Maine Agricultural Experiment Station

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CEREAL FOODS.

This bulletin contains a general discussion of the cereal breakfast foods and the results of digestion experiments made with them at this station.

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CEREAL FOODS.

L. H. Merrill.

[In co-operation with the Office of Experiment Stations of the U. S. Department of Agriculture, the Maine and Minnesota Experiment Stations have, during the past ten years, made special studies on the composition and digestibility of cereal foods. The technical results thus obtained are published chiefly in the bulletins of the Office of Experiment Stations. This Station has published two bulletins upon the composition of the breakfast cereal foods that were found in the Maine markets. In the present bulletin Professor Merrill presents many of the general results which have been obtained in the course of this work. While the results of these investigations have been freely used in this bulletin, yet for purposes of definite illustration he has drawn chiefly upon the analyses and digestion experiments made at this Station.—C. D. W.]

Few phases of our modern civilization furnish a more curious and interesting study than the rapid increase in the number and variety of our foods. Among the causes that have contributed to this development may be mentioned: The extension of our commerce, which has placed a constantly increasing range of food materials within our reach; the efforts of our national government, which is actively engaged in the introduction of new food plants, and the production of new varieties of old types; the ingenuity of manufacturers, who have been quick to see that their sales must depend to a great extent upon the variety and attractiveness of their output; and in no slight degree, to an increased knowledge of the functions of food—i. e., the demands of the body, and the methods by which these demands may be met. To these causes may also be added a more or less artificial

demand, encouraged and stimulated by persistent advertising, for foods which may be quickly and easily digested. Perhaps it is a natural outcome of the strenuous age in which we live that the average business man is reluctant to devote the proper time and attention to his meals, with the result that dyspepsia in its various forms has become alarmingly prevalent. There has thus arisen a class of food products whose chief claim upon our attention is their alleged readiness to "slip into the tissues" of the consumer without the usual tax upon the digestive organs.

Just now we are passing through what might very properly be called the epoch of cereal breakfast foods. Never in our history have the cereal foods occupied so prominent a place in our dietaries. Twenty-five years ago practically the only cereal foods to be found upon our American market were wheat flour, corn meal, hominy, and hulled corn. Wheat and oat meals had been introduced by our Irish and Scotch immigrants, but their use was far from general. Barley, rye and rice were used only to a very limited extent. Today a half-hour's canvass of the shops of our large towns or cities would reveal fifty or more preparations of these cereals, most of which present special claims to our attention. Scarcely a week passes that does not see some new cereal claimant to the public favor and the list has grown to embarrassing proportions. Few of the brands appear to be long-lived and it is safe to say that of those on sale today fully one-half will disappear within three years or will survive only on the top shelf of the country grocery, a food for worms rather than for man.

A class of foods that has come to occupy so prominent a place in our dietaries certainly deserves more than a passing consideration. Many of these preparations have been analyzed at this Station and the results published in Bulletins 55* and 84. It is proposed here to study these foods from a more general standpoint. To do this, we must take into consideration not only their chemical composition, but their palatability, digestibility, ease of preparation, relative cost, the claims made for them, and the extent to which these claims are made good.

* Bulletin 55 is no longer available.

CLASSIFICATION.

Notwithstanding the large number and variety of the cereal breakfast foods, the most of them fall readily into one of three groups. In the first of these may be placed those which are prepared by simply grinding the decorticated grain. The second group includes those which have been steamed or otherwise partially cooked, and then ground or rolled. The third group includes all those preparations which have been acted upon by malt, by the action of which a portion of the starch has undergone a chemical change.

The earliest of these foods to come into general use in this country were of the first class, oats being the most widely consumed. While the old fashioned oatmeal found favor with many, there is reason to believe that it was not always welcomed, and in the memories of many of us the morning bowl of "oatmeal mush" went far to temper the joys of childhood. Although the dish possessed many virtues that seemed to adapt it peculiarly to the needs of growing children, the results of its enforced use were not always happy, and it can scarcely be regretted that it has been so largely supplanted by other preparations of oats, wheat, or corn, some form of which is quite sure to appeal to the palate and furnish a pleasing variety. The use of coarsely ground, uncooked wheat, does not seem to have become so general. Corn meal, however, has been widely used, and hominy continues in public favor.

Following the manufacture of the uncooked cereal meals came the foods of the second group, especially the so-called "rolled" oats and wheats. By far the larger part of the breakfast foods consumed today are of this class. The superiority of these goods over those formerly in use is easily demonstrated and will be referred to later.

It is claimed that the malted preparations represent a still greater advance in the perfection of these foods. The methods employed in their manufacture vary somewhat, but they are all based upon the same principle. Barley malt is mixed with the cereal under conditions favorable to the action of the ferment present, the result being that a portion of the starch is converted into a soluble form.

Some of the cereal foods are fully cooked and may be eaten dry without further preparation, or, as many prefer, with the addition of cream and sugar. In a few cases the manufacturers cater still farther to the popular taste by wetting the cereal with a salted or sweetened solution, after which it is again dried and slightly browned. Within a few years a statement has been quite generally circulated that certain foods of this class contain arsenic. Compounds of arsenic are not uncommon in soils; and since plants are unable to exclude many salts which occur dissolved in the water of the soil, it may be readily believed that arsenic may thus find its way into growing crops. The amount of this element which can accumulate in the cereal grains by natural methods is, however, too small to excite our apprehension. On the other hand it is difficult to conceive any motive which should lead to its intentional introduction. The writer has examined a number of samples of goods which for some reason had fallen under suspicion, using the most delicate tests, but always with negative results.

COMPOSITION.

The value of any food must depend primarily upon the kind and amount which they contain of certain proximate principles which experience has taught us are absolutely essential to the maintenance of life and health. The composition of these foods is, therefore, a matter of great importance. The accompanying table gives the average composition of those preparations of corn, oats and wheat which have been collected in Maine markets and analyzed at this Station. For purposes of comparison there is given in the same table the composition of three kinds of flour, all prepared from the same hard spring wheat.

The terms employed here for the most part require no explanation. For the benefit of non-scientific readers a few words regarding the "heat of combustion" may not be out of place.*

One very important function of food is to supply energy to the body, where it is developed in the form of muscular activity, body heat, and probably in mental processes also. It may be stated in a general way that the energy furnished the body by

*The reader is referred to Farmers' Bulletin No. 142, U. S. Dept. Agriculture The Principles of Nutrition and Nutritive Value of Food.

the digested portion of our food is believed to be proportional to the heat produced when an equivalent amount of these foods is burned in the laboratory under such conditions that the heat can be accurately measured. We know that this is not quite true of protein; yet the difference between the physiological and the physical fuel values of this class of bodies is so slight that the latter, which is readily obtained by laboratory methods, serves as a very useful index of the energy-producing power of our foods.

The method employed for determining the heat of combustion consists in burning a carefully weighed portion of the food examined and measuring the heat produced. The unit of measurement is the calorie—the amount of heat that will raise one kilogram (about two and one-fifth pounds) through one degree Centigrade; or, what amounts to nearly the same thing, one pound of water through four degrees Fahrenheit. Other things being equal, then, the food product yielding the highest heat of combustion will, if digested, yield the greatest amount of energy in the body.

Average composition of cereal breakfast preparations compared with wheat flour variously milled.

Number of analyses.		Water.	Protein.	Fat.	Carbohydrates.	Ash.	Heat of combustion.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Calories per gram.
14	Corn meal and hominy*	10.7	8.6	0.7	79.7	0.3	3.854
28	Rolled oats†	8.4	15.6	7.5	66.6	1.9	4.323
35	Rolled wheat†	9.9	12.0	1.9	74.8	1.4	3.966
1	Malted oats†	6.4	16.7	5.4	69.7	1.8	4.318
4	Malted wheat†	6.9	13.3	1.2	77.0	1.6	4.017
4	Graham flour	10.7	14.8	2.3	70.3	1.9	4.029
4	Entire wheat flour	11.4	14.1	2.0	71.5	1.0	3.967
4	Standard patent flour	11.4	13.9	1.4	72.8	0.5	3.959

* Uncooked preparations only.

† Cooked or partially cooked preparations only.

Of the unmalted cereal foods, the oats contain 25 per cent more protein than the wheat preparations, and nearly double that of the corn. The oats also furnish four times as much fat as the wheat and ten times as much as the corn. They are richer in ash constituents and furnish more energy (heat of combustion) than either of the other two grains. The only respect in which oats are excelled by the corn and wheat is in the amount of carbohydrates, the most abundant and least valuable of the nutrients named. Corn in its natural condition contains on the average over 4 per cent of fat. The small amount in the corn meal and hominy is due to the removal of the germ. The wheat products are intermediate in composition between the corn and oats.

The malted foods seem to have been more thoroughly dried than the other products, containing only from 6½ to 7 per cent of water. Otherwise their percentage composition does not vary greatly from that of the same cereals in the unmalted conditions, although there are other differences to be mentioned later.

Analyses made at different times of the same brand show great variations in composition. This is not strange when it is remembered that there are many varieties of these cereal grains, varying much in composition, and that even the same variety will show wide differences in composition according to the character of the season, soil, and fertilizer used. In the manufacture of patent flours the variations are carefully offset by the miller, who first informs himself concerning the quality of the wheats at his disposal, and then by judicious blending of several grades is able to turn out a very uniform product. Equally exact results might be obtained with these goods if the manufacturer found it for his interest to give the matter his study and care. Variations in the composition of these goods are not as easily discoverable as with bread flours, and the composition of the output, except for the limits imposed by nature, becomes largely a matter of chance.

Graham flour is made by grinding the entire wheat kernel. It contains, therefore, everything found in the kernel, including the woody and indigestible outer coatings. The so-called "entire wheat flour" is usually prepared in precisely the same manner, except that it is afterward subjected to a bolting or sift-

ing process by which some of the coarser bran is removed. It is sometimes claimed that only the least valuable portion of the bran is thus rejected, but a study of these products made at this laboratory does not substantiate this claim.* The composition of these flours is precisely what might have been expected. Starch attracts moisture much more than the woody bran. Hence we find the graham flour, which is rich in bran with a correspondingly less amount of starch, drier than the other flours. The aleurone layer, which forms a portion of the bran as usually milled, is very rich in protein. Hence the protein content is greatest in the graham and least in the patent flour. The germ is rich in fat and mineral constituents. Its removal in the patent flour brings down the percentage amount of fat and ash. The oxidation of fat produces more heat than that of any other constituent. Hence the same causes that reduce the amount of fat in the flour lower the heat of combustion. As the protein, fat, and ash fall, the amount of the remaining solids, the carbohydrates, must rise.

In looking over the table of composition one is likely to be impressed with the marked difference between the rolled oats and the other cereals in the amount of fat which they contain. Although corn in the kernel carries about 4 per cent of fat, most of this is in the germ, which in the manufacture of hominy is almost wholly removed, thus reducing the fat to about one-fifth of the original amount. Too much importance should not be attached to this difference in fat content, however, since fats and carbohydrates perform nearly the same function in the animal body, although the fats represent more than double the energy furnished by the carbohydrates.

Since the oxidation of the fats in the body produces heat, oats are often spoken of as "heating" food and their use in warm weather is sometimes discouraged by physicians. This fact might deserve more serious consideration if this cereal made up a larger part of our diet. As a rule they are eaten but once a day. An average serving of cooked rolled oats would be about 160 grams (5½ ounces), seven-eighths of which is water. The equivalent 20 grams of uncooked oats, containing 7½ per cent of fat, would furnish 1½ grams fat, or about one-twentieth of

* Bul. 103, Maine Expt. Station, pp. 68–69.

an ounce. If one were to take daily the amount of oats mentioned (160 grams cooked, or 20 grams dry) he would consume in eight months nearly as much fat as would be furnished by one pound of butter. If it be true that oats are a heating food, the fact cannot be due merely to the excess of fat which they carry.

DIGESTIBILITY.

The analyses of cereal foods show them to be rich in the compounds which are essential to life. It is evident, however, that the composition of our foods is a matter of little importance unless they can be converted into soluble and assimilable forms—that is, unless they are digestible. The experience of unnumbered generations, unassisted by any knowledge of chemistry, has led to the selection of foods which are both rich and digestible. In this list of time-approved foods the cereal grains occupy a deservedly prominent position. It still remains for us to ask if, in the light which modern research can cast upon the subject, it is possible to make a profitable discrimination in our selection from the large and increasing list of cereal products.

The cereals are no exception to the general rule that most vegetable foods require more cooking than those of animal origin. This is in part due to the fact that the composition of the animal foods more nearly approximates that of our bodies and they consequently require less change to fit them for absorption and assimilation. On the other hand, the nutrients of our vegetable foods are for the most part enclosed in small cavities (cells) the walls of which consist of woody matter (cellulose) upon which the digestive juices of man have but little action. The cellulose, therefore, is not only of no value as a food for man, but it prevents the digestive fluids from attacking the cell contents. In the crushing, rolling or flaking processes to which many of these preparations have been subjected, these insoluble cell walls have been ruptured and the cell contents are thus exposed to the action of the digestive juices. It is probable that this mechanical change in the grain is fully as important as the chemical changes which accompany the necessary preliminary softening of the grain by steam. The cereal foods contain from 60 to 80 per cent of carbohydrates, most of which is in the form

of starch. Raw starch, while a valuable food for our farm stock, is digested by man with extreme slowness. This seems to be due in part to the very thin covering, apparently of cellulose, with which each kernel of starch is invested. When subjected to high temperature the starch grains swell and burst, very much as a grain of corn "pops" under similar conditions. At the same time a portion of the starch—the amount varying with the temperature and the duration of the heating process—undergoes a chemical change. Whereas raw starch is practically insoluble in cold water, prolonged heat converts it into dextrin, a soluble carbohydrate into which all starch must be changed before it is transformed into a sugar, in which form only it can be absorbed.

The conversion of starch into a soluble form may be accomplished by other means. During the germination of the cereal grains the large amount of starch there stored up is converted into maltose, a soluble sugar, through the action of a ferment (diastase) which is there produced for this special purpose. The amount of the ferment formed is much more than is required to transform the starch of the barley itself. Advantage is taken of this fact in the use of malt, so extensively employed in breweries. This malt is produced by causing barley to sprout, the germinating process being checked when the amount of the ferment is greatest. If a quantity of malt be mixed with a cereal food under conditions favorable to the action of the ferment, a "malted" or predigested food results.

It would appear from the advertising matter that many manufacturers attach great importance to the conversion of the cereal starches into soluble forms. No attempt has been made in these laboratories to determine how far the efforts to accomplish this end have been successful. The matter has received attention elsewhere,* however, and the results are of interest. The table given below shows the amount of dextrin found by McGill in eight different cereal products.

Perfectly sound and untreated cereal grains contain practically no dextrin or maltose. Their presence in these foods is due to the action of heat or malt upon the starch. McGill found that the Ralston Breakfast Food (a rolled wheat) and rolled oats contained but small amounts of dextrin; while in Force and Grape-Nuts from one-fifth to one-third of the total starch had been dextrinized.

Relative percentages of starch and dextrin in certain cereal breakfast foods.

	Starch.	Dextrin.	Extent of dextrinization.
	%	%	%
Corn meal	69.5	.....	.....
Oat meal	63.8	.....	.....
Rolled oats	60.5	3.6	5.6
Ralston breakfast food	67.9	2.6	3.7
Malt breakfast food	71.7	3.2	4.3
Malta vita	62.4	9.3	13.0
Force	55.4	14.5	20.7
Grape nuts	49.5	24.9	33.5

*A. McGill, Bul. 84, Laboratory Internal Revenue Department, Ottawa, Canada.

How far is the value of these foods proportional to the solubility of the carbohydrates which they contain? This is a difficult question to answer, since the operations that bring about the desired mechanical changes in the starch at the same time induce chemical changes. It is safe to say that the average person in good health is able to digest starches in which there has been but little dextrinization, provided the starch grains have undergone the exfoliation or "popping" previously alluded to. The figures just quoted reveal the presence of but little dextrin in the ordinary rolled wheat or rolled oats as purchased. In the cooking to which they are afterward subjected dextrin is produced in much larger quantities. We may conclude, therefore, that the dextrinization of these goods by the manufacturers is in itself of little importance, so far as the digestibility of the food is concerned, unless the preparations are to be eaten without further cooking.

There is no evidence that maltose as a food is of any more value than dextrin. So far as the writer is aware, the amount of this sugar in the malted foods has never been determined. It is probably not large, since the long continued action of the ferment by which it is formed would produce undesirable flavors.

The housewife finds a material gain in time in the use of cooked or partially cooked cereals. Do these preparations possess any advantage other than those already mentioned over the raw goods? In other words, if the purchaser obtains the uncooked cereals and devotes the necessary care and time to their preparation, does not the final product possess all the virtues of the prepared goods?

This, too, is a difficult question to answer, inasmuch as the opportunities for comparison are few. There are very few cereal breakfast foods now on the market that have not been subjected to some cooking process. Steaming, which results in a partial cooking, is a necessary preliminary to the rolling to which so many of our cereal foods have been subjected. Indeed, with the single exception of hominy, there is scarcely a wholly uncooked cereal breakfast food to be found upon the market. Out of 28 oat preparations examined at this station, only three were entirely raw, and one of these was an imported article. So far as relates to the difference between the old fashioned, wholly uncooked wheat and oat meals and the modern rolled articles, it may safely be stated that the important difference is mechanical rather than chemical.

During the past few years a series of experiments have been carried out at the experiment stations of Minnesota, Connecticut (Storrs), and Maine, for the purpose of determining the digestibility of certain cereal foods. In some of these experiments the food consisted exclusively of cereal foods, cream and sugar; in other cases the cereals were used with a mixed diet, including bread and meat, but in which the cereal still played a very important part. Since the digestibility of cream and sugar have been quite accurately determined, it is possible, where the simpler diet is used, to calculate the digestibility of the cereal alone with a considerable degree of accuracy.

The details of these experiments will be found elsewhere, but the general results of those obtained at this Station are given in the table below. This shows the digestibility of the organic matter of the food—i. e., the dry matter of the food less the ash or mineral constituents; the digestibility of the protein, one of the most important classes of the necessary constituents of our food; and the percentage of the heat of combustion utilized by the body.

Digestibility of cereal breakfast foods as determined by digestion experiments.

Diet.	Number of experiments.	Total organic matter.	Protein.	Heat of combustion.
		Per cent.	Per cent.	Per cent.
Rolled oats with a mixed diet	17	96.2	90.1	95.3
with a simple diet	16	95.4	84.7	94.2
alone	16	92.3	78.4	89.8
Rolled wheat with a mixed diet	3	96.2	93.2	95.3
with a simple diet	3	95.2	91.6	94.6
alone	3	92.4	85.0	90.7
Force with a mixed diet	3	95.7	92.7	95.2
with a simple diet	3	94.6	89.6	91.1
alone	3	90.4	76.1	88.3
Grape-Nuts with a mixed diet	3	96.6	92.8	95.6
with a simple diet	3	94.0	87.6	93.1
alone	3	91.7	76.1	89.4
Shredded Whole Wheat with a mixed dlet	3	95.5	92.1	94.5
with a simple diet	3	92.8	84.1	91.4
alone	3	87.7	57.7	84.1
Hecker's Hominy with a mixed diet	4	97.1	88.9	96.3
with a simple diet	4	97.3	83.6	96.4
alone	4	-	74.5	94.4
Granulated corn meal, mixed diet	2	97.2	89.0	96.9
with a simple diet	4	97.2	82.3	95.9
alone	4	-	73.2	93.1

An inspection of the table shows that where the cereals were used with a mixed diet, they had but little apparent effect upon the digestibility of the total food. As regards the digestibility of the total organic matter, the corn products made a very favorable showing. At the same time a larger proportion of the energy of the food was utilized by the body than where the wheat and oat products were used. On the other hand, the use of the corn foods seemed to depress the digestibility of the protein of the total food.

When the simple diet was used, the corn products again made a favorable showing as regards both total organic matter and energy, least favorable of all, however, in digestibility of protein. If we value these foods in proportion to the digestibility of their protein when used with a mixed diet, we must place rolled wheat first and the corn products last. When the digestibility of the cereals alone is calculated, more striking results are obtained. It will be noticed that the rolled wheat now ranks

first, not only in the digestibility of the total organic matter, but also with respect to the protein. The rolled oats rank next, and the corn preparations and shredded wheat the lowest of all.

One of the most noticeable differences in these cereal foods is found in the digestibility of the protein when the cereal is eaten with a simple diet. This difference is most marked in the various wheat products, especially when the results are calculated to the cereal alone. Thus, while the protein of rolled wheat is 85 per cent digestible, that of Force and Grape-Nuts is 76.1 per cent, and that of Shredded Whole Wheat only 57.7 per cent.

It is not claimed that the results given in the table for the cereal alone exactly represent the proportion of these foods which becomes available to the body when they are eaten under ordinary conditions. No one subsists on these cereals alone, and the conditions are therefore abnormal and the results exaggerated. It is fair to assume—and the assumption is quite in accordance with the results of other experiments recorded elsewhere—that most articles of food are more fully digested when eaten with a mixed diet than when eaten alone. On the other hand, there can be no doubt that these figures correctly indicate the *relative* digestibility of the foods studied. The brands named were chosen for these experiments merely because they were well known articles and representative of the groups indicated.

McGill found (see table, p. 125) that the rolled wheat which he examined contained only 2.6 per cent dextrin, while Force and Grape-Nuts contained 14.5 and 24.9 per cent respectively. These facts suggest that the processes to which these latter products have been submitted to render the starch soluble have at the same time diminished the digestibility of the protein.

This conclusion seems to be confirmed by Snyder in a study upon the comparative digestibility of bread and toast.* He found that the toasting of bread "changes the form and solubility of the nutrients, particularly of the carbohydrates, to a much greater extent than it does the percentage amounts. Dur-

* Minnesota Expt. Station, Bul. 74, p. 166.

ing the toasting process, a portion of the starch was changed to dextrin, a soluble carbohydrate. The proteid compounds also suffered changes in composition, but opposite in character from the carbohydrates; tests showed that the proteids were rendered less soluble, while the carbohydrates were rendered more soluble."

Further confirmation is found in the work of Colby of the California Experiment Station upon toasted bread. He found that "brown toast made at 170° shows a sudden large increase of soluble matter, more than doubling that obtained at 150°. But there is at the same time a notable decrease in the amount of soluble nitrogenous matter as compared with the extract from the raw bread."*

While differences in the treatment may account for variations in the digestibility of the protein of the wheat products, it throws no light upon the difference noticed in the digestibility of the proteids of the various grains. These may be due to intrinsic differences in the nature of the proteids themselves.

Gudeman† found that the raw cereals, if sufficiently cooked, were as quickly digested as the best malted cereals, more quickly than the prepared cereals and a large majority of the so-called malted cereals.

CLAIMS OF MANUFACTURERS.

The claims made for some of the cereal foods are so absurd that any mention of them seems almost superfluous. It may be said in general that there is but little waste or indigestible matter in the decorticated kernel of our cereal grains. Beyond the removal of the outer coatings and the expulsion of a possible excess of water, little or nothing can be done to condense them. There is no mysterious alchemy known to millers whereby the cereal grains may acquire the marvelous nutritive qualities ascribed to many of them. The various methods by which they are prepared may render the starch more soluble or convert it into other and more soluble forms. Whether at the same time the foods gain in digestibility is another question which has been already discussed.

* California Expt. Station, Rept. 1901-3, p. 101.
† Journal Am. Chem. Soc., 26 (1904), p. 323.

The advocates of these foods lay much stress upon the large amount of mineral constituents (ash) which they are said to contain, and which are so largely lacking in white flour. Phosphorus is formed in the brain and other tissues; phosphorus and lime are especially abundant in the bones; iron occurs in the hemoglobin of the blood. These elements are much more abundant in the seed coverings and in the germ of the cereal grains than in the endosperm. The oat and wheat breakfast foods contain from 1½ to 2 per cent of ash constituents, graham flour carries an equally large amount, while patent flour contains only about one-half of one per cent. Hence it is said that we should eat the coarser flours; or, if we persist in eating bread of patent flour, we should supplement our diet by the use of cereal breakfast foods.

If there is any force in this argument, it lies in these two assumptions: First, that white flour as now milled no longer contains enough ash constituents to satisfy the needs of the body. Second, that bread flour and the cereal breakfast foods are the only sources from which the body may derive mineral matters. In point of fact, an average diet, even though it does not include coarse flour and cereal breakfast foods, probably carries the mineral salts in quantities largely in excess of our needs.

While the modern methods of milling cereal breakfast foods have changed the mechanical condition of the cereal, and in many cases the form of the carbohydrates as well, yet the actual nutritive value is for the most part a characteristic of the cereal itself, and is changed but little by its method of preparation. Comparisons made by the Storrs Experiment Station* showed that the average of 26 analyses of several different brands of rolled oats was almost exactly the same as that of 18 analyses of old fashioned oatmeal.

It has been claimed that cooked or partially cooked cereals possess superior keeping qualities. If this be true, it is probably due to the sterilizing effect of the heat employed in their preparation and the greater dryness of the product.

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*Storrs (Conn.) Expt. Station, 16th Annual Report (1904), p. 122.

COST.

Although these foods differ greatly in composition, we find an even greater difference in cost. Of the rolled oats examined, the prices range from 4 to 7.8 cents per pound. The rolled and partially cooked wheats range from 4 to 9.8 cents. But it is in the malted and otherwise "predigested" foods that we find the widest variation, the price running in one instance to 27.2 cents per pound, and in other cases from 13 to 22 cents.

Some of the standard preparations of rolled oats and wheat, of known excellence, may be obtained in bulk. When purchased from reliable dealers who are handling large quantities and whose stock is consequently frequently renewed, such goods are not only fresh, but, next to white flour, they are among our most economical foods. These cereals may often be purchased at 4 cents a pound, or even at a less rate. The same goods put up in pasteboard cartons retail for 2 or 3 cents more per pound.

The investigations made at this station have thus far failed to discover any fixed relation between price and nutritive value. It is only fair to add, however, that, whatever the relative food values of malted and unmalted foods, the cost of the former to the manufacturer is greater, and the increased price is to this extent justified. The following table gives the cost of wheat, oats, and corn breakfast foods purchased in packages, excluding the uncooked and malted oat and wheat foods.

Maximum, minimum and average cost per pound of wheat, oat, and corn breakfast foods purchased in packages.

Number of samples.	Kind of cereal.	Price per Pound.		
		Maximum—cents.	Minimum—cents.	Average—cents.
24	Wheat	11.4	4.9	7.8
17	Oats	7.8	4.1	6.0
10	Corn *	9.2	4.1	5.5

* Including only the hominies.

RELATIVE ECONOMY.

To find the relative economy of these goods, their cost should be considered in connection with their composition. By means of the data given in the tables on pages 121 and 132 it is easy to calculate the amount of nutrients which can be purchased for a given sum in any of these goods. This is done in the table below.

Pounds of nutrients and number of calories to be purchased for one dollar at the average price per pound.

	Average cost per pound.	Number of pounds for one dollar.	Pounds of Nutrients to be Purchased for One Dollar.				Heat of combustion.
			Protein.	Fat.	Carbohydrates.	Ash.	
	Cents		lbs.	lbs.	lbs.	lbs.	Cal.
Rolled Wheat	7.8	12.8	1.54	.24	9.57	.18	40.3
Rolled Oats	6.0	16.7	2.79	.90	11.64	.30	72.0
Hominy	5.5	18.2	1.56	.13	14.50	.05	70.2
Patent flour	3.5	28.6	3.98	.40	20.82	.14	113.2

At the prices given, flour is by far the most economical of the above named foods. It should be remembered, however, that few articles of food can compare with white flour in this respect. When it is possible to purchase rolled oats and wheat in bulk at prices scarcely exceeding one-half those given above, it will be found that they compare very favorably with flour as far as price is concerned, and present the double advantage of variety and ease of preparation. The latter consideration is one that should not be lost sight of. When it is found necessary to maintain a fire for the sole purpose of cooking food, the cost of preparation is largely increased and the consumer can readily afford to pay a reasonably higher price for goods the use of which will lighten his labors or effect a saving of fuel.

COOKING.

Too much cannot be said in favor of thorough cooking. The hominies and old fashioned oatmeals should be cooked an hour at least. It is asserted that some of the rolled products may be thoroughly prepared in from 10 to 20 minutes. In most cases it will be found advisable to use more time. Snyder attributes the difficulty in digesting imperfectly cooked oatmeal to "the large amounts of glutinous material which surround the starch grains and prevent their disintegration. When thoroughly cooked, the protecting action of the mucilagenous proteid material is overcome, and the compound starch granules are sufficiently disintegrated to allow the digestion juices to act."* The increased digestibility of fully cooked cereals he believes to be due largely to a physical change in the carbohydrates which renders them more susceptible to the action of the digestive solvents. In the digestion experiments carried on in the laboratories of this Station, the rolled oats and wheats were cooked 45 minutes in double boilers.

SUMMARY.

In selecting a cereal breakfast food the consumer may be guided by the claims of the manufacturers; by the chemical composition, as ascertained by a disinterested chemist; by the digestibility as determined by experimentation; by cost; by taste; by economy; or by their observed effect upon the individual.

Claims.—The claims printed upon the outside of the package are unfortunately not always to be relied upon. In some instances there can be but little doubt that they are intended to deceive the purchaser. In other cases the claims made are so reckless as to lead to a suspicion that their author was not familiar with the terms employed. Such claims are less harmful because less likely to deceive. The consumer has no difficulty in detecting the falsity of many of the statements made, and should be cautious in accepting those which appear too extraordinary.

Chemical Composition.—The chemical composition furnishes a more reliable guide, but should be considered in connection with digestibility and cost. Too much reliance should not be

* Minnesota Expt. Station, Bul. 74, p. 153.

placed upon a single analysis, since wide variations have been observed in the composition of two or more samples of the same brand. The differences in composition between foods of the three common cereals, wheat, oats and corn, are sufficiently constant and furnish reliable evidence.

Digestibility.—Digestibility is of no less importance than composition. In the digestion experiments made upon human subjects the rolled wheat seemed to be somewhat more digestible than the rolled oats, and so far as relates to protein, the most valuable constituents, both rolled oats and rolled wheat are superior to corn. The attempt to increase the digestibility of starch seems to have had a contrary effect upon the protein.

Cost.—The corn products are the cheapest of these foods, the hominies examined costing on the average 5½ cents a pound. The rolled oats cost on the average 6 cents and the rolled and granulated wheats (partially cooked preparations) 7¾ cents.

Taste.—A food should never be selected by taste alone, since a very inferior article may be so disguised as to prove acceptable to the palate. At the same time, palatability is a quality which should not be overlooked, since it seems to have some effect upon digestibility and also upon the amount eaten. It seems especially desirable that such foods as experience and a mature judgment have shown to be most fitting should appeal directly to the palate of the child. With the great variety of products now available, there should be little difficulty in finding a food which should be at once palatable, nutritious, and digestible.

Economy.—Economy in the use of a cereal food involves a consideration of several qualities. It by no means follows that the cheapest food is the most economical. The best food is that which for a given sum supplies the largest amount of digestible nutrients in a palatable form.

Individual Peculiarities.—Except in a very general way it is impossible to predict the choice of these foods to be made by the individual, or the effects of their use. Individual tastes are exceedingly capricious. In a family of four the writer has recently found three cereal foods served at the same meal. Cases frequently arise in which it is found necessary to discontinue the use of a food which has proved palatable. A food which disagrees with the consumer is not cheap at any price.