don	18.01	.....	.....	12.37	14.31	18.24
67	1350 Pererodka	.....	18.13	19.84	.....	.....	15.68
134	1515 Pererodka	.....	20.41	21.20	14.25	14.93	16.30
65	5800 Beloturka	.....	16.64	20.15	13.34	14.65	17.21
132	1513 Beloturka	.....	20.41	21.88	.....	.....	17.10
53	5351 Berdiansk	.....	19.04	19.95	12.71	17.04	17.39
54	5352 Novo Rossisk	.....	19.61	22.12	16.19	17.44	17.21
57	5355 Tagenrog	.....	17.10	22.29	14.99	14.71	18.35
128	1508 Spring Wheat (macaroni)	.....	19.61	22.00	.....	.....	17.33
140	1540 Chernokoloska	.....	19.95	21.32	.....	.....	17.16
	Southern or Mediterranean Wheats—						
55	5353 Algerian	.....	18.58	22.40	13.91	17.78	18.47
58	5380 Pellissier	.....	18.58	24.11	14.25	15.79	18.30
149	7785 Pellissier	.....	.....	.....	16.42	16.70	18.47
59	5492 Medeah	.....	16.93	19.67	15.90	15.62	17.16
146	7579 Medeah	.....	.....	.....	15.85	15.22	16.42
148	7581 Kahla	.....	.....	.....	16.70	17.67	19.10
152	7794 Kahla	.....	.....	.....	17.78	15.62	19.38
77	1428 Egyptian	.....	20.75	19.95	.....	14.36	16.47
112	1481 Ble dur	.....	18.64	21.26	.....	16.07	17.04
129	1509 Ble dur	.....	21.49	22.29	.....	.....	16.82
130	1510 Ble dur	.....	21.77	20.69	.....	.....	17.44
145	7578 Marouni	.....	.....	.....	15.90	17.16	18.47
147	7580 Adjini	.....	.....	.....	16.53	15.33	18.87
150	7792 Mahmoudi	.....	.....	.....	16.53	14.93	17.78
151	7793 Mohamed ben Bachis	.....	.....	.....	16.36	14.31	17.78
153	7795 Richi	.....	.....	.....	17.04	16.30	20.12
162	9130 Saragolla	13.28	.....	.....	.....	.....	19.72
	Miscellaneous Macaroni Wheats—						
56	5354 Argentine	.....	17.61	22.06	12.88	17.56	18.30
75	1377 Reali Forte	.....	19.89	21.20	16.30	18.07	18.35
122	1492 Nicaraugua	.....	19.32	22.74	.....	14.99	17.27
123	1493 Wild Goose	.....	19.72	22.52	13.97	15.90	17.73

Gliadin in Flour.

A few gliadin determinations were made in order to see if the results obtained in the baking tests conformed with the theory that from 55 to 65 per cent. of the total protein should be gliadin for a good baking flour. The method employed was the extraction by alcohol and polarization method as recommended by Snyder. By comparing the gliadin results with the baking tests it will be seen that a coincidence does exist and that an absence of gliadin will probably account for the poor baking qualities of some of the macaroni wheats. If this be true, and it probably is, the uselessness of trying to improve these poor wheats at once becomes apparent. The fault is a deep seated one peculiar to the variety and for which there is no remedy.

GLIADIN IN FLOUR.

	Per Cent. Gliadin in Flour	Per Cent. Gliadin of Total Protein
Blue Stem, Minn. No. 169	8.28	66.8
1354 Kubanka	8.53	59.1
1515 Pererodka	7.53	53.4
1537 Arnautka	7.02	48.0
8230 Yellow Gharnovka	6 02	44.9
1546 Gharnovka	7.78	48.6
5644 Velvet Don	6.27	45.1
8232 Black Don	7.78	49.4
1513 Beloturka	7.52	51.5
5355 Tagenrog	8.03	51.8
5351 Berdiansk	7.52	50.4
1377 Reali Forte	7.52	49.8

About 85 per cent. of the proteids of flour consist of gliadin, the sticky binding material found in gluten and glutenin, which aids little in giving tenacity to the dough. A good baking flour should have 55 to 65 per cent. of its total gluten in the form of gliadin.

In conclusion it was thought best to add a quantitative analysis of the best variety of macaroni wheat, Kubanka 5639, and for comparison that of Minnesota No. 169, one of the best of the Blue Stems. Note that the Blue Stem has a greater per cent. indigestible fibre and that the Kubanka carries more sugar, which accounts for the sweeter bread.

PROXIMATE ANALYSIS OF KUBANKA 5639 AND BLUE STEM MINNESOTA NO. 169.

	Air Dry Substance—Per Cent.		Water Free Substance—Per Cent.	
	Kubanka	BlueStem	Kubanka	BlueStem
Moisture	9.32	6.00	.....	.....
Ash	1.71	2.46	1.89	2.62
Ether extract	2.34	2.49	2.58	2.65
Crude fiber	2.52	3.35	2.78	3.56
Crude protein (N X 5.7)	14.46	13.21	15.95	14 08
Nitrogen—free extract	69.65	72.49	76.80	77.09
Total nitrogen	2.53	2.32	2 79	2.47
Albuminoid nitrogen.	2.11	1.91	2.33	2.03
Soluble carbohydrates				
Starch	.....	.....	.....	.....
Reducing sugar	.....	.....	.....	.....
Sucrose	3.26	1.52	3.58	1.61

The writer wishes to acknowledge his indebtedness to his assistants, Messrs. Norton and Hepner. The latter is now connected with the Wyoming Station. As in the previous work recorded in Bulletin No. 82 of this Station, Mr. Hepner made most of the nitrogen determinations, while Mr. Norton has been more closely occupied with the baking and macaroni tests. But much of the work was done conjointly. The careful and painstaking work of these two young men have made it possible to bring this laborious work to a successful completion within the allotted time.