GRADUATION THESIS.

RAW GRAIN AS HUMAN FOOD.

by

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RAW GRAIN AS HUMAN FOOD.

1. Modern diets are customs, not natural habits.

The age and universality of a human habit, the origin of which cannot be accounted for by natural selection, are no proof that such a habit is in harmony with the best development of mankind. Since the time that man's dominating intelligence has given him marked advantage over other animals, human diet has been a constantly decreasing factor in natural selection. The diet of a wild animal has been developed in harmony with the digestive functions and is a natural diet. The distinctive diets of modern men are not in this sense natural, for they have been developed as have habits of architecture, dress or etiquette. Such customs for the reason that they are not active factors in determining who shall survive may develop in lines antagonistic to the ultimate well being of the race.

2. Dietetic customs do not harmonize with ultimate utility.

A man in determining what he shall eat considers taste, cost, and effect upon his physical and mental well being. The great habit-making mass of unthinking men give consideration to these points in the order mentioned. But a thinking man and one to whom the gratification of taste is of comparatively small concern may reverse the order of consideration. Whereas the people who have established the customs require only that food have no immediate ill effects upon the system, the thoughtful man requires that food must be such as will produce the greatest physical and mental fitness for a well lengthened life time. Moreover where the majority of men are willing to spend a large portion of their substance to

increase the pleasures of the palate the man to whom other things give greater pleasures would gladly reduce the expenditure for food so long as he does not lessen the health giving qualities. By these considerations are we to account for the plea for a simple diet.

3. The consensus of dietetic opinion.

The writer in his search after a diet best for the man and least in cost found that on some points students are of very similar opinions while on other questions contradictions and inconsistent opinions are common. The following seems to be the consensus of opinion of modern investigators:

Man is physiologically fitted to utilize foods of both animal and vegetable origin. Foods of animal origin are not essential to health and if used should constitute the smaller portion of the diet. Animal food is most readily assimilated raw, but is digestible when cooked and in the case of flesh has the added advantages of flavor and freedom from parasitic organisms. The majority of fruits, nuts and vegetables are ranked as wholesome food and are considered to be little affected by cooking.

Grains are considered to be one of the chief sources of food supply for man, but the almost universal opinion is that they are unfit for human consumption until they have undergone various processes of milling and cooking.

4. The chief bugbear of the natural dietist.

A man in search of a simple, wholesome and inexpensive diet would from these teachings have no difficulty in choosing a dietary of animal foods, fruits, nuts and vegetables with which all elab-

orate processes of preparation, and if desired all cooking whatsoever, might be dispensed with. But on the question of grain food the accepted teachings do not harmonize with what would otherwise be a return to a natural and unelaborated diet.

There is one school of dietists who would avoid this difficulty by living wholly upon nuts and fruit and banishing grain from the human bill of fare. Another set of food specialists would subject all grain food to elaborate processes of predigestion. Grain, because of its abundance and wide spread distribution, must continue to be the chief food supply for mankind, and either of the above plans represents a great economic loss. With these considerations in mind the writer asks, is raw grain suitable for human food?

5. The teachings of natural selection.

That wild animals have by means of natural selection become fitted for the diet upon which they subsist is assumed in this paper and I shall not deal in any trite analogies between the diets of various animals and their specific traits. On the other hand, I do not wish to fall into the error of assuming that diet is a matter of as close adherence to the specific characteristics as is breeding for such is abundantly proven not to be the case.

Grains constitute the fruit or food storage portion of the grass plants. This fact, together with the consideration that many species of animals are fitted for a grain diet and chiefly subsist thereon, shows that grain may be a suitable food for animals.

This brings us to the question commonly asked, "What is the natural diet of man?" By the term "natural diet of man" I here mean the diet for which man's organism has been fitted by natural selection. Omitting all discussion the general answer is that man, in matters

of diet, is a tertiary animal and not adapted to any highly specialized diet. Roots, fruits, nuts, insects, tender buds and leaves, seeds, birds' eggs and such birds and small animals as he could capture constituted the natural diet of man. Grains or other closely related seeds undoubtedly constituted part of the diet of primitive man; but not a large part and probably not an essential part. Tubers and roots did, however, compose a goodly portion of man's natural diet and starch, the chief constituent of these is also the chief constituent of grains. Any inability of man to utilize grains would therefore seem to come from their greater hardness and dryness than from the chemical composition.

Before leaving this topic it is well to call attention to the fact that man is not completely omnivorous, as is often stated. Man is not as well adapted to assimilate the structural tissues of animals as are carnivora, but a much more marked deficiency is his lack of fitness for masticating and his inability to digest the structural tissue of plants. Lignified tissue is to man wholly indigestible and cellulose is practically so.

6. The teachings of animal husbandry.

The feeding of domestic animals gives us abundant information which with due consideration of all the facts involved should throw much light upon the problem of human nutrition. Ruminants and the horse are herbivora. That wild herbivora are not chiefly grain eaters is evident; that they eat less grain than primates is probable. Under domestication grain has become their chief diet and for storing flesh is undoubtedly an improvement over forage. It is believed, however, that these animals retain more vitality and reproductive ability on their natural grass diet; but this may be partly or

wholly due to the natural exercise and more contented life of an animal turned out to grass.

The domestic hog is an instructive example of diet change. The hog is omnivorous and more like man in his natural habits of nutrition than any other domestic animal. The hog under domestication has been fed on grain diets and lays on fat to a remarkable degree. While the same thing is true with swine as with other animals in regard to greater reproductive power upon a natural diet, yet it is evident that the hog which in a state of nature lived upon a general diet, can utilize grain foods to a degree limited only by the fat storing powers of the animal.

One particular fact worth relating here because of its bearing upon the subject in hand, is the history of the custom of cooking feed for swine. Several years ago the idea was conceived that if grain should be cooked for man it should also be cooked for hogs. Many experiments were tried and results were obtained which approved and disapproved of the practice. The present general conclusion is that no gain in growth is to be obtained by the cooking of food for swine.

The students of animal nutrition have made greater progress in experimental knowledge than have students of human nutrition. The first requisite for the utilization of this knowledge in its application to human nutrition is a well grasped idea of domestication. Associated with this must be the realization that man,who is in environment the most artificial of domestic animals,is in breeding the least restricted animal known.

7. Prevailing dietetic customs.

The distinctive origin of food customs compared with natural adaptations has been pointed out. Whether the natural diet of man will produce a better individual development than the preparations of a modern cook is a question which cannot be positively answered without more definite knowledge than we at present have.

Two very important divergences from a natural diet have been the increase in the proportion of grain food consumed and the use of fire in preparing food.

The amount of grain used by different peoples varies greatly. The Eskimo eats no grain, while the Hindoo eats little else. The comparison of races or the attributing of racial traits to dietetic habits will not be entered into here for this subject more properly belongs to a work on the folklore of dietetic beliefs. The chief thing to be observed is that man still lives and appears to progress after he has changed from a diet where grain was a small factor to a diet of which grain is the chief component.

The greater portion of grain is eaten cooked. The world seems about divided between the ground grain or bread eaters and the boiled grain or porridge eaters. Moist heat of some kind is almost universally used in preparing grain food. We know that man can live and thrive on cooked grain, although this is no proof that he might not thrive better upon raw grain or without grain. The facts that ground and cooked grains are capable of various combinations and artificial flavoring, and that less time is required to masticate such food, are sufficient reasons to account for the origin and establishment of the present customs.

It may be well to mention some of the views advanced by those who, believing that the present diet of cooked grain is better for the modern man than a primitive diet, attempt to give a natural explanation. One inference is that the principle of natural selection continuing to operate with man has changed his organism in harmony with his diet until he has become fitted for a cooked diet and a cooked diet only. I cannot enter at length into the facts necessary to refute this theory. The unnatural diets of domestic animals, the small part played by the kind of food in determining what men shall leave offspring, the numerous parallel customs whose origin cannot be accounted for by natural selection and the immense time believed to be necessary for such changes in nature, are among the facts that throw doubt upon the above theory. Another consideration sometimes advanced is that while the present diet has not arisen through natural selection, yet by continued use man has become fitted for such a diet and unfitted for a natural diet. This is but a form of the old belief in the inheritance of acquired characteristics. This belief has been steadily losing ground among evolutionists and there is no more reason to expect that a modified function of the stomach would be inherited than there is to believe in the inheritance of small feet among Chinese nobility or circumcision among the Jews.

There is a condition in nature which is often taken for the inheritance of acquired characteristics but which is in reality not so. If a mother acquires a weak digestion, her child may be weak through malnutrition and being of the same line of descent and perhaps exposed to the same environment the weakness of the child will localize in a disease similar to that of the mother.

Until we learn more than is at present known the proposition must stand that the healthy child of today is in its capacity for nutrition practically like the primitive child, who by the natural selection of its ancestors had been fitted to live upon a varied diet of unelaborated natural foods. But as certain desired traits of domestic animals are developed by unnatural breeding and feeding, to a degree far in advance of the wild species, so it may also be that the traits which man desires in men may ultimately be found to be best developed by a diet unlike that of the present or of primitive man.

8. Raw grain from the standpoint of the physiological chemist.

The qualities of a substance that determine its fitness for food are its physical structure and chemical composition. Again we may consider a food from the viewpoint of its ultimate use in the animal body and from the consideration of the effect upon the animal of the digestion of that food.

Digested grains resolve themselves into a small portion of fats and proteids and a large amount of dextrose. That these are the food substances needed by man is unquestioned and if Chittenden's recent work is to be accepted, grains furnish these substances in nearly the correct proportions. These facts assumed the worth of grains for human food depends upon their digestibility and the effect of their digestion upon the system. The assumption that the final chemical products of digested grains are those needed by the body is open to dispute, especially in regard to proteids.

The structure of the typical grain, as wheat or corn, consists of an outer covering of cellulose and lignified tissue, within which is contained the germ and the large bulk of starch forming the

endosperm. This starchy tissue is composed of very thin-walled cells. Within the cellulose walls of these starch cells is the dried remnant of the cellular protoplasm and a mass of starch and proteid granules.

The effect of moist heat upon grain is to cause it to absorb water rapidly, which results, if the process is long enough continued, in the bursting of both the cellulose walls of the starch cells and the outer covering of the grain. The starch granules swell up and form a gelatinous mass. No chemical change is thought to take place in the starch. The effect of moist heat upon the proteids of grain is to cause coagulation, while fats are supposed to be unaffected.

The following differences in the digestion of raw and cooked grains have been recorded. The raw grain, because of greater hardness and dryness, will be given more mastication than will cooked grain, the difference depending upon individual habit and the extent of the milling and water absorption of the cooked product. In the stomach the proteids of the cooked grain will digest more slowly and the starch more rapidly than the raw grain. These results are from the work of Dr. Kellogg. He also found that mastication hastened the digestion of starch in the stomach.

As to the comparative digestibility of raw and cooked grain in the intestine or the comparison of the speed and completeness of the entire digestive process, the writer has found a remarkable lack of definite knowledge. General statements and artificial digestion experiments are numerous, but nothing more conclusive have I found.

9. The writer's experiments.

With a view to obtaining more definite knowledge upon the question, the writer with himself as subject undertook the following experiments:

First, to determine the action of the digestive process upon various grain substances by observing the remnants of grain kernels that had passed through the alimentary canal.

Second, a comparison of the dry matter and starch content of the feces from a week on a raw grain diet with the feces from a week on a diet of boiled grain.

The subject is twenty-two years old, weighs 140 pounds, takes active exercise, such as distance running, and has an apparently normal digestion. For eighteen months previous to this experiment the diet had been chiefly but not entirely of grains, fruit and milk. The grain was generally eaten boiled, but raw and roasted grains frequently formed a portion of the diet.

The method of experimenting on whole grains was as follows: A full dinner was eaten at noon and at about 7 P.M. a meal of boiled rice and milk was taken, during which the grains to be experimented upon were swallowed without mastication. The remnants were recovered by soaking the feces in hot water and washing in a sieve under a faucet.

The evidence of a grain being found whole after passing through the digestive tract is proof that it is not digestible, but the contrary evidence that grain is not found is not proof of digestibility, for it is possible that a grain kernel could be broken up and lost in the body or in the recovering process. This is not, however, probable as the firm structure of the recovered grains

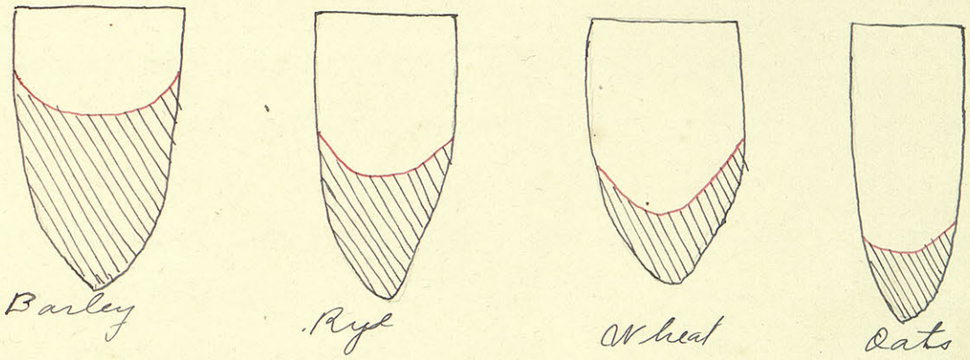
and the completeness of starch digestion shown in the later experiment indicate.

The grains were first experimented upon whole, and then by cutting them in variqus ways so as to expose the interior portion of the grain. With the exception of rice, which is artificially hulled, all the grains were found to have an outer hull or epidermis, which effectually shielded the interior from digestive action. When the end of the grain was clipped off the digestive juices attacked the interior portion, leaving the hull in the shape of the grain. The surface exposed being alike in similar grains, this eating out of the interior formed a method of judging the comparative rate of digestibility.

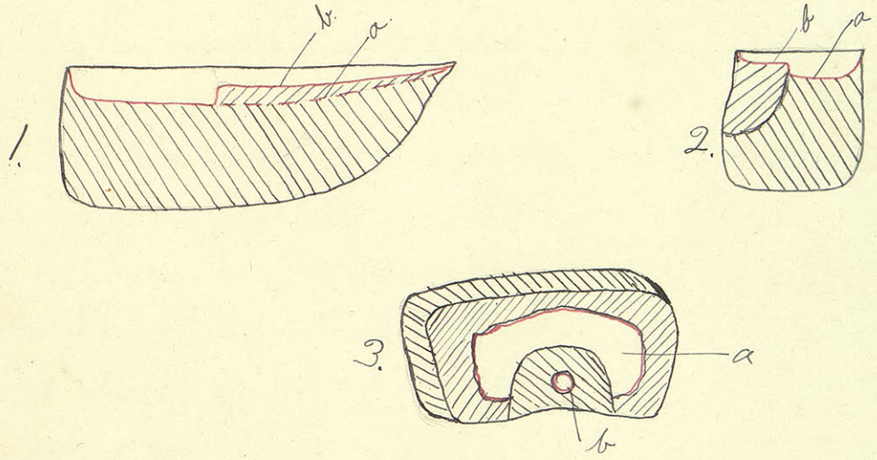
The following notes include the chief results, although they could be increased with many interesting details did space permit:

Commercial rice grains, pieces of raw potato and of almond kernels, cotyledons of navy beans and cow peas, were all entirely digested. Pieces of walnut and hazelnut kernels and the cotyledons of soy beans were almost entirely digested. Whole wheat, Kaffir-corn, hulless oats, hulless barley, rye, beans, soy beans, cow peas, and corn were recovered in their entirety. All of the above grains when the interior is exposed are digestible, but at varying rates. The drawings of the accompanying plate show the extent of this difference. The rate at which such digestion proceeds is slowest in corn, next coming Kaffir-corn, barley, rye, wheat and oats in the order named.

Three kinds of wheat were experimented upon, the varieties being distinguished by the angle of the cutting. Of the hard, soft and macaroni wheats, no difference in digestibility was observed.



Black outline represents the shape of the grain as swallowed. The red line shows the distance to which the interior was digested away, the outer hull retaining the original shape.



Corn.

1 Longitudinal half. a surface of the starchy part. b. surface of the germ. 2. A cross section of 1. 3. A cross section about $\frac{1}{8}$ in thick cut from the lower portion of a corn kernel. The central starchy portion (a) and the plumule (b) have been digested entirely away.

A cooking experiment was conducted by taking two sets of similar wheat kernels and the opposite halves of corn kernels and boiling one set for one hour, the others being taken raw. The results of this experiment were rather surprising for the boiling for one hour softens the grain as much as would soaking at the body temperature for many hours. The two sets of grains were recovered and carefully compared. To the writer's eye they showed no difference in the rate of digestive action. A non-interested observer, being asked for an opinion, gave the advantage to the raw corn kernels and to the cooked wheat kernels.

Another experiment was conducted in which the grains were roasted. Roasting seemed to have no effect on the rate of digestion of the wheat kernels. The roasted soy-bean cotyledons were entirely digested, while the digestibility of corn was increased by roasting because the grains pop and become cracked and porous.

A noteworthy observation in regard to corn is that whether boiled, raw or roasted the starchy portion of the kernel is attacked more rapidly than the germ. Another important thing to be borne in mind is that the length of time that the grain is in passing through the digestive tract will have a direct effect upon the extent of its digestion. This makes the comparison of the results of different days uncertain and it is only by the use of different angles of cutting that grains subjected to different preparation may be fairly compared.

The second experiment consisted of living for two weeks as uniformly as possible save that the grain of the first week was boiled for two hours, while that of the second week was taken raw with only such soaking as was necessary to render masticating agree-

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able. The following is the bill of fare for both weeks:

800	grams	wheat	700	grams	sugar
700	"	rice	550	"	raisins
200	"	Kaffir-corn	150	"	dried apples
200	"	rolled oats	7		lemons
100	"	rye	14		eggs
100	"	corn	7	pints	milk.

The feces were separated by lamp black. The cooked diet gave the more bulky and more moist feces. The dry weights were as follows:

Cooked grain	298.6 grams.
Raw grain	256.5 "

Both samples were analyzed for starch plus reducing sugars, by digestion in hydrochloric acid and titration with Fehling's solution. Accurate results could not be obtained because of numerous discolorations and precipitates. It was evident that the dextrose in both samples was small, probably between .005 and .01 of the dry feces.

The results of this experiment are of course not conclusive. The possible errors due to different bodily conditions and to inaccurate separation of the feces is large. But as in the first experiment the evidence is strong that while cooking may change the rate of the action of saliva upon starch it does not change materially the completeness of the digestive action of the whole alimentary canal. The considerable bulk of the feces is to be accounted for by the large amount of grain hulls and raisin seeds in the diet. That the digestion is very complete is shown by the small amount

of starch and sugars found in the feces. Unfortunately no nitrogen determination was made. Thorough digestion when compared with figures commonly given would be expected in this case as the diet consisted of about two-fifths the protein and three-fifths the energy of the Atwater standard. Lest some be inclined to think the diet meager it might be stated that the subject ran two hard races during the experiment, making in the two mile road race the time of 11 minutes and 9 seconds.

The commonly accepted statement that cooking is necessary to break the cell walls before the enclosed starch granules can be acted upon by the digestive juices is absolutely inconsistent with the results of the above experiments. The cellulose walls of starch cells have been given more prominence than they deserve as they form only a fraction of one per cent of the starchy portion of the grain.

From the evidence here presented I do not wish to argue that a diet of raw grain would be superior to a diet of cooked grain. I do, however, believe that the common teaching ~~is~~ in regard to the unfitness of raw grain for food is founded upon incomplete physiological knowledge and is inconsistent with the teachings of biology. I believe I am justified in raising the question as to whether man is what he is because of his cooking, or in spite of his cooking, and I think that a thorough and unprejudiced study of the relative benefits of a diet of raw grain and of cooked grain promises to be productive of much useful knowledge.

CONCLUSION.

10. The final method in the study of human nutrition.

The determination of the best diet for man has been attempted by analogous reasoning from the diets of lower animals, but for reasons clear to a biologist such conclusions avail nothing. Likewise the attempt to determine the proper diet from a study of prevailing diets will, for obvious reasons, not correct prevailing faults. With this latter source of information has been combined the results of the physiological chemist. Of this class of knowledge there is not much fault to find save its incompleteness. The development of this science must add greatly to the understanding of nutrition and the determination of the best diets but the chemist must admit that the subtler organic changes that constitute the vital processes and determine the intensity and length of life are at present beyond his reach.

If all these methods fall short of solving the problem of the optimum diet of man, by what method, it may be asked, is the problem to be solved. There is, it seems to me, one final test to which any theory of diet must submit and that is the test of careful experimental study of the effect of the diet upon men. The opinion of the mass of men in regard to food is not to be accepted as it is based upon immediate pleasures; neither the rapidity nor completeness of digestion nor the results of an isolated experiment are to be accepted as conclusive, for these may be only incidental. The worth of a diet for man is to be determined by the effect of that diet upon his fitness for living and, as with the dairy cow, this must first be determined for the race, by combined experiment and then adapted in the details to each individual.