Time.	After June drop.	Hardening of stone.	Market ripe.
Sucrose, grams	0.01	0.16	3.94
Acid as H_2SO_4, grams	0.018	0.044	0.379
Nitrogenous bodies, grams.	0.060	0.099	0.181
Albuminoids,[1] grams	0.047	0.075	0.140
Amido bodies,[2] grams	0.013	0.023	0.041
Ash, grams	0.046	0.083	0.227

TABLE III.—COMPOSITION OF THE FLESH OF PEACHES AT MARKET RIPENESS AND AT FULL RIPENESS.
(Percentage of Total Solids.)

Serial No.	Variety.	Date. 1904.	Marc.	Reducing sugar.	Sucrose.	Acid as sulphuric.	Albuminoids.	Amido bodies.	Total nitrogenous bodies.	Ash.
			Market ripe.							
11248	Elberta	Aug. 25	18.71	14.42	41.85	3.34	.....	.....	.....	3.56
11295	Orange smock	Sept. 21	18.65	14.10	35.02	3.95	1.86	0.54	2.40	.....
11249	Stump	Aug. 25	17.70	13.04	40.77	3.24	.....	.....	.....	3.54
			Full ripe.							
11258	Elberta	Aug. 30	12.80	12.15	47.81	2.89	.....	.....	.....	3.28
11298	Orange smock	Sept. 26	17.05	17.49	46.07	3.37	1.82	0.374	2.19	.....
11250	Stump	Aug. 25	12.96	12.50	43.04	2.60	.....	.....	.....	3.43
Average, market ripe			18.35	13.85	39.21	3.51	.....	.....	.....	.....
Average, full ripe			14.28	14.05	45.64	2.95	.....	.....	.....	.....

A STUDY OF DURUM WHEAT.

BY F. A. NORTON.

Received June 5, 1905.

THE Departments of Agronomy and Chemistry of this station have been carrying on an extensive investigation of the so-called macaroni wheats during the past four years.

This variety of wheat, *Triticum durum*, is largely grown in the Mediterranean regions and on the plains of Southern Russia and Siberia, also to some extent in Argentine and India. It was recently imported for trial, especially in the semi-arid parts of the middle West, by the agricultural explorers of the Department of Agriculture. In the past France and Italy have consumed the greater part of the macaroni wheat produced, the wheat being used largely in the manufacture of macaroni, but to some extent as a

[1] By Stutzer method—albuminoid nitrogen, times 6.25.

[2] Amido nitrogen, times 4.25.

bread wheat. If adapted to our soil and climate it was thought that these wheats might afford a cereal for the areas of low rainfall of this country; that they might stimulate the manufacture of macaroni in the United States and enable us to compete with other countries in the supply of durum wheats to France and Italy.

The work of this station has been in collaboration with that of other stations and the Department of Agriculture to ascertain the adaptability of these wheats to this country. The Department of Agronomy has carried on field tests and cross-breeding work with nearly one hundred different samples, representing all the important varieties of the durum wheats. The cross-breeding work has not yet developed any important modifications, but the field tests have demonstrated their adaptability for the more arid portion of this and neighboring states. In those portions of the state having an annual rainfall of twenty inches or more, results have been less gratifying, though the macaroni wheats seem to be more rust-resistant.[1]

The Department of Chemistry of this station first took up nitrogen control investigations to determine whether the high protein content would persist under our climatic and soil conditions, and later took up milling, bread and macaroni tests. The milling tests were made by Prof. J. H. Shepard, who has had the direction of the chemical work. The nitrogen control determinations and determinations for nitrogen content of the mill products have been made by Mr. Hepner, now connected with the Wyoming station. The bread, macaroni and gluten tests have been the work of the writer, also the color determinations and other work recorded in this paper.

The Wheat.—The durum wheats have a very large kernel, the grains being nearly twice as large as those of the ordinary bread wheats. They are hard, of an amber color, and, when plump, appear almost translucent; they yield well and grade heavy, the yield usually being from one-third to one-half more than that of the best bread wheats. The drought-resistant qualities are shown by the crop of 1903, grown at the substation at Highmore, S. Dak.,[2] where the rainfall for the year was only fifteen inches. The average yield for all of the durum wheats grown at the substation that season was 14.7 bushels per acre, while the maximum yield was

[1] Lessons from Grain-rust Epidemic of 1904, Farmer's Bulletin, No. 219. U. S. Dept. of Agr.

[2] Report of Investigations at Highmore Substation for 1903, Bulletin No. 84, S. D. Expt. Station.

20.2 bushels per acre, and several of the best wheats gave a yield of from 18 to 20 bushels. The bread wheats the same season and at the same place produced only 4 or 5 bushels per acre. The durum wheats were of excellent quality, five of the best of the crop of 1903 giving an average grade of 62.3 pounds per bushel, while five bread wheats of exceptional quality, such as Fife and Blue Stem, milled for control, in the milling, bread and macaroni tests, graded only 59.9 pounds per bushel.

Mill Products.—The milling tests were made on a miniature Allis-Chalmers mill, provided with corrugated and smooth rolls and bolting arrangement. Power was furnished by a gasoline engine. No middlings purifier was used and the mill products were separated only into bran, shorts and straight flour.

Reduction was first made on the corrugated roll and completed on the smooth roll. That portion which remained on a 30-mesh sieve after complete reduction was taken off as bran. The portion passing through a 30-mesh sieve, but remaining on a No. 12 bolting-cloth, was returned as shorts, while the portion passing through the cloth was taken as the flour yield. These conditions gave very satisfactory results for total flour yield and would compare favorably with commercial milling for straight flour.

There were very marked differences as to the milling properties of different wheats. All of the durum varieties were somewhat harder to mill than the bread wheats and some were very difficult of reduction. The Russian varieties, however, were easier to mill, possessed thinner skins and gave larger flour yields than those from the Mediterranean region or from miscellaneous sources. The following table gives the comparative yield of mill products, 500 grams of wheat being used for each quantitative milling test:

MILL PRODUCTS.

	Number of analyses.	Bran. Per cent.	Shorts. Per cent.	Flour. Per cent.	Error. Per cent.
Macaroni wheats.....	45	20.48	17.93	61.60	+0.01
Bread wheats.....	5	20.40	10.56	68.56	—0.48
Best Russian wheats[1]	5	15.91	16.25	67.60	+0.24

Proximate Analysis.—In order to determine more definitely the general composition of the durum wheats as compared with the bread wheats, a proximate analysis of one of the best Russian wheats (Kubanka 5639) and one of the best bread wheats (Blue Stem, Minnesota, No. 169) was made. The determinations were

[1] Kubanka, Pererodka, Arnanka, Beloturka, and Yellow Gharnovka which will be referred to on other occasions as the five best durum wheats for the Great Plains Region.

carried out in duplicate according to the Official Methods of the Association of Official Agricultural Chemists.[1] In the following table may be found the results of the analysis, together with the mean of domestic wheats, as published by the Bureau of Chemistry of the Department of Agriculture:[2]

PROXIMATE ANALYSIS.

	Kubanka. Per cent.	Blue Stem. Per cent.	Mean of domestic wheats. Per cent.
Moisture	9.32	6.00	10.62
Ash	1.71	2.46	1.82
Fat or ether extract	2.34	2.49	1.77
Crude fiber	2.52	3.35	2.36
Crude protein, N×5.7[3]	14.46	13.21	12.23
Carbohydrates other than crude fiber	69.65	72.49	71.18

Soluble Carbohydrates.—On account of the sweetness of the macaroni wheat products determinations of dextrine and sugar were made on Kubanka 5639, and of sugar on Blue Stem, Minnesota, No. 169. The method of the Association of Official Agricultural Chemists[4] was used for the sugar determination, with the exception that after inversion the sugar was determined by the Defren-O'Sullivan method,[5] the sugar being calculated from the cupric oxide by the factor 0.4307. As thus determined, the Kubanka gave 3.26 per cent. of sugar and the Blue Stem 1.42 per cent., invert sugar and soluble starch being absent in both wheats. Dextrin was determined according to the Stone method[6] and a content of approximately 1.25 per cent. was found for Kubanka. There are not many sugar or dextrin determinations on wheats recorded. Villier and Collin, however, in their summary of cereal products, give the sugar content of whole wheat as 1.45 per cent., while Stone[6] reports 0.52 and 0.72 per cent. of sucrose, and 0.27 and 0.41 per cent. of dextrin on two whole wheats analyzed. This would indicate a much higher sugar and dextrin content for the durum wheats than for the bread wheats.

Flours carry somewhat less sugar than the whole wheat. Stone[6] records 0.18 and 0.20 per cent. on two samples of flour analyzed, while determinations by Krug and Wiley[7] would show that 0.3

[1] Bulletin No. 46, pp. 23–24, Bureau of Chemistry, U. S. Dept. of Agr.

[2] Bulletin No. 13, Part 9, p. 1186, Bureau of Chemistry, U. S. Dept. of Agr.

[3] For use of N × 5.7 see Bulletin 13, Part 9, p. 1191, Bureau of Chemistry, U. S. Dept. of Agr.

[4] Bulletin No. 46, p. 24, Bureau of Chemistry, U. S. Dept. of Agr.

[5] This Journal, 18, 749.

[6] Bulletin 34, Office of Experiment Stations, Dept. of Agr.

[7] Bulletin 13, Part 8, Bureau of Chemistry, U. S. Dept. of Agr.

per cent. is the maximum for most bread wheat flours. However, corrections necessary in the gliadin determinations would indicate that the macaroni wheat flours contain from 1 to 2 per cent. of sugar as sucrose.

Protein Content and Nitrogen Control.—The protein content of durum wheats is very high and as wheats have been shown[1] to be extremely susceptible to changes of soil and climate in regard to this most important constituent of wheats, as concerns food and milling values, nitrogen determinations have been made each year on the whole wheat to ascertain whether the protein content would persist under our soil and climatic conditions.

In the following table the trend of the protein content is shown, the results being calculated to the water-free basis:

PROTEIN CONTENT.

	Number of analyses.	Protein, N × 5.7. Per cent.
Imported seed	7	15.73
Crop of 1901	31	18.13
Crop of 1902[2]	32	14.57
Crop of 1903	45	17.34

FLOUR.

Color, protein, gluten and gliadin determinations, also baker's sponge test and baking tests were made on the flour from the various wheats. For this purpose straight flour, milled by Prof. Shepard, was used, both with the bread and durum wheats.

Color.—Durum wheats possess a yellow coloring principle, which gives a more or less noticeable color to all their products. This coloring-matter, very characteristic of the macaroni wheats, might perhaps be used as a test for identity of macaroni wheat flours. The color it imparts to macaroni is used by experts as one of the criteria of quality. It gives to alcohol and ether extracts of the flour a beautiful, deep yellow color. This principle is insoluble in distilled water, but is somewhat more readily soluble in dilute alkalies than in alcohol or ether, while it is discharged from solution by acids and precipitated by lead subacetate and some other salts.

Color determinations on the flour from the various wheats gave the following results, which show the macaroni flours to have rather more color than bread wheat flours. The determinations

[1] Bulletin No. 13, Part 9, p. 1118, Bureau of Chemistry, U. S. Dept. of Agr.

[2] A very unfavorable year for macaroni wheat.

were made by means of a Lovibond tintometer and expressed in units of yellow and orange.

COLOR OF FLOURS.

	No. of tests.	Yellow.	Orange.
Bread wheat flours	5	0.18	0.05
Durum wheat flours	45	0.25	0.17
Best durum wheat flours	5	0.25	0.11
Patent macaroni wheat flours[1]	2	0.20	0.10

Protein.—The protein content of the durum wheat flour, as milled, in all cases approximated very closely to that of the whole wheat. The following table will give a comparison between the flours of the durum and the bread wheats.

PROTEIN CONTENT OF FLOUR.

	No. of analyses.	Protein air-dry. Per cent.
Bread wheat flours	5	12.66
Macaroni wheat flours	45	15.00
Best Russian wheat flours	5	14.51
Mean of domestic flours[2]	..	9.30

It is evident from the above that the protein content of the macaroni wheat flours is considerably larger than that of the bread wheat flours, and a simple calculation from the mill products and protein content shows that five of the best durum wheat flours contain 10.08 pounds of protein in 100 pounds of flour as against 8.69 pounds of protein in 100 pounds of flour from the five bread wheats milled.

Gluten.—The amount and quality of the gluten has a very important bearing upon a flour as to bread-making qualities. In all the durum wheats the gluten content is large, but the quality is not as good as that of the bread wheat flours. The gluten of many of the flours showed very poor adhesive qualities and was, with difficulty, collected on washing out the starch in the gluten tests. It also seemed lacking in elasticity, both of which characteristics would indicate a deficiency of gliadin. The gluten determinations were made by the method outlined by Wiley.[3] The results with the mean given by Wiley[4] for American wheat flours follow:

[1] One milled by Farmer's Mill and Grain Co., Milnor, N. D., and the other by the Brookings Roller Mill, Brookings, S. D.

[2] Bulletin No. 13, Part 9, Bureau of Chemistry.

[3] "Principles and Practice of Agricultural Analysis," Vol. III, p. 435.

[4] Bulletin No. 13, Part 9, p. 1186, Bureau of Chemistry, U. S. Dept. of Agr.

GLUTEN CONTENT.

	No. of determinations.	Moist gluten. Per cent.	Dry gluten. Per cent.	Water held by 1 gram dry gluten. Grams.
Bread wheat flours	5	45.99	14.82	2.10
Macaroni wheat flours	45	53.77	17.68	2.04
Best macaroni wheat flours	5	51.20	16.94	2.02
Macaroni patent flours	2	48.40	13.38	1.87
Mean for domestic flours		26.50	10.25	1.58

Gliadin in Flour.—Osborne and Voorhees have shown the importance of this proteid and state[1] that upon it the formation of the gluten largely depends. Snyder emphasizes the same point and suggests[2] that a flour to possess good bread-making qualities should contain 11 per cent. of protein ($N \times 5.7$) and that from 55 to 65 per cent. should be in the form of gliadin. Snyder also states[3] that while poor bread-making qualities may be due to other causes than either an excess or a deficiency of gliadin, that it is, however, due more frequently to an unbalanced condition of the gluten than to any other cause. Fleurent[4] gives the limits of gliadin as 32 to 60 per cent. of the gluten, which constitutes from 85 to 90 per cent. of the total proteids and states that when there is an excess of glutenin and consequently a deficiency of gliadin the dough neither rises during the fermentation nor in the oven, and the bread is heavy and indigestible. This is the case of the bread made from many of the poorer durum wheat flours, and hence the gliadin determinations are of special interest.

The determinations were made by the method recently proposed by Snyder.[5] However, it was necessary to precipitate the gliadin with mercuric nitrate and make corrections for sucrose, which has been shown to be present in considerable quantity in the durum wheats. The corrections varied from 0.7 to 1.8 per cent. on the sugar scale of a Schmidt and Haensch polariscope. The results on ten durum flours are summarized below:

GLIADIN DETERMINATIONS—WATER-FREE BASIS.

	Gliadin nitrogen. Per cent.	Gliadin $N \times 5.7$. Per cent.	Gliadin of total protein. Per cent.
Maximum	1.51	8.61	50.00
Minimum	1.04	5.93	35.74
Average five best durum wheats	1.38	7.87	47.17

[1] "The Proteids of the Wheat Kernel," pp. 78-79.
[2] This Journal, **26**, 266.
[3] Bulletin No. 85, Minn. Expt. Sta.
[4] Manual l'Analyse Chimique, 1898, pp. 308-314.
[5] Bulletin No. 85, Minn. Expt. Sta.

Baker's Sponge Test.—This test gives valuable information as to the water-absorption capacity of a flour and the strength of the dough, or its ability to rise. The test is made in bakeries in order to determine the value of strong and weak flours when it is desired to blend them for baking purposes. It also indicates the amount of water necessary to use for the sponge. The method[1] employed was that followed at the Minnesota Experiment Station in their work on wheats. The tests show the time required and the volume of a dough from a given amount of flour at its maximum expansion. On breaking, the dough is again allowed to rise and the results recorded are the average of the first and second rises.

BAKER'S SPONGE TEST.

	No. of tests.	Av. time of rise. Minutes.	Av. vol. of rise. cc.	Av. rise for each gram dry gluten. cc.	Water held by dough from 100 grams flour. Grams.
Bread wheat flours	5	80	652	44.00	77.4
Macaroni wheat flours	45	66	596	33.76	77.1
Best Russian wheat flours	5	72	670	39.45	79.1
Macaroni patent flours	2	64	650	48.60	76.0

The above results would indicate that the larger gluten content makes up for the poorer quality of the gluten of the durum wheats. In fact, the five best durum wheat flours give a somewhat greater average expansion than the five bread wheat flours, though the expansion for each gram dry gluten is considerably less.

Baking Tests.[2]—Macaroni wheat flour seems to have a greater tendency to hydrolyze and become sticky than bread wheat flours and must be treated more like whole wheat flour than like our best patent flours. This is true even of patent macaroni wheat flours. Also, if kneaded a little too stiff the dough does not rise properly and the bread is heavy, of poor texture, and very dark-colored. In the baking tests 300 grams of flour, 15 grams of cottolene, 10 grams of sugar, 5 grams of salt, 1 cake of compressed yeast, and water, according to the sponge test, were used. The sugar, yeast and cottolene were mixed in a porcelain dish in the amount of lukewarm water indicated by the sponge test. When the yeast became active the salt was added and flour stirred in with vigorous

[1] Annual report, 1899, p. 350. Minnesota Experiment Station.

[2] The writer is indebted to Miss Ruth Wardall, Professor of Domestic Science in the South Dakota Agricultural College, for valuable assistance in determining the best method of treating macaroni wheat flour for bread-making. Also the following studies on bread have been found very helpful: "Chemistry of Wheat, Flour and Bread, and Technology of Bread Making," Jago. "Bread and Principles of Bread Making," Helen Atwater. "Studies on Bread and Bread Making," Voorhees and Snyder. Also the later "Study on Bread and Bread Making," by Snyder.

mixing until a dough that could be kneaded was secured. The dough was then transferred to a plate glass slab and the rest of the flour kneaded in. The sponge was placed in a warm place and when it had doubled its volume was again kneaded slightly, shaped and placed in a baking-tin. When the loaf had doubled in volume it was placed in an oven at 220° C., after fifteen minutes the heat was increased to 230° to 240° C., and after fifteen minutes more allowed to fall to 200° C., forty-five minutes being required for baking. The bread was then removed from the tins and allowed to cool in free access of air. The process, as above described, usually required five hours. The volume and weight of each loaf were determined about three hours after baking, and color, texture, and flavor about eighteen hours after baking. The tests, being made on straight flours, were a severe trial of the bread-making qualities of the durum wheats, for a straight flour contains not only the first and second patents, but also the lower-grade flours, which, as pointed out by Woods and Merrill[1] and other investigators, are much darker and greatly inferior in quality of gluten. However, the tests were comparative and very satisfactory.

RESULTS OF BAKING TESTS.

	No. of tests.	Volume. cc.	Weight. Grams.	Color. Yellow.	Color. Orange.
Bread wheat flours	5	1630	447	0.38	0.15
Macaroni wheat flours	45	1480	449	0.50	0.40
Best macaroni wheat flours	5	1580	455	0.51	0.28
Patent macaroni wheat flours	2	1650	430	0.45	0.20

It will be seen from the above that the durum wheat breads have rather more color. All breads tend to be much darker, if not perfectly light and the macaroni breads are no exception, but, if well made and light, durum wheat breads have a fine light cream color, only slightly more pronounced than that of bread wheats. The color is pleasing and should not be objectionable to any one. In volume, weight and texture the best durum wheat breads compare favorably with those from the best bread wheats, in fact, the writer has seldom seen a much finer texture in bread than that yielded by some of the best macaroni wheat flours. The flavor of the macaroni wheat bread is decidedly pleasing and, personally, we would pronounce it superior to that of the bread from the regular bread wheat flours. On account of the higher protein content

[1] Bulletin No. 103, p. 69, Maine Experiment Station.

the breads are more nutritious and should offer a very desirable addition to the dietary of the people of the United States.

MACARONI.

Macaroni, when correctly prepared, is an excellent food and it only remains for a really first-class article to be produced, and a proper appreciation of its food value, for the consumption to be greatly increased in the United States.

Italy, and later France, have been the first countries to use macaroni to any great extent as a food. As to the increase of the consumption of macaroni in France, Robert P. Skinner, Consul-General at Marseilles, quotes[1] M. Scaramelli, an important macaroni manufacturer, as follows:

"In 1866, when I first traveled about the country selling the output of our then small factory, I once reached the village of the Grande Combe where I found that the only dealer in macaroni was the local druggist, who said that he bought 25 pounds per annum, which was sold exclusively for consumption by invalids. At the present time the same village takes 25,000 pounds of macaroni per month, which is sold to practically every family in the place. It has become a staple article of diet. In the city of Marseilles the consumption has tripled in twenty-five years."

In visiting a number of the most important factories in the United States the writer found that most of the domestic macaroni was made from bread wheat flour and that since there was a prejudice against the domestic brands most manufacturers were putting out their best grade under their own label, and their second-class goods, which constitutes the larger part of their product, under foreign labels. As a result, and also on account of the shipping and storing of the imported macaroni, a poor article is often secured and the use of macaroni tends to be discredited.

Macaroni should be manufactured from semolina, a coarse granular flour, varying degrees of fineness being used. If the semolina is crushed to a powder[2] it is so separated that what macaroni manufacturers call its "force" is lost and it makes an inferior product. The durum wheats being hard, lend themselves readily to the manufacture of semolina, while other wheats tend to go to flour, so that a much larger yield of semolina can be obtained from macaroni wheats. Another requirement is a high gluten

[1] "Manufacture of Semolina and Macaroni," Bulletin No. 20, Bureau of Plant Industry Dept. of Agr.

[2] See "Manufacture of Semolina and Macaroni," p. 25.

content. Skinner, in the bulletin quoted, places the limits at from 45 to 50 per cent. Reference to the gluten table will show that the average of the durum wheats considerably exceeds these figures.

The various paste products which go under the name of macaroni, vermicelli, spaghetti, etc., are made by mixing about 30 per cent. of water with semolina in a mechanical mixer and then kneading to a homogeneous mass by means of a powerful kneader, capable of exerting great pressure. The dough is then placed in a press and forced through a die which gives it the proper shape. It must then be dried or cured.

Soup pastes are largely dried on trays, but macaroni and spaghetti are cured either between strawboards (the French system) or on rods (the Italian system). In this country the French system is most largely used. In the work at this station the semolina used was milled by Professor Shepard. For kneading, a butter worker, which was found to give good results, was employed, while the pressing was done in a small press such as is used in the smaller Italian factories. For the curing, one of the most difficult operations, the Italian system was used, a specially arranged chamber in which heat and moisture could be controlled being constructed. The semolina, as milled, could not be entirely freed from bran particles and the kneading and pressing were not as satisfactory as with power kneaders and pressers. However, excellent samples of macaroni were made and the results of the tests were very gratifying.

The object of these tests was primarily to determine the value of wheats as raised in this country for macaroni purposes and the quality of the macaroni which the different varieties would make. At the same time macaroni was made from semolina from the bread wheats for control.

Skinner further states, in his description of macaroni manufacture, that a good macaroni should be bright, clear, semi-translucent and of a very light amber color. It should be elastic before cooking and have sufficient "force" to retain the original form after being cooked. Judging of the macaroni from the various wheats in regard to these points and also as to flavor, the macaroni from twenty-two out of forty-five durum wheats yielded a product which was graded 100 per cent., while the average of the forty-five was 96 per cent. On the other hand, the highest average quality which could be accorded a bread wheat macaroni was 85 per cent.,

and the average of the five was 82 per cent. This superiority showed itself in nearly every way. The macaroni from the bread wheats was duller and less translucent and might be described as somewhat chalky in appearance. It was also less elastic and on cooking was poorer in consistency, in fact, lacked "force." As regards flavor, the comparison was still more in favor of the macaroni from the durum wheats. Its sweetness and rich nutty flavor seem to be a quality almost entirely lacking in the macaroni from bread wheats. Miss Wardall, Professor of Domestic Science in the South Dakota Agricultural College, and various ladies favored with samples, were very enthusiastic in their praise of the durum wheat macaroni as compared with that found on the market.

Several factories, notably Fould's, of Cincinnati, and The Minnesota Macaroni Co., of St. Paul, are making an excellent quality of macaroni from durum wheats raised in this country, but it hardly seems that their process of curing, which is the French method, conserves the full sweetness and flavor of the durum wheats.

Breakfast Foods.—The durum wheats lend themselves readily to the manufacture of grits, and their high protein content, richness in sugar and characteristic and pleasing flavor, should make them a favorite for the production of breakfast foods.

The Varieties.—Little has been said so far as to the description of the varieties and individual tests which may be found in the various bulletins on macaroni wheat, published by the South Dakota Experiment Station. In general, probably on account of greater similarity in the soil and climatic conditions, the Russian wheats have given much the best results. Of these Kubanka 5639 has given somewhat the best flour yield and is one of the easiest to mill. Its yield per acre meets the average for Russian wheats, though it is excelled somewhat by several of the best wheats. It is also somewhat below the average in protein and gluten, though the gluten is of excellent quality. Kubanka, Pererodka, Arnautka, Beloturka and Yellow Gharnovka are all excellent varieties in nearly every respect and are of much the same quality. In fact, they seem to be the best varieties for the Great Plains Region.

Pellissier, the best of the Mediterranean wheats, is one of the best yielders of all the macaroni wheats. However, it gives much less flour than the Russian varieties and makes only indifferent

bread. Velvet Don and one or two others, which have been reported as especially rust-resistant, are very inferior both in respect to bread-making and macaroni, and also give a very low flour yield. Saragolla, the famous Italian macaroni wheat, has a very high protein content, but gives a low flour yield and makes poor bread, though the macaroni is of good quality.

SUMMARY.

The durum wheats are adapted for culture in many parts of the middle west, particularly in the semi-arid regions.

They yield especially well and grade high.

While many of the durum wheats are difficult of milling and give low flour yields, yet the best Russian varieties may be readily milled and compare favorably in flour yield with the best bread wheats.

The protein content, which is very much higher than that of bread wheats, tends to increase rather than diminish under our soil and climatic conditions.

They are especially rich in sucrose and dextrin.

The flour and other products have somewhat more color than those from bread wheats, due to the presence of a yellow coloring principle, but this color need not be objectionable in any of the products and is a criterion of quality in macaroni.

The gluten content is high but the gluten is of rather poor quality due to a deficiency of gliadin. However, in the best wheats the gliadin deficiency seems to be compensated for by the greater gluten content.

The best durum wheats will make excellent bread.

They are greatly superior for the manufacture of macaroni and other edible pastes, and should be well adapted for the preparation of breakfast foods.

They possess a decidedly characteristic and pleasing nutty flavor.

Of the different varieties which have been employed for trial at the South Dakota Experiment Station and Highmore substation, Kubanka, Pererodka, Beloturka, Arnautka and Yellow Gharnovka have given considerably the best results.

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EXPERIMENT STATION.