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The Distribution of Phosphorus and Nitrogen

1890

THE DISTRIBUTION

OF

PHOSPHORUS AND NITROGEN

IN THE

PRODUCTS OF MODERN MILLING.

BY

ELLEN H. RICHARDS,
INSTRUCTOR IN SANITARY CHEMISTRY,
AND
LOTTIE A. BRAGG, S.B.

[REPRINTED FROM THE TECHNOLOGY QUARTERLY, VOL. III. NO. 3.]

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THE DISTRIBUTION OF PHOSPHORUS AND NITROGEN IN THE PRODUCTS OF MODERN MILLING.

THE wheat product of the United States is now about 500,000,000 bushels annually, while the production of Indian corn is nearly four times this amount. The wheat is mainly used for human food, while Indian corn is largely fed to animals, so that whatever concerns the best use of wheat concerns the human race. Whole wheat has long been considered one of the few perfect foods containing all the elements necessary to healthful life. When the law of civilization (division of labor) required the large mill to replace the family mortar, it became essential to prepare a flour which would bear transportation from the place of manufacture to the place of use. This requirement could be met only by the removal of the germ and the outer coating of bran, both of which contain certain active ferments, which soon begin to act upon the starch, and so cause the flour to spoil. In order to secure the keeping of the prepared flour for an indefinite time, it was necessary to remove both these substances by a process of sifting or bolting.

After chemical analysis showed the germ to be the richest in nitrogenous substances of any part of the grain, and the bran to be richest in phosphates, it was cleverly argued that the sifted flour had lost its high character as a food, and for the past forty years or more white flour, and white bread made from it, have been the targets at which all food reformers have levelled their arrows.

A measure of opprobrium lingers long after the cause of it has been removed. Although the whole process of flour manufacture has undergone a revolution since 1872, and roller milling has, in the larger establishments at least, taken the place of horizontal stone grinding, and thus the character of the products has been materially changed, the same old arguments still serve, and the same abuse of white bread is found in all books upon food.

It was our intention to compare the products of the two processes as to the per cent of phosphorus and nitrogen in the finer grades of flour; but on consultation with the Flour Inspector of the Boston

Chamber of Commerce, Mr. Towne, we found to our surprise that no mills of any considerable size were using the old stones alone, although a few mills were known to use a combination of both methods. Inquiry in all directions failed to bring to our knowledge even a small country mill turning out the old ground and bolted flour, so complete has been the revolution accomplished in eighteen years.

It was then determined to endeavor to obtain a comparison of flour made from winter wheat and from spring wheat, not only as to composition, but as to distribution of the important elements in nutrition.

We are indebted again to Mr. Towne and to Mr. J. O. Frost for the suggestion of the names of manufacturers whose reputation for progressive spirit and scientific method could be counted upon to respond to our somewhat troublesome request, which was nothing less than a set of samples guaranteed to be fair averages of a lot of wheat and of the products of milling, and also the per cent of each product, in order that we might construct a balance sheet of the phosphorus and nitrogen, and determine its proportionate distribution in the various products.

Well aware that this was a great deal to ask, we preferred our request, with some misgivings, to Messrs. E. T. Archibald & Co., of Dundas, Minnesota, for samples of spring wheat, and to Messrs. E. O. Stannard & Co., of St. Louis, for samples of winter wheat. Both these firms responded with the greatest courtesy and cordiality, and we take great pleasure in acknowledging our indebtedness to them.

Since these samples are from mills not included in the Bulletin of the Department of Agriculture, "An Investigation of the Composition of Wheat and Corn," by Clifford Richardson, the results have an additional value.

The samples came directly from the mills, in little sacks carefully protected, and were put into tightly closed jars as soon as they reached the laboratory.

The samples of St. Louis winter wheat comprised

Whole Wheat,	Low Grade Flour,
Royal Patent Flour,	Middlings,
Extra Fancy Flour,	Bran.

The samples of Minnesota spring wheat comprised

Whole Wheat,	Low Grade Flour,
Patent Flour,	Shorts,
Bakers' Flour.	Bran.

Five determinations were made of the weight of each wheat, the average result being: —

100 grains of St. Louis Wheat weighs	2.64 grams.
100 " Minnesota " "	2.74 "

The analytical work consisted in the determination of the moisture, nitrogen, and phosphorus in all the samples.

The nitrogen was determined by the Kjeldahl process, as follows: —

The flour was weighed out in a small tube with a loop of platinum wire fused in the end of the glass, so that, when weighed, it could be lowered into a pear-shaped digestion flask without leaving any flour on the neck of the flask. Ten cubic centimeters of strong sulphuric acid were then added, and from 0.25 to 0.3 gram of pure mercury. The flask was placed over a low flame and digested until the solution was colorless. At this stage a few crystals of potassium permanganate were added, until a green color remained. When cool, the contents of the flask were transferred to a round-bottomed flask, using 200 c.c. of water free from ammonia to rinse the flask well. Then 15 c.c. of potassium sulphide solution were added, and lastly 80 c.c. of caustic soda, washing down the neck of the flask with water free from ammonia. The flask was then connected with a proper condenser. Twenty-five cubic centimeters of standardized hydrochloric acid solution were run from the burette into a 250 c.c. receiving flask, and water added, if necessary, to seal the exit tube of the condenser, which was of glass with a bulb at the top. About 200 cubic centimeters were distilled off. Into this was run from a burette enough ammonia solution to make it alkaline, as shown by the yellow color of the solution from the methyl orange, a few drops of which had been added. This alkaline solution was then titrated with standard hydrochloric acid solution, to the exact point of neutralization. The flask was saved, and the color of this used as a standard in titrating the duplicate.

The following are the results obtained by this method.

Nitrogen Determinations in Minnesota Spring Wheat and its Products.

	No. of Determinations.	Nitrogen. Average per cent.
Whole Wheat	5	2.236
Bakers' Flour	7	2.403
Patent Flour	9	2.099
Low Grade Flour	8	2.594
Shorts	8	2.784
Bran	6	2.552

Nitrogen Determinations in St. Louis Winter Wheat and its Products.

	No. of Determinations.	Nitrogen. Average per cent.
Whole Wheat	6	1.875
Extra Fancy Flour	6	1.787
Royal Patent Flour	7	1.396
Low Grade Flour	5	2.084
Middlings	6	2.738
Bran	6	2.622

To determine the moisture in the wheat and flour several methods were used, with varying success. It was first attempted to dry the samples in tubes made from test tubes, which fitted closely so as to make a nearly air-tight joint. The tubes were placed in a sack which held the covers also, and dried at 110° C., and cooled over calcium chloride. The results were uniform, but in all there was a gain at the third or fourth weighing. After some experiments in drying in an atmosphere of hydrogen, it was decided to adopt an arbitrary method mentioned in one of the Bulletins of the Agricultural Department.

The sample was weighed between watch-glasses, the cover and clip were removed and left in the desiccator, while the flour was put in the hot closet for two hours, then taken out, covered, and cooled in the desiccator for fifteen minutes, weighed, the cover removed, and put back for half an hour. This process was repeated until a constant weight was obtained or the flour showed signs of oxidation. With this conventional method good agreeing results were obtained.

Moisture in St. Louis Wheat and Products of Milling.

	Per cent.
Whole Wheat	12.85
Extra Fancy	12.51
Royal Patent	13.37
Low Grade	11.94
Middlings	11.21
Bran	12.15

Moisture in Minnesota Wheat and Products of Milling.

	Per cent.
Whole Wheat	11.09
Patent	12.29
Bakers'	12.14
Low Grade	11.47
Shorts	11.27
Bran	11.23

In the determination of phosphorus in wheat, there has often been doubt expressed whether the phosphorus found in the ash represents the total phosphorus in the wheat. The possibility of losing phosphorus in the incineration naturally suggests itself, but no experiments have been made, as far as we know, to determine whether there was actually any loss under these conditions.

A large number of phosphorus determinations were made on the same sample of flour, by treatment with nitric acid and by fusion with acid potassium sulphate. The results thus obtained were not found to be higher than when the ash of the flour was used, showing that there is no loss in the incineration.

Following are the methods and results of this investigation.

About 2 grams of the flour were heated in a covered beaker with nitric acid of 1.4 sp. gr. until the residue of the evaporation was white; this required many hours, and a large excess of nitric acid. This white residue, dissolved in nitric acid, was precipitated by ammonium molybdate, and the solution of the yellow precipitate treated, as usual, by magnesia mixture.

In the bisulphate process, 2 grams of the flour were intimately mixed with 50 grams of potassium bisulphate, in a large platinum crucible, and a layer of the bisulphate put on top of the mixture. On heating the crucible for about twenty minutes with a good Bunsen burner, the flour is completely burned, and a perfectly white mass remains. This is porous, and disintegrates and dissolves readily in water. To the watery solution was added, when boiling, 20 c.c. acetic acid 1.04 sp. gr., 25 c.c. ammonia 0.96 sp. gr., and 5 c.c. of a solution of ferric chloride containing about 10 milligrams of metallic iron to the cubic centimeter. The precipitate of basic ferric acetate containing all the phosphoric acid was filtered off (after settling), dissolved in nitric acid, and the phosphoric acid precipitated by molybdate solution. A blank analysis gave the phosphoric acid in the reagents used.

The ash of the flour was obtained by igniting in a platinum dish in a muffle, or over a Bunsen burner. The ash was fused with a little sodium carbonate, the silica separated by evaporation with hydrochloric acid, and the phosphoric acid precipitated directly by magnesia mixture, using a little nitric acid to keep up any iron or alumina that might be present.

The results obtained by these processes on a sample of "pastry" flour, source unknown, were as follows: —

	Per cent of Phosphorus.		Per cent of Phosphorus.
Nitric Acid Method,	0.13	Ash,	0.12
" "	0.13	"	0.11
" "	0.13	"	0.11
" "	0.13	"	0.12
Potassium-bisulphate Method,	0.12	"	0.11
" " "	0.11	"	0.12
" " "	0.11		

The following tables give in a condensed form the results of the analyses of the two samples of wheat, and the products derived from them, and a balance sheet deduced therefrom.

St. Louis Winter Wheat.	Water.	Phosphorus.	Nitrogen.	Minnesota Spring Wheat.	Water.	Phosphorus.	Nitrogen.
	Per cent.	Per cent.	Per cent.		Per cent.	Per cent.	Per cent.
Whole Wheat	12.85	0.262	1.87	Whole	11.09	0.230	2.24
Royal Patent	13.37	0.051	1.39	Patent	12.29	0.050	2.10
Extra Fancy	12.51	0.100	1.78	Bakers'	12.14	0.091	2.40
Low Grade	11.94	0.100	2.08	Low Grade	11.47	0.192	2.59
Middlings	11.21	0.225	2.73	Shorts	11.27	0.560	2.78
Bran	12.15	0.828	2.62	Bran	11.23	0.830	2.55

BALANCE SHEET.

St. Louis Winter Wheat.

	Pounds.		Pounds of Phosphorus.		Pounds of Nitrogen.	
Whole Wheat . .	....	100	....	.262	....	1.87
Royal Patent . . .	22.72	....	0.0116	....	0.3158	....
Extra Fancy . . .	39.76	....	0.0397	....	0.7077	....
Low Grade . . .	8.52	....	0.0085	....	0.1772	....
Middlings	3.26	....	0.0073	....	0.0889	....
Bran	24.47	....	0.2066	....	0.6411	....
Total . .	....	98.73	....	.273	....	1.93
			Per cent of total Phosph.		Per cent of total Nitrog.	
In the three grades of Flour	....	....	22.2	....	62.2	....
Middlings and Bran	....	....	77.8	....	37.8	....

Minnesota Spring Wheat.

	Pounds.		Pounds of Phosphorus.		Pounds of Nitrogen.	
Whole Wheat . .	....	100	....	.230	....	2.24
Patent	51.50	....	0.0257	....	1.0815	....
Bakers'	17.50	....	0.0159	....	0.4200	....
Low Grade . . .	3.50	....	0.0070	....	0.0906	....
Shorts	11.00	....	0.0616	....	0.3058	....
Bran	15.50	....	0.1286	....	0.3952	....
Total . .	....	99	....	.238	....	2.29
			Per cent of total Phosph.		Per cent of total Nitrog.	
In the three grades of Flour	....	....	20.4	....	69.5	
Shorts and Bran .	....	....	79.6	....	30.5	

This balance sheet defines the position of fine white flour very clearly. It shows that hard spring wheat gives a flour rich in nitrogen, 69.5 per cent of the total being saved in the three grades of flour. Winter wheat does not show quite as well: not only is there more bran, but it is richer in nitrogen. Nevertheless 62.2 per cent of the total nitrogen is saved. There is, therefore, no need to eat whole wheat bread in order to obtain a food rich in nitrogen.

Quite another story is told by a study of the proportion of phosphorus. The two varieties of wheat more nearly approach each other, but the spring wheat loses 79.6 per cent, and the winter wheat 77.8 per cent of its total phosphorus. Here then, is the bone of contention. The fine white flour is sadly deficient in phosphorus, but is the phosphorus which is contained in the bran available for human food? According to the latest experiments of Professors Voit and Rübner in Munich, it would seem that not only is the bran quite indigestible, but that by its irritating action it causes a loss of both nitrogen and carbo-hydrates which would be available in its absence.

It would seem, therefore, fair to conclude that the bread made from fine flour which is most tempting to eyes and palate may, after all, be the one best adapted to the needs and conditions of the human system.