UNIVERSITY OF MINNESOTA.

Agricultural Experiment Station.

BULLETIN NO. 63.

CHEMICAL DIVISION.

JULY, 1899.

MISCELLANEOUS ANALYSES.
COMPOSITION OF TOMATOES.
PROTEIDS OF WHEAT FLOUR.

ST. ANTHONY PARK, RAMSEY CO., MINNESOTA.

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☞The bulletins of this station are mailed free to all residents of the state who make application for them.

Corrections to Bulletin No. 63.
Page 500. No. 1265, nitrogen free extract, 70.39, not 71.49.
Page 528. Sample 2, total nitrogen .359, not 369.

MISCELLANEOUS CHEMICAL ANALYSES.

HARRY SNYDER.

The first part of this bulletin contains the results of analyses of various agricultural products and other materials sent by farmers of this state to the Agricultural Experiment Station for chemical analysis. The act of congress creating experiment stations has limited the work of the stations to strictly agricultural lines; hence free analyses cannot be made of minerals, ores, or mineral waters, or work undertaken for individuals or corporations that is of merely a personal nature. Free analyses are, however, made for the farmers of the state of all agricultural products or materials, when the work is of such a nature that the results are of general public value. Questions relating to the sanitary condition of water should be directed to the State Board of Health; those relating to minerals to the University, School of Mines; and those relating to the adulteration of food and dairy products to the State Dairy and Food Commission.

OIL MEAL.

Occasionally complaints are received from farmers that the oil meal which they purchase is of poor quality, and that it fails to promote the growth of young stock or stimulate the flow of milk, as high class oil meal should do. In a few cases samples of the oil meal have been sent for chemical analysis. In all, twenty samples have been received, and of this number three

have been found to be adulterated, and a number of others have been found to be deficient in the most important nutrient, protein. The adulteration consists in mixing flax screenings with the fine ground oil meal. The mixture is ground so fine that the screenings are not easily detected. The composition, digestibility, and feeding value of pure oil meal are given in a former bulletin (No. 47) of this Station.

No. 2613. Oil meal sent by E. Cooley, Minneapolis, Minn. This sample caused stock to be very thirsty, and gave poor milk returns. When mixed with warm water there was a distinct odor of mustard.

No. 2747. Oil meal received from P. P. Eddy, Willmar, Minn. This meal gave poor results when fed to dairy calves. Purchased direct from linseed oil mill.

No. 3075. Oil meal brought to the laboratory by Mr. Scofield, Bloomington, Minn.

No. 2758. Oil cake direct from the press of an oil mill. The material was ground in the laboratory. Sample known to be pure.

TABLE LXVII.—Composition of Oil Meal Samples.

	No. 2613. Per Cent	No. 2747. Per Cent.	No. 3075. Per Cent.	No. 2758. Per Cent.
Water	9.22	8.47	.....	9.79
Ash	5.21	5.75	4.77	5.73
Fat	8.13	8.32	8.84	7.17
Protein	25.95	26.93	30.12	32.80
Fiber	.....	.....	.....	8.40
Nitrogen Free Extract	.....	.....	.....	36.11

Samples Nos. 2613 and 2747 are adulterated to the extent of at least 25 per cent. with flax screenings. The oil meal and screenings are ground very fine, but the foul weed seeds can be detected by a microscopic examination. The strong mustard odor in 2613 and its perceptible odor in 2747 is caused by the mustard seeds of the screenings. Sample No. 3075, when examined microscopically, showed the presence of wheat starch grains. This sample contains wheat shorts.

In purchasing oil meal, preference should be given to the coarser grades, rather than to those that are ground so fine as to conceal the screenings. Flax screenings can be more readily detected in the coarser grades. The odor of the sample when mixed with boiling water should be noted, and any distinct mustard odor may be taken as an indication of poor quality. A pound of crushed oil cake should absorb at least a quart of warm water, adding the water a little at a time and stirring well. The larger the amount of water absorbed, as a rule, the greater the per cent. of protein (or muscle-producing and milk-stimulating nutrient) and the more valuable the oil meal.

AMERICAN AND FOREIGN FLAXSEED.

Some European buyers believed that Russian flax was richer in oil than American, and preferred the foreign seed on that account. For purposes of analysis, the Minnesota State Railroad & Warehouse Commission collected samples from the European markets. The amount of oil in the various seeds is given in the following table:

TABLE LXVIII.—Oil in Flaxseed.

	Oil Per Cent.
Odessa, Russia	36.31
Bombay	39.08
Calcutta	37.88
Minnesota	37.61
American	37.50

There is practically no difference in the oil content of the American, Calcutta, and Minnesota samples; duplicate samples from the same car often show as great a variation as the results given here. The Russian flax contained the least oil.

WATER FOR RETTING FLAX.

The quality of linen produced from flax fiber is influenced to a great extent by the quality of the water used for retting the flax. The fiber retted in the river Lye, Belgium, is believed to be of such high commercial value because of the unique character of the river water. In order to secure the best results with the Cannon river, Minn., water, a chemical analysis was made, with the view of adding to the Cannon river water any materials that may be present in and characteristic of the Lye river water.

No. 1824, water from the Cannon river, Minn., used for retting flax.

No. 1825, water from the Lye river, Belgium, used for retting flax which produces the highest grade of linen.

It is to be observed that the Cannon river water differs from that of the river Lye in containing less of the alkaline chlorides and carbonates, a difference that can be largely corrected by adding these materials to the water in the retting tanks.

TABLE LXIX.—Composition of Water for Retting Flax.

	Cannon. River. Grams per litre.	Lye River. Grams per litre.
Total solids	.242	.3512
Calcium oxide	.0504	.0959
Magnesium oxide	.0044	.0092
Iron oxide, aluminia and phosphric anhydrid	.0050	.0062
Sodium oxide	.0114	.0293
Potassium oxide	.0102	.0127
Chlorine	.0035	.0412
Carbon dioxide	.092	.0869
Silica	.0037	.0070
Organic matter and undetermined	.0614	.0628

ANIMAL FOODS.

The composition of bran, shorts, corn meal, and other mill products, when pure, has been so well established by the many analyses made at the different experiment stations that there is no apparent need of farther chemical analysis of individual samples

for the purpose of determining their feeding value, except when the materials are prepared in some unusual way. Wheat bran is less liable to be adulterated than wheat shorts, because any foreign matter can be readily detected in the coarse bran. In the case of shorts, however, there is a tendency to mix with the shorts the fine ground wheat screenings and weed seeds; the foreign material is not easily detected because the mixed shorts and screenings are ground so fine. A few new foods, mainly stock foods made by mixing various materials, have been analyzed, and in most cases the prices charged for the mixtures were found to be greatly in excess of the market value of the ingredients used.

No. 3000. Oat bran from oat meal mill, sent by John Matheson, president of the State Dairymen's Association.

No. 1822. Oat feed, from John Shields, Darwin, Minn.

No. 3076. International stock food, sent by F. W. Schrapel, Ottawa, Minn. "The package contains one cent's worth of material." The package weighed 26 1-2 grams,—nearly an ounce.

No. 2160. Wheat screenings, received from W. C. Currie, Euclid, Minn.

TABLE LXX.

	No. 3000. Oat Bran. Per Cent.	No. 1822. Oat Feed. Per Cent.	No. 2160. Wheat Screenings. Per Cent.	No. 3076. International Stock Food. Per Cent.
Water	5.95	12.29	12.47	5.43
Ash	6.45	2.93	2.13	13.11
Ether extract (fat)	1.53	4.62	2.13	5.11
Protein	3.75	16.26	12.28	14.18
Nitrogen free extract	41.11	.....	63.53	.....
Fiber	41.21	.....	7.46	.....

The oat bran contains a very low per cent. of protein, about the same as present in straw. Oat feed, however, contains a high per cent. of protein, and is a more valuable food. Occasionally oat bran is sold as oat feed. There is, however, a great difference in the feeding value of the two. The wheat screenings contain a fair amount of protein, but are so variable in composition that what is true of one sample would not necessarily

be true of another. The International stock food has about the same amount of protein and fat as oats. The high per cent. of ash is due to salt and other minerals.

No. 1864. Cattle-feed mixture, from E. D. Childs, Crookston, Minn.

No. 3060. Speltz wheat, used for feeding animals, from Prof. Haecker, Dairy Division.

No. 1268. Corncobs, from corn raised on University farm.

No. 2854. Wild rice, from F. G. Bradbury, St. Paul. Occasionally used as human food.

No. 1264. Yellow corn, grown on University farm.

No. 1265. White corn, grown on University farm.

TABLE LXXI.

	No. 1864. Mixture Per Cent.	No. 3060. Speltz Wheat. Per Cent.	No. 1268. Corn Cobs. Per Cent.	No. 2854. Wild Rice. Per Cent.	No. 1264. Yellow Corn. Per Cent.	No. 1265. White Corn. Per Cent.
Water	12.89	10.02	10.75	9.29	12.06	11.91
Ash	4.34	3.25	1.20	1.42	1.51	1.47
Fat	5.72	2.25	.44	.73	3.92	3.81
Protein	16.20	11.25	1.43	12.50	10.12	10.14
Fiber		9 22	32.15	4.89	2.21	2.28
Nitrogen free extract			54 03	71.17	70.18	71.49

The Speltz wheat has about the same protein content as ordinary oats. The hulls are the cause of the larger per cent. of fiber and ash than is found in ordinary wheat. The small amount of protein and digestible carbohydrates in corncobs suggests a low food value. Their main worth is probably due to the indigestible fiber diluting the feces, which from grains are apt to be small in amount and concentrated in composition. The wild rice sample contains as much protein as our ordinary grains. In some parts of the state wild rice grows abundantly in swamps, and when it can be easily obtained it furnishes a cheap and valuable food. These statements do not apply to ordinary rice.

It is to be observed that, when grown under similar conditions, there is no material difference in protein or fat content between yellow and white corn. The main difference, chemic-

ally, between yellow and white corn is in the coloring matter that is present in one and not in the other. There is no reason why any discrimination should be made against white corn on the ground that it contains less nutrients than yellow corn. The seed and conditions under which the corn has been produced, as soil, cultivation, and the use of manures, determine its character more than does its color.

RAPE.

The extensive use of rape as a forage crop for sheep has caused many inquiries to be made regarding its composition. The following analyses are calculated on the basis of the dry matter. When green the plant contains from 70 to 92 per cent. water, according to the stage of growth:

TABLE LXXII.—Composition of Rape.

	Water. Per Cent.	Composition of Dry Matter. Per Cent.		
		Ash.	Protein.	Fiber.
Rape, entire plant, nearly mature	84.51	7.60	11.75	15.29
Rape, leaves	88.16	7.50	17.04	11.06
Rape, half grown	92.48	9.24	12.44	.....
Rape, nearly mature	86.46	9.68	12.14	.....
Rape, first stages of growth	95.11	16.48	14.76	10 38
Rape, mature	76 44	8.01	9 21	12.03

The dry matter of the rape plant contains as much protein as clover hay. No figures are given for fat, because of the difficulty in separating this material. The ether extract is unusually high, ranging from 3 to 5 per cent., a large proportion of which is non-fatty material. The high protein content of rape makes it a valuable forage crop,—a fact that has been verified by practical experience.

MISCELLANEOUS FODDERS.

Under the head of "Miscellaneous Fodders" are given a few of the forage crops about which the most inquiry has been

made. In Bulletin No. 36 of this Station the composition and feeding value of our common grains and fodders are given. To this the reader is referred for the composition of foods not found in the following list:

Nos. 3072, 3073. Corn fodder, grown at the Grand Rapids, Minn., sub-station.

No. 1931. Oat hay, as cut and cured for winter feeding.

No. 983. Pea hay, cut when small pods were beginning to form.

No. 2425. Dwarf German kale, cut when green, grown by Division of Animal Husbandry.

No. 2433. Sand vetch, grown on University farm.

No. 2421. Cured sorghum, grown on University farm, cut and cured as hay.

No. 2422. Peas and oats. Cut green, and used as soiling crop.

Bromus Inermis samples (Austrian brome grass) Nos. 1916, 1917, 1918, 1919, 1920, 1932, grown on University farm in 1895. Nos. 2406 and 2406a, crop of 1896, were less mature than the 1895 samples.

TABLE LXXIII.—Composition of Green Fodders.

	Water. Per Cent.	Composition of Dry Matter. Per Cent.			
		Ash. Per Cent.	Ether Extract.	Protein. Per Cent.	Fiber. Per Cent.
No. 3072. Corn fodder	53.32	4.82	2.24	7.18	.....
No. 3073. Corn fodder	41.48	5.96	2.23	7.66	.....
No. 1931. Oat hay	20.37	8.01	3.45	9.55	31.28
No. 983. Pea hay	9.75	12.72	2.63	14.58	27.46
No. 2425. Dwarf German Kale	91.80	11.80	.....	22.68	15.20
No. 2433. Sand Veitch	7.50	10.60	3.81	18.56	29.30
No. 2421. Cured Sorghum	54.80	6.60	3.61	9.02	42.87
No. 2422. Peas and Oats	72.41	9.12	2.94	12.84	29.16
No. 1916. Bromus Inermis	58.49	.....	.....	6.64	28.35
No. 1917. Bromus Inermis	49.35	6.98	.....	6.61	31.13
No. 1918. Bromus Inermis	58.81	6.03	.....	6.32	34.40
No. 1919. Bromus Inermis	49.25	5.22	.....	6.43	32.81
No. 1920. Bromus Inermis	33.06	6.56	.....	6.03	29.63
No. 1932. Bromus Inermis	44.58	7.84	.....	6.00	31.06
No. 2406. Bromus Inermis	68.30	9.50	.....	8.64	.....
No. 2406a. Bromus Inermis	64.40	9.26	.....	8.32	.....

The corn fodder samples Nos. 3072, 3073, grown in the northeastern part of the state, contain a normal amount of protein

and other nutrients. These samples were analyzed to determine whether corn fodder grown so far north contained the full amount of nutrients. The analyses indicate that, so far as nutrients are concerned, these samples compare very favorably with corn fodder grown in other parts of the state. There has been some hesitancy on the part of farmers in the northern part of the state to grow corn fodder, because of the possibility of the corn not being fully matured before early frosts. For fodder purposes, the corn before it reaches maturity has passed that stage in its development when it contains its normal protein content. Although the protein may not be deposited in the form of mature kernels of corn, it is nevertheless present in the crop, and is in a valuable form for feeding purposes. There is no reason, as far as feeding value is concerned, why corn fodder should not be grown in all parts of the state.

The oat hay sample No. 1931 is characteristically rich in protein. Oats cut when fully headed out and cured as hay form a fodder that contains more protein than average timothy or prairie hay. In regions where clover is grown with difficulty, oat hay should be used as one of the main forage crops.

The high value of peas and oats as a forage crop is so well known that it is scarcely necessary to mention the fact. The analysis shows 12.84 per cent. of protein in the dry material, a much larger amount than is present in ordinary hay, and very nearly as much as in clover hay. From a chemical point of view, there are but few crops that have such a high forage value as peas and oats.

The bromus inermis samples analyzed in 1895 show a lower protein content than the 1896 samples. In 1896 the samples were taken at an earlier stage of growth, while those of 1895 were taken when the crop was nearly matured. If cut or fed before the crop becomes too mature, a valuable forage is secured. When overripe the protein content of bromus inermis is between that of oat straw and prairie hay. When properly cut and fed, it produces a valuable crop; but if allowed to mature it is less valuable for fodder purposes.

LIMESTONE FOR REFINING BEET SUGAR.

The limestone used for refining beet sugar must be of high purity, as the presence of gypsum, magnesium compounds, and alkaline matter causes trouble in the various refining operations. There is an abundance of limestone in the state, but all of the analyses made prior to 1897 showed that no stone had been found that could be used for sugar-house work. Prior to the opening of the St. Louis Park Beet Sugar Factory, in 1898, Hon. Henry Keller collected samples of limestone from various parts of the state. These samples were analyzed and high grade limestone was found in three localities. Other samples have been received during the past year. Limestone suitable for making cement is frequently unsuitable for refining beet sugar, and this is particularly true of our dolomite stone, from which a good grade of cement is made. The analyses are given of only those limestones that are suitable for beet-sugar work. Undoubtedly other localities will be found that contain equally good stone. For the development of this industry, it is particularly fortunate that there is an abundance of high-grade limestone in the state, as at least a car-load of limestone per day is used by an ordinary beet sugar factory. In addition to the Faribault samples reported, a number of others have been analyzed, showing that there are a number of high-grade limestone quarries at this place.

TABLE LXXIV.—High Grade Limestones.

No.	Locality.	Silaca.	Iron and Aluminia.	Lime.	Carbon Dioxide.	Magnesia.	Sulphuric Anhydrid.	Soluble in Water.	Purity of Stone.
2945	Faribault	6.53	.91	52.11	39.58	.39	.04	.24	91.6
2946	Faribault	4.15	1.06	52.78	41.75	.35	.01	.23	94.4
2947	Faribault..... ...	3.88	1.02	53.04	41.92	.06	03	.17	94.9
2950	Fountain	2.49	1.58	52.50	41.30	.56	.....	.14	93.8
2953	Cannon Falls.....	7.30	2.78	48.99	40.05	.08	.....	.16	89.0
2959	Faribault.....	4.10	.96	53.17	41.20	.50	.01	.07	94.0
2992	Winthrop.....	.21	.61	55.67	42.80	.36	.10	.20	97.0
3460	Rockton.....	2.71	1.19	52.10	41.59	.28	.....	.....	93.6
3461	Shuster's Quarry	1.76	4.56	49.76	42 81	.40	.24	.....	92.5
3462	Shuster's Quarry	4.48	5.59	48.83	41.42	.45	.26	.....	90.2
3528	Faribault.....	2.60	.48	54.00	41.90	.04	.05	.20	95.9

SORGHUM SYRUPS.

TABLE LXXV.—Sorghum Syrups.

	No. 2739. Per Cent.	No. 2799. Per Cent.
Water	19.52	19.85
Cane Sugar	35.15	37.72
Reducing Sugar	28.27	25.24
Total Sugar	63.42	62.96
Ash	2.00	3.74

No. 2739. Sent by J. W. Steed, Anoka, Minn.

No. 2799. Sent by Seth H. Kenney, Morristown, Minn.

Both samples compare very favorably in composition with the published analyses of the best grades of sorghum produced in more southern latitudes.

SUGAR.

No. 3019. Sugar manufactured at the St. Louis Park Beet Sugar Factory. Sampled by a representative of the Experiment Station.

Sugar by polarization, 99.4 per cent. pure.

Inquiries are frequently received as to whether beet sugar is like cane sugar. Both are sucrose ($C_{12}H_{22}O_{11}$). When subjected to the same degree of refining, there is no difference between beet sugar and cane sugar. In fact, the difference cannot be detected by chemical analysis.

BUTTER.

The United States Department of Agriculture, in order to encourage a foreign market for butter, has, during the last two years, sent trial shipments of Minnesota creamery butter to the London market. Samples of some of this butter have been analyzed at the Minnesota Experiment Station, with the object of determining the composition and general character of the butter.

TABLE LXXVI.—Composition of Butter.

	Water.	Fat.	Salt and Ash.	Casein, etc.
No. 2748	10.83	86.84	1.68	.65
No. 2731	11.48	86.74	1.26	.52
No. 3044	12.86	84.68	1.55	.91
No. 3092	12.32	85.40	1.42	.86

The per cent. of salt and ash is less than that present in butter made for home use. The per cent. of casein and foreign matter is materially less than is found in many butters. It is apparent that by our improved processes of butter making less foreign matter is left in the product than by the old methods. The samples contain an average amount of water, and are quite uniform in composition.

DAIRY SALT.

Samples of dairy salt have been received and analyzed, including the Diamond Crystal, Worcester, Vacuum Pan, and other brands. The salts were all found to be of high purity, a difference in purity of less than one per cent. being observed. One of the main differences in the salt samples examined was in the fineness of the salt crystals. (The order of the numbers does not correspond with the brands given).

TABLE LXXVII.—Composition of Dairy Salt.

	Pure Sodium Chloride. Per Cent.
No. 1134	99.10
No. 1208	98.95
No. 1080	98.20
No. 1081	98.38
No. 1082	99.10
No. 2022	99.30

TESTING SKIM MILK.

The testing of separator skim milk by the double-necked Ohlson bottle, suggested by Farrington, has led to many inquiries as to what the small divisions should be called, .05 or .10 per

cent. Five samples of skim milk, analyzed by the chemical gravimetric method, gave the following results when tested with the Ohlson bottles, calling the divisions .05 per cent.:

TABLE LXXVIII.—Fat in Skim Milk.

	Per Cent. Fat.	
	Chemical Method.	Ohlson Test Bottles.
No. 1	.086	.05
No. 2	.072	.02
No. 3	.167	.08
No. 4	.082	.05
No. 5	.051	trace.

When the divisions are called .05 per cent. it is to be observed that the results are lower than those obtained by the chemical process. On the other hand, if the results are doubled they are slightly greater than the chemical results. Calling the divisions .10 per cent. brings the results nearer to those by the chemical method than when the scale is read .05 per cent. Farrington and Woll state that, "practically speaking, each division may be taken to show one-tenth of 1 per cent., if the column of fat obtained fills only one or two divisions of the scale."

PRESERVATIVES.

The extensive sale of preservative powders and liquids for the preservation of milk, fruit, meats, and human food products in general, has lead to many inquiries in regard to their influence upon health. The preservative powders generally contain one or more of the following chemicals: borax, boric acid, salicylic acid, or formalin. Sanitary authorities, as a rule, seriously object to the use of any of these chemicals for the preservation of human foods, on the ground that they are all injurious to health. Since

their use can be avoided, it is safest and best not to employ them for preserving milk fruits or other foods.

No. 3020. Liquid milk sweet, a preparation manufactured by the National Preservative Company, for the preservation of milk. This material was sent to the laboratory by Mr. Geo. W. Haigh, secretary Mankato County Dairy Association. A chemical analysis of the material showed that it is a 40-per cent. solution of formalin, worth 35 cents per pound. Trials made in the laboratory showed that a normal lactic acid fermentation could not be induced in milk which contained formalin. It is questionable whether a butter of the best flavor can be produced when formalin is used for preserving the milk, because, by destroying the lactic acid ferment, it prevents normal ripening of the cream. Hence it will be seen that its use results in a financial loss to the creamery. Formalin is one of the most active germicides known, and is extensively used in anatomical laboratories for the preservation of specimens.

No. 3122. Preservative compound, manufactured by J. R. Rockwell & Co., Jackson, Mich. Sent by Mrs. N. J. Solly, Pelican Lake, Minn. The substance contains phosphoric acid, soda, and free salicylic acid. The chief ingredients in this powder are salicylic acid and sodium phosphate. Prescott states (Organic Analysis) that salicylic acid is "irritant to mucous surfaces." In many countries the use of salicylic acid for the preservation of foods is forbidden by law.

During the last session of the legislature a law was passed prohibiting the use of preservatives in milk and dairy products.

FERTILIZER MATERIALS.

An extended discussion of the different kinds of farm and commercial fertilizers is not attempted in this bulletin. Analyses are given of only those materials that have been sent for ex-

amination by farmers and others. At the present time no commercial fertilizers are regularly offered for sale in the state. Except in special cases, as market gardening, it is doubtful if it would pay to use them, because the reserve fertility of the soil has not been drawn upon to such an extent that it demands replenishing. For ordinary crops, the use of farm manure, supplemented by waste and by-products, such as ashes, tankage, dried blood, and the manure from the large stock yards, the growing of clover and the judicious rotation of crops, will suffice to prevent decline in crop production.

No. 3124. Tankage from South St. Paul stock yards. Sent to the laboratory by T. P. Smith, St. Paul.

No. 3123. Dessicated sheep manure. Prepared at South St. Paul stock yards. Sent by T. P. Smith, St. Paul.

No. 1410. Tankage from Twin City Stock Yards. Analyzed for Horticultural Division.

No. 1411. Tankage from W. W. Rich Rendering Company. Analyzed for Horticultural Division.

No. 2757. Tankage mixture, Union Refining Company. Analyzed for Horticultural Division.

No. 2718. Sheep manure. Sent by Northrup, King & Co., Minneapolis.

No. 2751. Soft coal soot, from boiler flues of boilers of Minneapolis Water Works. Sent by Wyman Elliot, Minneapolis.

No. 2736. Nitrate of soda, sent by Farmers' Seed Company, Faribault, Minn.

Nos. 2020, 2021. Peat bog ashes, brought to the laboratory by C. C. Dikes, White Bear Lake, Minn. From a peat bog that had been burned over in 1896.

No. 1120. Ashes from sawmill. Soft wood and sawdust used for fuel; ashes unprotected from rain.

No. 1129. Hard wood ashes. From schoolhouse furnace, maple and oak used as fuel.

No. 1156. Dried Blood. From Twin City Stock Yards. Received from Horticultural Division.

TABLE LXXIX.—Composition of Fertilizer Materials.

		Nitrogen. Per Cent.	Phosphoric Acid. Per Bent.	Potash. Per Cent.
No. 3124.	Tankage	7.05	11.13	
No. 3123.	Dessicated Sheep Manure.	3 04	2.64	
No. 1410.	Tankage	4.71	13.26	
No. 1411.	Tankage	6.13	13.01	
No. 2757.	Tankage Mixture	2.20	6.84	
No. 2718.	Sheep Manure	.93		
No. 2751.	Soft Coal Soot		.75	.50
No. 2736.	Nitrate of Soda	14.75		
No. 2020.	Peat Bog Ashes		1.90	2.15
No. 2022.	Peat Bog Ashes		2.15	2.68
No. 1120.	Sawmill Ashes		1 00	1.20
No. 1129.	Hardwood Ashes		3.00	7.80
No. 1156.	Dried Blood	11.26		

The tankage samples show extreme variation in composition. The same price per ton, however, was charged for all the samples. Sample No. 1411, for example, has an agricultural value of $3.36 per ton greater than No. 1410. The tankage mixture No. 2757 contains a large amount of land plaster. Tankage contains so little potash that this ingredient was not determined in the samples analyzed.

The dessicated sheep manure has been dried and treated so as to destroy weed seeds. It varies in composition according to the proportion of straw and litter originally present, and also according to the nature of the food which the animals receive. Sheep manure sample No. 2718 was taken from a carload lot of fresh manure. It was analyzed with the object of determining to what extent losses by heating and volatilization of ammonia had occurred during shipment. Five samples from different parts of the car showed a difference of less than .07 per cent. nitrogen. Compared with the fresh manure, there were only slight losses during the three weeks' shipment of the manure.

The soft coal soot, No. 2751, contains but little fertility. It has some mechanical value on sandy soils, enabling the land to hold more moisture; but the material supplies but little plant food. The nitrate of soda is about 92 per cent. pure. The peat bog ashes are not of any great value. It is doubtful if it would pay to draw them any distance. They are so exceedingly light in weight, and low in potash and phosphoric acid that they make

a very dilute manure. When the bogs are covered with timber, the ashes are more valuable. The sawmill ashes are of very poor quality, being soft wood leeched ashes. The hard wood ashes from the schoolhouse furnace may be taken as a type of high-grade ashes. The best grades of ashes should be more extensively used for gardening purposes than they are at present.

MISCELLANEOUS SUBSTANCES.

No. 2077. Murnane's Germicide for hog cholera, brought to the laboratory for analysis by T. A. Haigh, Mankato, Minn. Manufactured at 317 Washburn block, St. Paul. A nostrum sold for curing hog cholera. Extract from circular: "Take a piece of flannel 1x2 inches in size, and apply a portion of Germicide about twice the size of a pea. Fold the flannel once with the preparation on the inside, rubbing it slightly so that it will adhere to the flannel. Fasten this to the ear of the hog with an ordinary hog ring." Why it is placed on the ear in preference to some other part of the body is not stated. The Division of Animal Industry of the United States Department of Agriculture states that no medicine has yet been found that will cure or prevent this disease. The material contains:

Carbolic acid, Copper, Aluminia, Magnesia, Glycerine, Zinc, Soda, Sand, Tar, Lead, Potash, Sulphuric anhydrid, Vasoline, Iron, Lime.

About five cents' worth of the above mixture is put in a small jar and sold for $5.

No. 2078. Siebner's Potato Bug Exterminator Compound. Manufactured at Waukesha, Wis., P. O. Box 1024. Brought to the laboratory by Dr. Lugger. A nostrum proposed to render potatoes "bug-proof." The seed potatoes are treated in a box or barrel with layers of this material, and left 15 hours. The chemical and microscopic analyses showed that the material was made of wood ashes, land plaster, clay, and a small amount of corrosive sublimate, a very poisonous material. No

explanation was offered as to how this treatment of the seed potatoes was expected to kill the bugs on the potato vines.

No. 1133. A germicide, insecticide, and fertilizer. Brought to the laboratory for analysis by Dr. Lugger. Put up in Chicago. Place of manufacture, and name of manufacturer not given. The solution contained arsenic and caustic potash. When used according to directions, Dr. Lugger reports that it destroyed all the leaves on a plum tree.

No. 2095. The American Soil Renewer and Insecticide. A preparation for fertilizing crops, killing insects, etc. Brought for analysis to the laboratory by Dr. Lugger.

Common salt	79.61 per cent.
Land plaster	4.50 per cent.
Organic matter	11.67 per cent.
Water	4.22 per cent.

The organic matter gave alkaloid reactions, resembling veratrine, the alkaloid found in white hellebore.

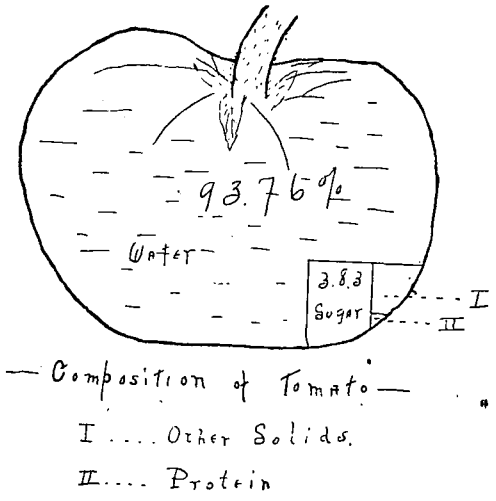
No. 2180. Russian Thistle Exterminator. A preparation sold for destroying the Russian thistle by spraying. The substance contained arsenic and soda. There was no label on the package, or any indication that it was a poisonous substance. This is a dangerous material to use, because poisoned thistles are liable to be blown into wells, watering troughs, or into haystacks, and so cause the death of animals feeding upon the hay or using the water.

TOMATOES.

COMPOSITION AND FOOD VALUE.

HARRY SNYDER.

The extensive use of tomatoes as an article of food has caused many inquiries to be made as to their food value. The nutrient present in tomatoes in the largest amount is sugar, while the organic acids are the main substances which give individuality or character. In tables of analysis tomatoes are given as con-



taining from 92 to 95 per cent. water, .45 per cent. ash, .90 to 1.00 protein, and 3.80 to 4.80 per cent. of carbohydrates. The per

cent. of sugar, which constitutes the main part of the carbohydrates, is given by various analysts as ranging from .6 to 4.50 per cent. This wide range of sugar is greater than can reasonably be expected in a material containing so little dry matter as the tomato. When calculated on the water-free basis, it would be equivalent to a range of from 10 to 80 per cent., or more of the total dry matter. On the water-free basis is 10 per cent. of the tomato sugar, or is there a larger amount? In view of this lack of uniformity of results as to the composition of the tomato, complete analyses were made of three typical samples: (1) Acme; (2) Livingston; (3) Dwarf Aristocrat.

Sugar.—For this determination 100 grams (nearly 4 ozs) of the fresh sample was reduced to a pulp, and the sugar determined by the official gravimetric process. The results were as follows:

	Sample No. 1. Per Cent.	Sample No. 1. Per Cent.	Sample No. 3. Per Cent.
Levulose and dextrose	2.25	2.44	2.06
Sucrose (cane sugar)	1.60	1.62	1.73
Total	3.85	4.06	3.79

A compound sample, made of equal parts of Nos. 1, 2 and 3, was prepared, and submitted to further examination. The polarizations before and after inversion, combined with the usual gravimetric observations, showed that the reducing sugars were composed approximately of equal parts of levulose and dextrose, making the sugar content of the sample as follows:

	Per Cent.
Levulose	1.12
Dextrose	1.12
Sucrose	1.65
Total	3.89

The same amount of sugar could not be obtained from the dry residue of the tomato as from the fresh material. When sample No. 1 was dried in a water oven, and the sugar in the dry residue extracted and determined, only 2.04 per cent. was

obtained, while the fresh tomato yielded 3.85 per cent. The tomato yields when dried in the water oven a black charred mass which resembles charcoal. Before the water is entirely removed the substance appears to undergo a material change. The combined action of the heat, organic acids, and ferments, undoubtedly has some influence upon the sugar of the tomato, particularly upon the levulose which is exceedingly easily decomposed by heat and acids (O'Sullivan). In order to determine the extent to which the heat and acids influence the sugar content of the tomato, a solution containing by analysis 1.79 grams of levulose and .25 grams of malic acid was evaporated to dryness upon asbestos fiber and left in the drying oven the same length of time as the tomato samples. A black, charred mass was obtained, of less intensity of color than that from the tomato. Only .41 grams of reducing sugar could be recovered from the 1.79 grams originally taken, equivalent to a loss of 77.7 per cent. of the levulose or fruit sugar. The destruction of the levulose by the prolonged drying in the presence of the malic acid explains the discrepancy in the sugar per centage of the tomato as obtained by different analysts, because some have obtained their sugar results from the dried residue, while others have used the fresh material. This chemical change is not necessarily confined to the levulose of the fresh sample. When the tomato is dried the sucrose undergoes inversion, and the levulose thus formed undergoes the same change as the pre-existing levulose. That this is true is indicated from the results and by direct experiments. In the compound sample reported the theoretical amount of levulose formed from the sucrose is .82 per cent., which, added to the levulose already present, gives a total of 1.94 per cent., leaving 1.95 per cent. of dextrose. The 2.04 per cent. of total sugar secured from the dried residue was, therefore, mainly dextrose. This same change was observed when solutions composed of sucrose, levulose, and malic acid were evaporated and heated in a water oven.

The fact that the mixed sugars of the tomato suffer such a material change in drying indicates that the sugar in the dried residue of fruits and vegetables may not always be taken as repre-

senting the sugar content of the fresh substance. Drying in a vacuum would probably be the only way of avoiding these changes.

Protein.—The tomato contains relatively a low per cent. of protein. The samples examined yielded about .5 per cent. The tomato is ordinarily considered as containing from .9 to 1.00 per cent. protein. Fifty-five per cent. of the total nitrogen of the tomato is, however, in non-proteid forms. The samples analyzed gave the following results:

	No. 1. Per Cent.	No. 2. Per Cent.	No. 3. Per Cent.
Total nitrogen	.17	.18	.16
Proteid nitrogen	.08	.08	.07
Non-proteid nitrogen	.09	.10	.09

Fat.—The direct extraction of the dry matter of the tomato gives about .5 per cent. of ether extract, commonly called fat. If the residue is first extracted with alcohol, a much smaller amount of ether extract is obtained, as will be observed from the following results:

	Ether Extract. Per Cent.
1. Direct extraction of residue	.49
2. After extraction with alcohol	.05
3. Ether extract 1, soluble in alcohol	.41

From these results it is evident that about 90 per cent. of the ether extract of the tomato consists of non-fatty material.

TABLE LXXX.—Composition of Tomatoes.

	Sample 1. Per Cent.	Sample 2. Per Cent.	Sample 3. Per Cent.
Sucrose (cane sugar)	1.60	1.62	1.73
Dextrose (glucose)	1.12	1.12	1.03
Levulose (fruit sugar)	1.13	1.12	1.03
Protein	.50	.50	.44
Amides	.36	.40	.36
Fat	.05		
Malic Acid	.37	.47	.41
Ash	.69	.56	.54
Insoluble in Acid	.32	.34	.37
Undetermined	.25	.11	.16
Water	93.61	93.76	93.93
Total	100.	100.	100.
Total Solids	6.39	6.24	6.07

LOSSES OF NUTRIENTS IN CANNING TOMATOES.

When the tomato is to be used for food, care should be taken to retain all of the juice, as the nutrients are present largely in soluble form, and any diminution of the amount of juice entails a corresponding loss of nutrients.

In the canning of tomatoes it is sometimes customary to allow the juice to drain from the solids, with the object of securing a more concentrated product. In order to determine the losses by this method of preservation, two cans were prepared, one with and one without the juice. The amounts of material taken, and the weights of the products secured are given in the following table:

TABLE LXXXI.—Canned Tomatoes.

	Can 1. Grams. With Juice.	Can 2. Grams. Without Juice.
Tomatoes used, 3 lbs	1362	1362
Refuse excluded	302	643
Weight of canned product	708	564
Loss of Water, etc., by evaporation	352	155

When 301 grams (11 ozs) of juice, from 3 pounds of tomatoes, were excluded from can 2, the losses as determined by analysis, compared with can 1, were 11.74 grams of sugar. The total amount in the three pounds of tomatoes was 53.11 grams. An unnecessary loss of 22 per cent. of the total sugar of the tomato resulted from the exclusion of the juices.

When the juice was retained, and the product concentrated by evaporation, as in can No. 1, the material finally yielded 9.62 per cent. solids and 5.5 per cent. sugar. As prepared for the table, a pound of canned tomatoes like No. 1 would contain about 24.4 grams of sugar (6/7 oz), and about 18.4 grams of all other nutrients combined (a little over 1/2 oz.). Calculated on the basis of nutrients, this is not a large amount, but the tomato has an additional value, difficult to determine,—its favorable influence upon the digestibility of other foods.

THE PROTEIDS OF WHEAT FLOUR.

HARRY SNYDER.

The proteids of wheat have been studied by a number of investigators. One of the earliest and most complete investigations of the subject was made by Ritthausen,[1] who identified four proteids, namely, (1) gluten-casein, (2) gliadin (plant gluten), (3) mucedin, and (4) gluten-fibrin. Gluten-casein is insoluble in hot and cold alcohol, but soluble in dilute alkali solutions from which it may be again precipitated by acids. Gliadin also is soluble in dilute alkali solutions, and may be re-precipitated by acids. It is soluble, too, in warm dilute alcohol, from which it is again precipitated on cooling. Mucedin is similar to gliadin, though less soluble in strong alcohol. It is readily soluble at ordinary temperatures in 60 to 70 per cent alcohol, and also in acetic acid. Gluten-fibrin is soluble in dilute boiling alcohol; it is again precipitated on cooling.

Among the more recent contributions to this subject is the work of Osborne and Voorhees.[2] According to their investigations, there are five separate proteids in wheat; namely, (1) gliadin, (2) glutenin, (3) edestin (a globulin), (4) leucosin (an albumin), and (5) a proteose.

From the results reported in this bulletin it will be observed that about 89 per cent of the total proteids of flour is in the form of gluten. In the testing of flour, gluten is obtained by washing a sample of dough with cold water to remove the starch and other

[1] Die Eiweisskorper der getreidearten, Hulsenfruchte und Oelsamen. Bonn, 1872. (Contains references to his earlier publications.)

[2] Amer. Chem. Jour., 15 (1893), p. 392.

compounds. The gluten mass is usually very elastic and tenacious, varying in quality according to the nature of the flour from which it is obtained. Inasmuch as both the food value and the baking quality of flour are determined mainly by the character of the proteids, it is unnecessary to speak of the importance of a study of these bodies in relation to the milling of wheat, practical bread making, and human food investigations.

In a former report, Minn. Bulletin 54, it was shown that wheat gluten is composed of two proteids, gliadin and glutenin; these two bodies form about 85 per cent of the proteids of wheat. The gliadin may be extracted from either gluten or flour with a 70 per cent solution of alcohol. The gliadin obtained after evaporating the alcohol is in the form of thin, transparent flakes which resemble gelatine. In fact, gliadin was called by the earlier investigators plant gelatine. When moistened the gliadin expands and forms a mucilagenous mass. When more water is added, a small amount is dissolved. Gliadin is soluble in dilute acid and alkali solutions, and in many samples of flour, particularly those which have been kept for some time, there is sufficient acid developed to combine with and render soluble appreciable amounts of this proteid. Gliadin, like all of the wheat proteids, is characterized by a high per cent of nitrogen. It takes a very important part in bread making, and is the material which binds together the flour to form dough and enables the mass to expand by retaining the gas generated by the yeast. The gluten from ordinary flour contains from 60 to 70 per cent of gliadin, the remaining 30 to 40 per cent being glutenin.

Glutenin is the proteid which remains after extracting the gliadin from the gluten. When dry and pure it forms a light gray mass, which may be reduced to a fine powder. It is insoluble in dilute alcohol and salt solutions, and is only sparingly soluble in water. It is readily soluble in dilute acid and alkali solutions. This proteid also takes an important part in bread making. It combines mechanically with the gliadin, and "serves

*Note. The summary of the work by Ritthausen, Guthrie, Fleurent and O'Brien was contributed by Dr. Langworthy, of the office of Experiment Stations N. S., Department of Agriculture, Washington, D. C.

as a nucleus to which the gliadin adheres" and prevents the dough from becoming too soft and sticky. When these two proteids are present in flour in the proportion of 65 per cent of gliadin to 35 per cent of glutenin, a much better quality of bread can be produced, than from flour containing the same amount of total proteids, 75 per cent of which is gliadin and 25 per cent glutenin.

In addition to gliadin and glutenin, which are the two main proteids of wheat, there are small amounts of other proteid bodies present in wheat, which, according to Osborne and Voorhees, have the following characteristics: Leucosin, an albumin, is soluble in water and coagulated at 52° C. (Ordinary flour contains from 0.25 to 0.40 per cent albumin.) Edestin, a globulin, is soluble in dilute salt solutions, and coagulated at temperatures above 100° C. (Flour ordinarily contains from 0.75 to 1.50 er cent of globulin.) After removing the albumin and globulin from the water and salt solutions used in separating the above proteids, there remains a soluble proteid, a proteose which is coagulated by tannic acid and other reagents.

The gliadin-glutenin ratio is an important matter to consider in determining the bread-making qualities of flours. Girard [1] states that the gliadin-glutenin ratio in winter wheat is about 75:25. From Osborne and Voorhees' investigations it would appear that wheat gluten is composed of nearly equal parts of gliadin and glutenin.[2] This matter was recently studied by Guthrie. [3] A number of experiments were made on (1) the strength, i. e. the amount of water which flour made from various sorts of Australian-grown wheat would absorb; (2) the gluten content; (3) the proportion of glutenin to gliadin in the gluten; and (4) the physical nature of the gluten of the various flours. The author concludes that the strength or water-absorbing capacity of flour depends directly upon the relative proportion of the glutenin and gliadin of the gluten. When these two bodies are present in about the same proportion, the flour is stronger than that which contains a larger proportion of glutenin. Flours in which glutenin predominates

[1] Compt. Rend. Acad. Sci. Paris, 123, p. 327.
[2] Am. Chem. Jour., p. 392.
[3] Ag. Gaz. N. S. Wales, 7, 1896.

yield strong, tough, elastic, non-adhesive glutens. When gliadin predominates the gluten is weak, sticky, and inelastic. In a later publication[1] Guthrie, with E. H. Gurney, reports the determination of gluten and the strength of a number of samples of flour.

Acocrding to Fleurent the respective proportions of gladin and glutenin in gluten are about as follows: Glutenin, from 18 to 25 per cent of the total gluten; gliadin, from 60 to 80 per cent of the total gluten. The gliadin is regarded as the true agglutinating matter, and not the glutenin, and the reason the proteids of the other cereals do not form a sticky dough is because the quantity of gliadin is comparatively small, ranging from 8.17 per cent of the total amount of proteids in barley to 47.50 per cent in maize.

The distribution of gluten and its constituents in the starch layer of wheat has also been recently investigated by Fleurent.[2] The results were published after the investigations described in this bulletin were completed. Fleurent determined the gluten in flour at different stages of grinding and the amount of glutenin and gliadin in the gluten in several sorts of wheat. In his opinion the results show that the gluten content and the composition of gluten vary in different varieties of wheat and also in the products obtained from the same wheat at different stages of grinding. The quantity of gluten increases from the center of the wheat grain toward the periphery of the starch layer, while the gluten contains a higher percentage of glutenin as it approaches the interior of the grain.

An extended study of the proteids of wheat flour and wheat germ has been reported by O'Brien.[3] According to this author flour contains the following proteids:

1. Globulins: precipitated by carbon dioxide and by dialysis from neutral saline solutions.

   (a) myosin-type: coagulating at about 55°; soluble in dilute sodium chloride and magnesium sulphate solutions, precipitated by excess.

[1] Ag. Gaz. N. S Wales, 8, 1897.
[2] Compt. Rend. Acad. Sci. Paris, 126, p. 1592.
[3] Ann. Bot. 9 (1895) pp. 171 and 543.

(b) *vitellin-type*, coagulating at 75-80°; soluble in dilute sodium chloride solution, not precipitated by excess; soluble in dilute magnesium sulphate solution, precipitated by excess.

2. Proteose: not coagulated by heat.

3. Mother-substance of gluten; only attainable in hydrated form as either gliadin by extracting flour with 75-90 per cent alcohol; or gluten, by treating flour with water.

The correspondence between the globulins of the germ and those of flour are regarded as fairly complete. O'Brien regards the vitellin and myosin which make up what he calls globulin as identical with the globulin (edestin) and albumin (leucosin) of Osborne and Voorhees. The proteoses are also regarded as identical. The author does not agree with Osborne and Voorhees' conclusions that gluten is made up of gliadin and glutenin; that these constituents exist in flour in the same proportion as in gluten, and therefore that gluten may be said to exist as such in the flour. In his opinion these substances may be extracted from gluten in varying proportions according to the method employed. "This suggests that the one may be derived from the other; and it is probably the less soluble substance (zymom) that is derived from the more soluble (gliadin); hence the alcohol-soluble substance (gliadin) is ultimately co-extensive with gluten."

O'Brien believes his investigations indicate "the existence of one mother-substance in flour which readily undergoes hydration, giving rise to gluten. For we can, as it were, intercept hydration at any point and obtain consequently a larger or a smaller amount of alcohol-soluble substance by extracting gluten with alcohol at an earlier or later stage in its progress to almost complete insolubility. Moreover, it seems almost impossible completely to extract from flour the whole of the alcohol-soluble proteid with 75 per cent alcohol in the cold; this again is suggestive of a gradual hydration of the mother-substance."

O'Brien's article includes an extended review of the literature of the subject, covering a period from the discovery of gluten by Beccari in 1766 to the present time.

Inasmuch as the bread-making qualities of different flours are so variable it was considered advisable to make a study of the proteids of a number of samples of flour and mill products. In general, the methods proposed by Osborn and Voorhees for the separation of these proteids were followed.

METHODS EMPLOYED IN SEPARATION OF PROTEIDS.

Water-soluble nitrogen.—Fifteen grams of flour were weighed into a flask and 250 cc. distilled water added, the temperature being kept at about 30° by placing the flask in water of that temperature. The flask was shaken occasionally. After two hours, 200 cc. of the clear filtrate were placed in a Kjeldahl digestion flask containing a little sulphuric acid and evaporated nearly to dryness, when the remainder of the acid necessary for oxidation was added and the determination of nitrogen completed in the usual way. When it was also desired to separate water-soluble gliadin 30 grams of flour and 500 cc. of water were used. One half of the filtrate was evaporated nearly to dryness and the residue treated with 70 per cent alcohol to extract the soluble gliadin. The extract was filtered through a small filter. The filter paper with the insoluble proteid residue was placed in a Kjeldahl flask and the nitrogen in it determined in the usual way.

Salt-soluble nitrogen.—After removing the water-soluble proteids, the flour residue was placed in a flask and 500 cc. of 5 per cent sodium chlorid solution added. After standing for about two hours at 30°, the nitrogen in the extract was determined as in the case of proteid soluble in water.

Gliadin.—Five grams of flour or other material were weighed into a flask and 250 cc. of 70 per cent alcohol added, the contents of the flask being shaken at intervals of half an hour for three hours. The alcohol was left in contact with the flour for about eighteen hours. The alcoholic extract was then filtered and 100 cc. of the filtrate placed in a Kjeldahl digestion flask connected

with a condenser . The alcohol was removed by distilling and the nitrogen in the residue determined in the usual way. With old or unsound flours a correction must be made for soluble amid bodies.

Glutenin.—The residue from the gliadin determination was washed with 70 per cent alcohol until the washings no longer gave a reaction for proteids. It was then transferred to a flask and 200 cc. of a 5 per cent solution of sodium chlorid added to remove globulin and other proteids. After two hours' extraction the residue was washed with distilled water and transferred to a flask, 250 cc. of a 0.2 per cent solution of potassium hydroxide added, and after three hours' extraction the solution filtered, and the nitrogen in 200 cc. of the filtrate determined in the usual way. The glutenin determination is the most troublesome of all because the other proteids must be removed before it can be extracted with potassium hydroxide. For all practical purposes the glutenin may be estimated by difference. Results thus obtained are within 0.1 per cent of the actual amount recovered with potassium hydroxide.

Amid nitrogen.—Fifteen grams of flour were treated as described for the determination of water-soluble proteids. Fifteen cubic centimeters of Stutzer's copper solution were added to 200 cc. of the filtrate and the albuminoid nitrogen determination was made in the usual way. The difference between the nitrogen of the water-soluble proteid and the albuminoid nitrogen represents the amid nitrogen.

Tannic acid was also used to precipitate the total soluble proteid matter, and gave satisfactory results. The usual method for the determination of albuminoid nitrogen is not applicable to flour because a paste-like mass is formed which can not be readily filtered.

The complete separation of the several proteids in flour can only be approximately secured, because the solubilities of the separate proteids will not permit of the extraction of one proteid without being more or less contaminated with other proteids. For general comparative purposes, however, the separation of the proteids into water-soluble, salt-soluble, alcohol-soluble, and in-

soluble proteids gives valuable results. The presence of variable amounts of organic acids in wheat and flour causes the formation of acid proteids, so that the analyst is dealing with proteid derivations rather than "native" proteins.

DESCRIPTION OF SAMPLES USED.

No. 1. First grade Patent flour, highest grade made from spring wheat. The flour was milled by the Consolidated Milling Co., of Minneapolis, March 16, 1897. The roller process was used. About 75 per cent of the wheat is recovered as flour.

No. 2. Second Grade Patent flour, just a shade darker in color than No. I. This sample was also milled by the Consolidated Milling Co., and was from the same lot of wheat as No. 1.

No. 3. Third grade or straight flour: From the same wheat as No. I. The gluten from the flour was slightly different in physical properties from No. I, which possessed greatest power of expansion, producing the lightest as well as the whitest grade of bread.

No. 4. Patent flour, highest grade, made from spring wheat. The flour was milled by the Washburn-Crosby Co., of Minneapolis, Minnesota, March 18, 1897. The roller process was employed and about seventy-five per cent of the wheat was recovered as flour.

No. 5. Patent flour made from winter wheat grown in Washington. A type of flour from soft winter wheat.

No. 6. First bakers' grade of flour, a product of the same wheat as flour No. 4. The bakers' grades of flour are not as light in color as the patent grades, and the gluten does not possess as great a power of expansion. The greatest difference between the patent and bakers' grades of flour is in the physical properties of the gluten, as power of expansion, capacity to absorb water, color, elasticity, etc.

No. 7. First bakers' grade of flour, a product of the same wheat as flour sample No. I.

No. 8. Second bakers' grade of flour, another grade of flour from the same wheat as flour No. I.

No. 9. Red dog flour: From the same wheat as No. I. This is the lowest grade of flour that is manufactured. It is frequently used for feeding animals. The gluten in this flour has very poor physical qualities compared with No. I.

No. 10. Red dog flour, produced in the milling of flour No. 4.

No. 11. Wheat germ obtained in the milling of flour No. 4.

The germ, although very rich in protein, is excluded from the flour on account of the poor physical and baking qualities of its proteids. It is used for making "Breakfast Foods," compressed yeast, and for feeding purposes. From four to seven per cent of the wheat is obtained as wheat germ.

No. 12. Wheat germ obtained in milling sample No. I.

No. 13. Wheat shorts, a product obtained in milling sample No. 1.

No. 14. Wheat shorts, obtained in the milling of sample No. 4.

No. 15. Wheat bran, a product obtained in the milling of sample No. I.

No. 16. Wheat bran from the milling of flour No. 4.

TABLE LXXXII. Nitrogen in the Proteids of Flour and Milled Products.

No. of Sample.		NITROGEN OF				
		Water-Soluble Proteid.	Salt-Soluble Proteid.	Alcohol-Soluble Proteid.	Potash-Soluble Proteid.	Total Nitrogen.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1	First grade patent flour	.465	.218	.791	1.000	2.297
2	Second grade patent flour	.369	.181	.817	.931	2.177
3	Third grade patent flour	.282	.149	1.108	.878	2.111
4	First grade patent flour from spring wheat	.391	.348	.869	1.287	2.410
5	Patent flour from winter wheat	.277	.194	1.075	.472	1.455
6	First grade baker's flour	.258	.235	1.046	1.091	2.837
7	Baker's grade flour	.388	.422	.770	1.340	2.559
8	Baker's grade flour	.381	.311	1.524	.927	3.284
9	Red dog flour	1.112	.496	.802	1.283	3.530
10	Red dog flour	1.027	.647	.914	1.128	3.669
11	Wheat germ	1.460	.876	1.106	1.134	4.296
12	Wheat germ	1.804	.915	1.084	1.248	5.706
13	Wheat shorts	1.100	.515	.832	.886	3.130
14	Wheat shorts	.732	.818	.739	.762	2.818
15	Wheat bran	.787	.884	.802	.622	2.871
16	Wheat bran	.559	.958	.801	.428	2.620

DISCUSSION OF RESULTS.

The water-soluble nitrogen reported in the above table represents the amid, albumin, and proteose nitrogen, with variable amounts of gliadin nitrogen. The amid nitrogen was determined in six samples with the following results:

TABLE LXXXIII. Amid Nitrogen in Flour, Shorts and Wheat Germ

	Per Cent.
No. 1, Patent flour	.019
No. 2, Patent flour	.012
No. 7, Bakers' flour	.021
No. 8, Bakers' flour	.024
No. 12, Shorts	.074
No. 13, Germ	.12

The nitrogen of water soluble gliadin in a number of samples of patent flour was also determined by evaporating an aliquot portion of the solution nearly to dryness and extracting the residue with 70 per cent alcohol. The following table shows the total nitrogen and the nitrogen of water-soluble gliadin in the sample, as well as the nitrogen of albumin and proteose, this being obtained by subtracting the nitrogen of water-soluble gliadin from the total.

TABLE LXXXIV. Nitrogen of Water Soluble Gliadin, and Albumin and Proteose in Flour.

Sample.	Total Nitrogen.	Nitrogen of Soluble Gliadin.	Nitrogen of Albumen and Proteose.
	Per Cent.	Per Cent.	Per Cent.
Patent flour No. 1	.465	.389	.076
Patent flour No. 2	.369	.284	.075
Patent flour No. 3	.282	.203	.079
Patent flour No. 4	.391	.308	.083
Bakers' flour No. 6	.258	.122	.136
Bakers' flour No. 8	.381	.287	.094

The aqueous extract from the flours contained from 0.203 to 0.389 per cent of proteid nitrogen, soluble in dilute alcohol. Making corrections for the soluble gliadin and for the amid nitrogen, the albumin-proteose nitrogen was found to range from 0.075 to 0.083. A flour containing a high per cent of soluble proteids as albumin and proteose bodies possesses poor keeping qualities. Such a flour usually contains a high percentage of

germ proteids which are associated with the soluble ferments that cause the flour to become unsound.

The nitrogen of the salt-soluble proteids in the flours ranged from 0.14 per cent in the patent to 0.42 per cent in the low grade bakers' flour. In the four patent flours the average globulin content was 0.95 per cent. The proteids in the form of albumin, globulin, and proteose amounted in all to 1.45 per cent, equivalent to nearly 11 per cent of the total proteids of the flour. The amid nitrogen in the flour was slightly less than 1 per cent, consequently the gluten proteids constituted about 88 per cent of the total nitrogen in the flour.

In the offal products examined, bran, germ, and shorts, the relative percentage of the water-soluble as well as salt-soluble, proteids was much higher than in the samples of flour. In the bran the gliadin and glutenin make up less than half of the total. The germ contained the highest percentage of water-soluble proteids. From the results it appears that more non-gluten proteids (albumin, globulin, and proteose), are present in the offal products than in the flour products.

The process of milling results partly in a mechanical separation of the various proteids, the non-gluten proteids being recovered mainly in the by-products, while the gluten proteids are recovered mainly in the flour. In the wheat from 80 to 85 per cent of the total nitrogen is in the form of gluten, while in the flour there is from 86 to 89 per cent in this form.

In the table it will be observed that in some cases the sum of the water, salt, alcohol, and potash-soluble nitrogen in flour exceeds the total nitrogen by 0.1 to 0.3 per cent. This is due to the fact that all the determinations were not made from the same weighed quantity of flour and that some of the proteids are classed in more than one group. The nitrogen of water-soluble proteids, as previously stated, contains from 0.12 to 0.38 per cent soluble gliadin nitrogen. Many of the gliadin determinations for the flour were made from separate portions of flour or by extracting the gluten mass with alcohol. This resulted in part of the gliadin being recovered in two places. When, however, corrections are

made for the soluble gliadin, the sum is always less than the total nitrogen.

Osborne and Vorhees'[1] determinations of the different proteids of finely ground wheat are as follows:

TABLE LXXXV. Proteids of Wheat.

	Spring Wheat.		Winter Wheat.	
	Nitrogen.	Protein.	Nitrogen.	Protein.
Glutenin	.8245	4.683	.7346	4.173
Gliadin	.6977	3.96	.6884	3.910
Globulin	.1148	.624	.1148	.625
Albumin	.0657	.391	.0603	.359
Coagulum	.0453	.269	.0379	.223
Proteose	.0341	.213	.0791	.432
From H20 washings of gluten	.2239	1.272	.1552	.881
Total	2.005	11.415	1.87	10.60
Flour	2.10	11.93	1.94	10.96

Osborne and Voorhees state that "the washings of the glutens were collected in jars and allowed to settle; the sediments washed with water and with very strong alcohol, and dried and weighed. The nitrogen in each case was then determined."

It is to be observed that in the case of the spring wheat 11 per cent, and of the winter wheat nearly 9 per cent of the total nitrogen was found in the washings from the gluten. The method as described above would indicate that this nitrogen is present as insoluble nitrogen, presumably as particles of gluten lost in the washings.

They also state that "Direct treatment of the material with alcohol yields extracts containing gliadin in exactly the same proportion as is obtained from the gluten made from an equal quantity of flour, and extracting either flour or gluten with alcohol after complete exhaustion with sodium chlorid gives the same proportion of gliadin."

In Osborne and Voorhees' determinations the sum of the albumin, coagulum and proteose nitrogen for the spring wheat amounts to 0.14 per cent, and for the winter wheat to 0.176 per cent. In the determinations reported in this investigation the

[1] Am. Chem. Jour., 16 (1893), p. 461.

total amount of albumin, coagulum and proteose nitrogen is given as ranging from 0.072 to 0.129 per cent. It is also found that the water-soluble matter contained from 0.12 to 0.39 per cent of gliadin nitrogen.

In the investigations reported in this bulletin it was found that the direct extraction of the flour with alcohol for the determination of the gliadin gave better results and offered fewer difficulties than the extraction of the gluten mass. Some glutens form a rubber-like mass which is nearly impervious to the action of alcohol.

The figures given in table LXXXII for the nitrogen of alcohol-soluble proteids can not be taken as representing the total gliadin-nitrogen of the flours except in those cases where the flour was directly extracted with alcohol since (1) the gluten mass often resists the action of the alcohol; (2) mechanical losses occur in obtaining the gluten; and (3) if the flour is first extracted with distilled water from 0.1 to 0.3 per cent of gliadin nitrogen is dissolved.

Because of the important part which gliadin takes in bread-making, a separate series of gliadin nitrogen determinations was made with six samples of flour in the following way: Five grams of flour were weighed into a flask, 250 cc. of 70 per cent alcohol added, and the flask shaken at half hour intervals for three hours. The alcohol was left in contact with the flour for fifteen hours; 100 cc. of the filtered solution was then measured into a Kjeldahl digestion flask which was connected with a condenser, and the alcohol distilled. The nitrogen was then determined in the usual way. The results were as follows:

TABLE LXXXVI. Gliadin Nitrogen in Wheat Flour.

	Gliadin Nitrogen.	Total Nitrogen.	Gliadin Nitrogen in Total Nitrogen.
	Per Cent.	Per Cent.	Per Cent.
Patent flour	1.23	1.95	63 09
Patent flour	1.26	1.96	64.28
Soft white winter wheat flour	1.075	1.455	73.90
Straight flour	1.30	2.10	61.91
Baker's flour	1.40	2.40	58.34
Red Dog flour	.914	3.67	24.91

It is to be observed that in the red dog or lowest grades of flour there is 50 per cent more total nitrogen than in the lowest grade of bakers' flour and nearly 90 per cent more than in the patent flour, but the gliadin nitrogen content of the red dog flour is only 24.91 per cent of the total nitrogen, while in the first patent flour it is 63.09 per cent. The patent flour from soft winter wheat contained the highest proportion of gliadin of any of the samples. The dough made from this flour was very sticky and the bread was of poorer quality than that produced by the flour with a gluten containing 63.09 per cent gliadin. It would appear that the high per cent of gliadin was the cause of the sticky character of the dough.

In the examination of hard and soft wheats, reported in bulletin No. 54, from this station, a marked difference in the gliadin-glutenin ratio was observed. The gluten from the best types of hard winter wheat contained approximately 60 per cent gliadin and 40 per cent glutenin, while the soft wheats contained a higher per cent of gliadin and a lower per cent of glutenin. The same general ratio of gliadin to glutenin is observed in the flours made from hard and soft wheat, the flours, however, contain a higher relative per cent of gliadin than the wheats.

In a high grade patent flour, made from Scotch Fife (spring) wheat, the several proteids are present in about the following percentage amounts:

	Per Cent.
Albumin	0.3
Globulin	0.9
Proteose body	0.2
Gliadin	6.8
Glutenin	4.5
Total	12.7

SUMMARY.

1. In the milling of wheat a partial mechanical separation of the various proteids takes place. The germ proteids are com-

posed largely of albumin and globulin bodies, while the bran and shorts contain only about 50 per cent of the total nitrogen in the form of gliadin and glutenin. The removal of the bran shorts and germ from the flour in the process of milling results in an increase in the gliadin-glutenin content of the flour, the non-gluten proteids being removed mainly in the offal products.

2. In the patent flour from soft winter wheat 73.90 per cent of the total nitrogen was in the form of gliadin, while in the patent flour made from hard winter wheat an average of 63.68 per cent of the total nitrogen was in the form of gliadin. The sticky character of the dough of the soft wheat was probably due to an excess of gliadin, and a deficient amount of glutenin. A well balanced gluten is composed approximately of 65 per cent gliadin and 35 per cent glutenin.

3. The gliadin-glutenin ratio in the different grades of flour made from the same wheat varies from 25 to 75 in the red dog, to 65 to 35 in the highest patent. The lower grades of flour contain appreciably more protein than the higher grades, but the gliadin and glutenin in the lower grades are not present in the right proportion to form a well balanced gluten, capable of expansion, and able to produce bread of the best physical properties.