THE COMPOSITION OF PREPARED CEREAL FOODS.

BY THE CHEMIST.

Bulletins will be sent free upon request. Address: Director Experiment Station, Laramie, Wyo.
Wyoming Agricultural Experiment Station.

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The Composition of Prepared Cereal Foods.

E. E. SLOSSON.

The introduction and extended use of the prepared cereal foods, ordinarily classed as "breakfast foods," amount to a veritable revolution in the food habits of the nation. Not many years ago the only foods of this character in use were hominy, rice and, later, cracked wheat. Oatmeal was almost unknown. Now, however, a great variety of cereal foods is in common use in almost all parts of the country and the market is flooded with package preparations of wheat, oats and corn, rivalling each other in ornateness of wrapper, novelty of name and ingenuity in advertising. The first foods of this character to be introduced were poorly prepared and required a long time and considerable skill to properly cook them but improved methods of milling have now produced many excellent cereal foods prepared for the table and already partly cooked. On account of the extravagance of the claims made for these foods and the wide difference in character and price it seemed desirable that some analyses should be made to show their real and relative value. Accordingly samples of all the prepared cereal foods to be found in Cheyenne and Laramie were purchased and analyzed with the results given in Tables I. and II.

EXPLANATION OF TERMS.

As this is the first bulletin issued from the Wyoming Experiment Station on the subject of foods a popular explanation of the meaning of the technical terms used and some discussion of the relative value of food constituents may be necessary.

Food is used in the body for two purposes, to supply the waste of the materials of which it is composed,
and to supply the necessary energy for its operations and movements. To meet these two requirements by food which shall be of agreeable flavor and not excessive in quantity or cost is the unconscious object of our choice of food. The three most important constituents of food are protein, carbohydrates and fats.

Protein differs from the other two classes in that it contains nitrogen, one of the essential elements of the human body, which can only be obtained in this form. The proteid compounds are often called albuminoids and form the principal part of lean meat and egg albumen. If one chews a mouthful of wheat for some time without swallowing it there will be left a gummy mass known as gluten, the most important form of protein in grains. Protein is the most expensive of the constituents of food.

The carbohydrates include what we know as starches and sugars. They contain no nitrogen so cannot enter into the composition of the muscles of the body but they have about the same value as sources of energy as protein and, being the cheapest food, they constitute the principal part of our diet. The carbohydrates of cereals are mostly in the form of small hard starch grains which are not easily attacked by the digestive fluids. By cooking these grains are broken into powder and the starch is partly changed into the more soluble and digestible forms of dextrin and glucose. In prepared cereal foods the starch grains have been crushed and partly converted into soluble forms by means of heat, pressure and moisture, thus lessening the time needed for cooking. The amount of these soluble starches and sugars has been determined by dissolving them in cold water and is reported in a separate column from the carbohydrates insoluble in cold water. Fiber is the woody portion of the grain. It is entirely indigestible by man and is therefore separated from the nutritious carbohydrates, the sugars and starches. Although it is of no food value yet it is not ob-
jectionable in the small quantity found in prepared cereals and it is not certain that it would be of advantage to free food absolutely from indigestible matter.

Fats, under which term are included all the oily matter of the grains, are similar in composition to carbohydrates but are a more concentrated form of food since they give two and a half times as much energy to the body as the carbohydrates and protein.

The mineral or earthy matter of food is reported under the name of "ash" or the incombustible portion of the grain. It includes a large number of elements such as potash, soda, lime, magnesia, sulphur and chlorine which are necessary for both bone and flesh but as there is usually no deficiency in any of these the analysis need not be carried further. Phosphorus, which is partly included in the ash, is an element of such importance that special efforts are made in milling to secure it. It forms seventeen per cent of the mineral matter of the bones and the body of a man contains about a pound and a quarter of it.

The water in foods of course is of no value, but to make food absolutely dry would be both expensive and undesirable. As the percent of water is so variable it is difficult to see the relative values of different foods by comparing the percent given in the complete analysis. For that reason the analytical results have been calculated to a water-free basis in Table II.

Fuel Value.—The compounds of hydrogen and carbon, which form most of our food, are transformed by their use in the body into carbonic acid and water just as they are by burning in air, consequently the same amount of energy in the form of heat or labor is obtained from them by using as fuel in a stove or as food in the body. The chief use of food is to supply energy to our bodies for warmth and work and the amount of energy to be obtained from any kind of food can easily be determined by burning a sample of it un-
under such conditions that the amount of heat produced can be measured accurately. Nitrogenous foods are not consumed so completely in the body as by burning and therefore do not give quite so much energy but the difference is known and can be allowed for.

METHODS OF ANALYSIS.

The methods used in these analyses are those adopted by the Association of Official Agricultural Chemists with the few variations here noted. All determinations were made in duplicate except some of the ash, phosphorus and fuel value estimations. Air was used as a drying medium instead of hydrogen. The determination of water-soluble carbohydrates was made to estimate the amount of previous preparation or cooking the food had undergone. After a good deal of experimenting the following method was adopted which is rapid and sufficiently accurate for the purpose. Ten grains of the food were treated with 100cc of cold water in a stoppered wide-mouthed bottle, allowed to stand with occasional shaking for twelve hours and then for twelve hours without shaking, filtered through a folded filter and measured. To this solution which amounts to 50 or 80cc and usually gives a purple reaction with iodine, ten per cent of its volume of hydrochloric acid is added and it is heated on a boiling water bath (at a temperature of 93 degrees here) for two hours. Then it is neutralized, measured and the determination made with Fehling's solution. In this way a solution of the proper strength is obtained with evaporation. Duplicates made at different times agree to one-tenth per cent. The fuel values were determined by combustion in Mahler's bomb calorimeter. A description of the apparatus and the determination of its water value may be found in a special bulletin on "The Heating Value of Wyoming Coal and Oil," published by the University of Wyoming in January, 1895. Readings were made with a tele-
scope to one-thousandth of a degree. The oxygen was passed through a red hot tube to prevent traces of oil being carried over from the pump.* The fuel value as determined by the calorimeter is almost always a little higher (one to five percent) than that calculated from the composition by the use of Stohmann’s factors,† 4.2 for starch and cellulose, 9.5 for fats and 5.7 for protein. The factors for carbohydrates since they are of known substances easily extracted are probably correct and constant, that for fats is less so, while the factor for protein is based on very insufficient evidence and is undoubtedly wrong in some cases. With such foods as these it is probably too low, as 5.9 gives better results, but our knowledge of the proteids is too incomplete and our method of determining them too inexact to decide upon a constant, if such were possible. Calorimetric determinations are now exact enough to afford some guide to composition.

*Stohmann, Kleber und Langbein, Journal für praktische Chemie, 39, 513.
†Zeitschrift für physikalische chemie, 10, 410, and 6, 354. Experiment Station Record, 6, 590.
<table>
<thead>
<tr>
<th>No.</th>
<th>NAME.</th>
<th>Water, per cent.</th>
<th>Fat, per cent.</th>
<th>Protein, per cent.</th>
<th>CARBOHYDRATES.</th>
<th>Ash, per cent.</th>
<th>Phosphorus, per cent.</th>
<th>Fuel Value, calories per gram.</th>
<th>Price per pound, cents.</th>
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<td>Total per cent.</td>
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<td>Fiber, per cent.</td>
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<td>14.17</td>
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Table II.—Composition of Prepared Cereal Foods Calculated as Water-Free.

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<th>No.</th>
<th>Name</th>
<th>Fat, per cent.</th>
<th>Protein, per cent.</th>
<th>Carbohydrates</th>
<th>Ash, per cent.</th>
<th>Phosphorus, per cent.</th>
<th>Fuel Value, calories per gram</th>
<th>Price per pound, cents</th>
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<td>Total per cent.</td>
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<td>Fiber, per cent.</td>
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*The Composition of Prepared Cereal Foods.*
Description of the Foods.

The names of the foods analyzed and of the manufacturers are given below together with quotations from the advertisements setting forth the special claims of the preparations. The price given is the cost of a single package in Laramie or Cheyenne. When different stores charge different prices, as is frequently the case, the lowest price is taken.

No. 1. Wheatena, manufactured by Health Food Co., N. Y. “Made from white wheat, the bran coats are removed and by a peculiar process the starch is converted into a soluble substance. Can be perfectly prepared for the stomach by simply adding it to boiling water or to cold or hot milk without any cooking whatever. Rich in phosphatic elements, abundant in nitrogen, deficient in starch.”

Size of package 4x3x$\frac{5}{4}$. Price 30 cents. Weight of contents 32.5 ounces.

No. 2. Cerealine Flakes. Cerealine Manufacturing Co., Columbus, O. “Prepared from pure white maize. Will cook in one minute.” Package $5\frac{1}{2}x8\frac{1}{2}x5\frac{1}{2}$. Price 15 cents. Weight of contents 25.8 ounces.

No. 3. Wheat Manna. Centennial Mills, Spokane, Wash. “From the choicest white wheat; hulls removed, leaving pure white berry; easily digested; cook ten minutes.”

Package $8x4\frac{3}{8}x4\frac{3}{8}$. Price 15 cents. Weight of contents 26.8 ounces.

No. 4. Quaker Rolled White Oats. American Cereal Co., Chicago. “Owing to our peculiar methods of manufacture we do not sacrifice the sweetness and flavor of the oat for the sake of rapid cooking.” “Boil twenty minutes or more.”
Package 4x4x8 inches. Price 15 cents. Weight of contents 30.6 ounces.

No. 5. Hornby's steam-cooked three-minutes Oatmeal. Manufactured by the Clover Mills, Buffalo, N. Y. "Analysis prove these Oats to possess a larger proportion of brain and muscle producing elements than any vegetable, flesh or other cereal food now used by man." "Analysis, Nitrates, 19.39, Carbohydrates 73.27, Phosphates 3.34, Water 4.00."

Package 3½x3x7½ inches. Price 25 cents. Weight of contents 31.2 ounces.

No. 6. Pettijohn's California Breakfast Food. American Cereal Co., Chicago. "From wheat, hulls carefully removed, leaving nutritious and no irritating parts." "Boil fifteen minutes or more."

Package 4½x4½x8 inches. 15 cents. Weight of contents 31.4 ounces.


Package 2½x4x7 inches. 20 cents. Weight of contents 30 ounces.

No. 8. F. S. Pure Wheat Farinose. American Cereal Co., at F. Schumacher Mills, Akron, O. "Made from the most nutritious parts of wheat and is rich in gluten, nitrates and other properties necessary for the nourishment of the muscles, nerves and bones." "Boil ten minutes."

Package 1½x3x6 inches. 15 cents. Weight of contents 15.1 ounces.


Package 4x2½x7 inches. 15 cents. Weight of contents 31.4 ounces.

Package 4x4x8½ inches. 25 cents. Weight of contents 54.2 ounces.


Package 4x4x8 inches. 10 cents. Weight of contents 31.8 ounces.


Package 4x4½x8 inches. 10 cents. Weight of contents 32 ounces.


Package 8x5x4 inches. 15 cents. Weight of contents 31 ounces.


No. 16. Ralston Health Club Breakfast Food. Purina Mills, St. Louis, Mo. “The Ralston Health Club in analyzing the various breakfast foods on the market found one that proved to be the only perfect and by far the most healthful breakfast food in the country.” “Cook in five minutes.”

Package 5x2½x7. 20 cents. Weight of contents, 31.6 ounces.
No. 17. Durkee’s Glutena Food. E. R. Durkee & Co., N. Y. “Of the various elements composing wheat, the nitrates, viz., gluten and fiber, form about 15 per cent, the phosphates 2 per cent, the remainder consists of about 70 per cent of carbonate of starch and about 13 per cent of water.” “Glutena consists entirely of the gluten and phosphates of wheat.” “Boil ten minutes.”

Package 3¼x2x6. 15 cents. Weight of contents 18 ounces.


Package 4x2½x7. 15 cents. Weight of contents 30.1 ounces.


Package 8x4½x4½. 15 cents. Weight of contents 28.9 ounces.


Package 5x3x8, 10 cents. Weight of contents 32.4 ounces.

No. 21. Velvet Meal, Quail Brand. Nebraska City Cereal Mills, Nebraska City Neb. “One pound of properly prepared corn meal is more than equivalent to two pounds of fat meat.”

Package 4x3½x7, 10 cents. Weight of contents 38.8 ounces.
Discussion of Results.

The chemical analyses and examination of the starch grains with the microscope showed no evidence of the presence of foreign cereals, so adulteration may be regarded as absent in foods of this class.

The packages are generally short weight but only in a few cases was there such a discrepancy between the actual weight of contents and that marked on the wrapper as to indicate an intentional fraud.

Leaving aside the customary claims of each food to be the best in the market and considering only the more specific statements of composition, food value, etc., it may be said that these are in many instances entirely unreliable and misleading as to the real character of the food. When the general public becomes better educated on the subject of foods we may expect advertising to take the form it already has taken in many other industries, that of an attractive and intelligent presentation of the real merits of the article. If purchasers of goods in packages and cans would always note the brand and afterwards buy according to the quality, it would be a good encouragement to honest manufacturers and the grade of such foods would no doubt be raised. The chief advantages of package goods is that the manufacturer is made directly responsible to the consumer.

It will be seen that there is more variation in price than in composition, and that there is no discoverable relation between quality and price. Some articles are four or five times the cost of others of the same class and apparently of the same merit. It is quite evident who pays for the beautiful advertisements that form the bulk of our magazines. At the same time it is not the most extensively advertised foods that are the dearest. The oatmeal sold in bulk is practically
the same in composition and, so far as can be judged by personal taste, in quality and flavor as that sold in packages for several times the price. Of course in buying bulk articles one is not so sure of getting the same grade or that the quality has not been injured by long keeping and exposure.

The claims made for quick cooking are generally fallacious. Almost all such preparations should be cooked for at least half an hour and usually longer to insure the complete digestibility of the starch. Except in the case of corn the addition of milk or cream is not needed to supply any deficiency in the foods. Sugar should be used only as a condiment. Most people in the United States eat so much sugar as to quite unbalance a ration already excessive in carbohydrates.

The question that will probably be asked by most people who read this bulletin "Which is the best food?" is one that cannot be answered. There is no "best food." The three grains used have each distinctive and useful qualities. Oatmeal contains more of the valuable ingredients, protein and fat, than the other two and approaches closely in composition to a correctly balanced food. These facts do not, however, exclude the use of wheat and corn preparations which are to many preferable. All that such a bulletin as this can do is to give the data on which the judgment of the reader can form his own estimates of the relative merits of the foods analyzed. Human food is generally selected on account of flavor and this as a question of taste is outside the bounds of discussion. The important question of digestibility and wholesomeness is also one which every man must settle with his own stomach. The older investigations on this subject are quite misleading. Not every man has a stomach like Alexis St. Martin's or Brown-Sequard's, still less like a test tube in a water bath. Recent experiments are giving more reliable results but individual differences are so important that the choice of food cannot be ultimately
decided by the application of general principles. About 85 per cent of the protein, 90 per cent of the fat and 98 per cent of the carbohydrates in cereals are digestible.* Composition cannot be taken as a perfect guide to the real value of a food. One series of experiments on the digestibility of whole wheat flour and fine flour showed that a less amount of the valuable constituents was digested from the whole wheat than from the fine flour although the former was superior in composition.† The popular articles in the newspapers on dietetics are for the most part misleading, either because they are premature judgments based on insufficient data or because they are written in favor of some food fad. Those interested in the subject may get reliable information from the bulletins of the Department of Agriculture at Washington and reports of experiment stations and kitchens. [Farmer’s Bulletin No. 23 on “Foods, Nutritive Value and Cost,” Farmer’s Bulletin No. 34 on “Meats; Composition and Cooking.” Bulletin No. 24, Office of Experiment Stations on “Chemistry of Food.” Also magazine articles by Prof. Atwater and others as in the Century for June, 1897.]

*Report of Storrs Agricultural Experiment Station, 1896, p. 188.