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RESULTS OF BORAX EXPERIMENT.[1]

The bulletin of the Bureau of Chemistry, No. 84, containing the first report on the influence of preservatives, coloring matter, and other substances added to foods, on health and digestion, contains several hundred pages. Under existing law no more than 1,000 copies of any bulletin containing more than 100 pages can be published. The edition above-named, therefore, will be sufficient to supply only the demands of libraries and a very limited number of specialists engaged in similar investigations. For this reason it is advisable to prepare in a condensed form a statement of some of the principal points considered in Bulletin 84 for more general distribution. The work of which the following digest is presented was undertaken in accordance with the authority conferred by Congress upon the Secretary of Agriculture to investigate the influence of various substances added to foods upon health and digestion. The exact wording of the act is as follows:

> To investigate the character of proposed food preservatives and coloring matters to determine their relation to digestion and health and to establish principles which should guide their use.

The necessity for an investigation of this kind is found in the very general use of certain chemical compounds for preserving foods, and also in the very common use of certain coloring matters for imparting to foods a tint resembling that of nature, which the foods may have lost, or of producing certain colors in food products which are attractive to the eye of the consumer.

The use of preservatives in food products is as old as civilization, and there is no occasion in these investigations for extending the scope of the authority given to the study of the long-established preservative agents. Moreover, these preservative agents which have been so long in use are condimentary in character and reveal themselves at once by taste or odor to the consumer. The more important of these common and long-established preservatives are salt, sugar, vinegar, and wood smoke. Alcohol has also been long used as a food preservative, but does not rank in antiquity and in generality of use with those just mentioned.

One of the chief characteristics of the modern chemical preservative is that it is often almost without taste or odor, and for this reason its presence in a food product, unless specifically proclaimed, would not

[1] Digest of Bulletin No. 84, giving the plan of work and conclusions as to effects of boric acid and borax on digestion and health.

be noticed by the consumer. But while this is true of most of the preservatives used in the preparation of foods (except the condimental substances mentioned) in the quantities employed, this does not mean that in a concentrated form they have neither taste nor odor. Quite the contrary is true. Nearly all of them in a concentrated state reveal themselves either by taste or by odor. For instance, salicylic acid in a pure state is easily distinguished by the taste, and sulphurous acid in the form of gas or in a nearly saturated solution is distinguished by its odor and irritant effect upon the nostrils. Nevertheless small quantities of salicylic acid can be placed in food products without the consumer being able to detect it, and the same is true of sulphurous acid.

Legislation of various kinds in different countries and in the different States of the United States[1] has been enacted concerning the use of preservatives and coloring matters in foods. This legislation is of varying character, prohibiting in some countries what is allowed in others, establishing rules and regulations which are local in character, and, in general, producing a state of affairs which is annoying to the manufacturer of food products and the dealers therein, and which, by the diversity of laws and decisions relating thereto, does not secure to the consumer the full benefit which was intended. The desirability of some investigation, therefore, was apparent, in order to establish certain principles concerning the use or prohibition of these substances, which, by reason of their more general applicability, may influence local and general legislation in a matter tending to secure a greater uniformity and efficiency. It is also evident that if these investigations could be conducted under some direction not particularly interested in the construction of any law, nor associated in any commercial way with the interests of either manufacturer or consumer, they would have a greater weight.

The Secretary of Agriculture is manifestly the proper official to undertake and direct such an investigation. The interests of the Department over which he presides are associated alike with producers, manufacturers, and consumers of food products, and thus any bias which might exist in other quarters in favor of any particular interest would be eliminated. For this reason the investigations conducted under his direction, even if no more thorough, painstaking, or reliable than if carried on under other auspices, would be commended more generally by reason of their freedom from influences which might tend to divert them from their intended purposes.

PLAN OF THE INVESTIGATION.

In determining the method by which these investigations should be conducted a careful study was made of similar researches carried on

[1] U. S. Dept. of Agr., Bureau of Chemistry, Bul. 69, Parts I–VI; Bul. 83, Part I.

under other auspices, both in this and in foreign countries. A survey of the field of research in this direction shows that three principal methods of procedure have been followed.

In the first case may be cited those investigations which have been conducted by means of artificial digestion. Fortunately for science, the various ferments which are active in digestion in the living animal have been isolated and prepared in a reasonably pure state. By securing as nearly as possible the other conditions which obtain during digestion in the living body, artificial digestion similar thereto can be secured. Thus if food properly comminuted and kept, at the temperature of the stomach, in motion similar to that produced by the peristaltic action of the intestines, be treated by the proper digestive acids and ferments, the chemical actions which occur are entirely similar to those which take place in the living organ itself. Thus the ferments which digest starch and sugar, those that act upon protein, and those that act upon fats can be studied without the living organism. The results which have been obtained by this method of investigation are most valuable, and when the preservatives and coloring matters in question are added, any changes which are produced, either in the degree or in the rate of digestion, can be easily ascertained.

In the second case the problem may be studied by experiments conducted upon the lower animals, and from the results of these experiments inferences may be drawn applicable to the human animal. This line of experiment and investigation has also great merit. The animals operated on are kept under close control. The amount of food which they consume is easily ascertained. The excreta they produce are collected, and a complete chemical control can be instituted in connection with the digestive process. When preservatives and coloring matters are added to the food of animals thus treated, any changes which take place in the digestive processes or any lesions which are produced in the organs of the body can be ascertained. This method of investigation also has the additional merit that at the end of the period of observation the animal may be killed, and changes in its organs, which were so slight as to produce no observable effects during life, may be sought and discovered. Thus, minute or incipient lesions of the digestive organs, or of the other organs of the body, are brought to light which otherwise would escape notice. If the digestive processes in the lower animals were exactly the same as those in the human animal this method of investigation would necessarily be accepted as final and conclusive; but each species of animal has its own peculiarities of digestion, and, therefore, the results produced on one species of animal by a certain course of treatment might not be secured with an animal of a different species or genus. This fact has led investigators to undertake a third kind of research, namely, experiments with the human animal itself.

This method of investigation also has advantages as well as many disadvantages. For the most part, such investigations are carried out upon volunteers, since no one could be forced to undergo any such experimental treatment except as a punishment for crime. In the second place the intelligence of the human animal may also be utilized in the study of the effects produced. Symptoms which the lower animals might have of distress or malaise, when in the incipient stage, might escape notice altogether, whereas similar symptoms in a man would be described. Further, it must be admitted that animals under confinement, as is necessarily the case when experiments are made with them, are not wholly in a normal state, whereas the man who volunteers for an experiment of this kind would not chafe or become restive under confinement. Again, it must be considered that as the object of the investigations above outlined is necessarily applicable to the digestion and health of man, it is evident that the experiments made upon man would be the most decisive in all cases.

The one great disadvantage of experiments of this kind is the inability to absolutely control the experimentee. Where a large number of persons is to be considered and the experiment is to extend over a long period, it is evidently impracticable to secure a direct personal control of every action of each one during the whole time. In the present case the young men selected, who volunteered for the experiment, continued their usual vocations. They were simply placed upon their honor and neither watched nor confined. The data which are obtained in this way are, therefore, open to the objection, in some cases, that the rules and regulations set for the conduct of the experiment may have been transgressed without the knowledge and consent of the observer. While this is a valid objection and should have full consideration, it must not be forgotten that among the twelve young men upon whom the experiments were conducted, it is not likely that the violations of their pledge of honor would be sufficiently numerous to affect in any marked degree the results as a whole. Further, it must be remembered that the greater number of those upon whom experiments were made were young men of approved character, many of them had college training, and a large majority of them were engaged in scientific pursuits. All these facts are of more or less importance in considering the character of the data secured. It would be unwise to claim that among so many persons, and amid so many temptations, no violation of the pledge took place, yet it must be admitted that upon the whole we can be reasonably certain that the obligations voluntarily assumed were discharged faithfully and conscientiously. Any departures from the set rules of conduct which might occur would not be made with any design of affecting the data, and, therefore, as a whole, the errors which might arise from this source would, according to the doctrine of probabilities, be largely compensatory. Thus, while in any individual case the data might be rendered unreliable by reason of such departures from the set rules, the results as a whole would not be seriously affected. The plan of the work, therefore, included the idea of conducting the investigation with volunteers—young men, most of whom were connected with the Department of Agriculture—and provided that during the period of observation they should continue in their usual vocations.

DETAILS OF ORGANIZATION OF THE WORK.

CONTROL OF SUBJECTS.

A large number of volunteers offered their services for the investigations above outlined, from whom twelve were selected. Each applicant was required to fill in a blank describing the usual conduct of his daily life. This blank is as follows:

Descriptive blank to be filled out by applicants for Hygienic Table.

1. Name and address.
2. Date of birth.
3. Have you had any sickness confining you to your room within a year? If so, state nature and duration.
4. Are you subject to indigestion? If so, state character and frequency.
5. Do you use coffee, tea, or chocolate with your meals? If so, state at which meals and which beverage you prefer.
6. Do you use tobacco? If so, state in what form, at what times, and quantity.
7. Do you use wine, beer, or other alcoholic beverages?
8. Do you go to stool regularly? At what hours?
9. At what hours do you usually urinate?
10. At what hours do you go to bed? How many hours do you usually sleep?
11. Do you engage in any unusual or violent exercise? If so, what?

All applicants who were addicted to the use of alcoholic beverages were excluded for the reason that alcohol, having a certain food value, and the habit of using it often being a strong one, the difficulty of refraining from its use would at times become very great. Moreover, it was desired not to complicate the character of the diet by the introduction of any alcoholic beverage. Applicants addicted to the modererate use of tobacco were accepted on condition that a statement be made covering the usual quantities of tobacco consumed, the character thereof, and the methods of consumption. Such applicants were admitted to the hygienic table agreeing, among other things, to continue the use of tobacco regularly during the whole period in the manner described. The members of the table having been selected, each one was required to subscribe to the following pledge:

I hereby agree, on my honor, to follow implicitly the rules and regulations governing the hygienic table of the Bureau of Chemistry during the time that I am a member thereof. I agree, during my attendance at the table of observation, to use no other food or drink than that which is provided for me, with the exception of water, and that any water not used at the table will be measured and reported daily as a part of the ration. I further agree that I will continue to be a member of the hygienic table for a period of at least six months, from December 1, 1902, unless prevented by some illness, accident, or unavoidable absence. I agree to continue the regular habits of my life, to indulge in no unusual excess of labor or exercise, and if tobacco be used it shall be used at such times and in such amounts as will be agreed upon between myself and the Chief of the Bureau of Chemistry.

I further agree that I will not hold the Department of Agriculture, nor any person connected therewith, responsible for any illness or accident that may occur during my connection with the hygienic table.

In experiments of this kind it is evident that it is necessary to rely to a certain extent upon the honor of the person under observation. The only other method would be to exercise continued surveillance day and night, which, under the circumstances of these experiments, was quite impracticable. At the completion of an experimental period, in retiring from the experimental table and passing to the recreation table, the candidate was required to subscribe to the following certificate:

I hereby certify on my honor that during the period beginning -------- and ending --------, I have not partaken of any food or drink (except water reported) other than that furnished at the hygienic table of the Bureau of Chemistry, and that I have accurately recorded all the items of food and drink received at the table.

I further certify that I have not engaged in any excessive or unusual physical exercise; that I have followed, in so far as possible, the regular tenor of my daily life in respect of work, exercise, and sleep; that I have observed to the best of my ability and recorded accurately the data relating to weight, temperature and pulse; and that I have observed faithfully all the regulations connected with the experimental work at the hygienic table.

By thus placing the young men on their honor, by interesting them in the work, and by giving them periods of rest during which they were at liberty to eat moderately at other tables than those set in the Bureau of Chemistry, practically the same results which would have been obtained by an absolute control of animals experimented upon both during the periods of eating and the intervening periods were secured.

HOURS OF MEALS.

The hours of meals were fixed as follows: Breakfast, 8 a. m., luncheon, 12 m., dinner, 5.30 p. m. The members of the table were urged to be as prompt as possible at meals, although in certain circumstances some latitude was allowed. Inasmuch, however, as the food had to be weighed in advance of the meal time, it was desirable that all should be present promptly at the hour in order that the food should not grow cold or stale. It perhaps would have been desirable to extend the meals over a longer period had it been convenient, since the arrangement above described made a very long interval between the dinner, which was finished usually by a quarter past six, and the breakfast of the next morning—in all about fourteen hours during which no food could be taken—while, on the other hand, all of the meals were included within a space of about ten hours. An earlier breakfast, say at 7 o'clock, and a later dinner would have been desirable, but the employment of the young men and other conditions of the environment, made any different arrangement from that adopted inconvenient to the majority of those under observation. Further than this it should be mentioned that the hours selected for the meals were those which are customary for those who are engaged in the civil service of the United States. For this additional reason it perhaps was wiser not to attempt to change the hours of meals in order to avoid having so long a period between the dinner and the breakfast.

The breakfast and dinner were made the principal meals, while the luncheon was of a lighter character, no meat being served.

THE BILL OF FARE.

Since the young men were to be kept under observation for periods of from 30 to 70 days, it was clearly desirable to make the bill of fare as varied as convenient. To this end the meats selected were roast beef, beefsteak, lamb, veal, pork, chicken, and turkey. Fish and oysters were also used. The eggs, which were served twice a week, may also be included with the meats. The butter was of the best quality which could be made, and was free from coloring matter and salt. The milk and cream were obtained from dairies carefully inspected by the authorities of the District of Columbia and personally visited by the Chief of the Bureau of Chemistry. The vegetables were those of the season, and where they could not be obtained otherwise, the best grades of vegetables preserved by sterilization alone were used. The soups, in order to secure uniformity in their composition, were purchased of large manufacturing firms making a specialty of soups. The fruits were those of the season or preserved without antiseptics. In all cases it was stipulated that none of the foods furnished should be treated with any preservative, and in no case was this injunction violated, in so far as our examinations extended. All the preserved foods which were employed had either been kept in cold storage, as was the case of the meats and the fowls, or been subjected to sterilization and subsequent exclusion of the air, as was the case with some of the vegetables, fruits, and soups. Assurances that these bodies were free from any chemical preservative or other antiseptic were secured from all the dealers, and the assurances were confirmed by our own examinations. Coffee and tea were allowed in moderate, uniform quantities to those who were in the habit of drinking these beverages. Desserts of various kinds were employed at regular times, consisting of custards, rice pudding, and ice cream made with the best cream, sugar, and a flavoring substance. A liberal supply of fruits was incorporated with the food supply, either those in season or those preserved by sterilization.

The bill of fare was varied every day, but recurred regularly in seven-day periods. This arrangement avoided the monotony of eating the same character of food on successive days, and, at the same time, favored simplicity by the regularly recurrent use of established rations. This was convenient, both for the cook and for the steward, to guide in the one case in the methods of the preparation of the food, and, in the other, to determine the character of the supplies to be purchased.

Two rooms in the basement of the laboratory building were equipped as kitchen and dining room respectively. The kitchen was supplied with two gas ranges and a full supply of culinary utensils. The dining room was plainly, yet substantially, furnished with the necessary articles for preparing a table in a neat, attractive, but not expensive manner.

SERIES AND PERIODS OF OBSERVATION.

Three divisions were made of each series of observations, namely, fore period, preservative period, and after period. The time assigned to each of these periods varied, and the total time of the three periods varied from 30 to 70 days.

During the entire time of observation the rations of each member of the table were carefully weighed or measured, and the excreta collected.

The object of the "fore period" was to determine as nearly as possible the quantity of food required to maintain the body weight at nearly a constant figure, and to determine the normal metabolism as a basis of comparison with that of the preservative period. Preceding the fore period the quantities of food freely chosen by each individual were noted, so that some idea might be formed of the proper amount to be weighed or measured. If it was evident that too much food had been habitually consumed, keeping the body in a plethoric state, the rations were cut down somewhat in order that this condition might be removed. The quantity of the ration was, therefore, varied either by increase or decrease, until at the end of about ten days there was no very marked daily change in weight. It was found impracticable, however, to secure an absolute constancy of body weight, since the climatic conditions, slight differences in the amount of exercise, and variations in the quantity of excreta all combined to produce variations in weight (as ascertained at any given period of the day), which are more or less independent of the actual quantity of food consumed. In order that these daily variations may be eliminated from consideration in the comparison of data, the average weight for the "fore period" is taken as the initial point.

The quantity of the ration having been thus determined by the observations of the "fore period" the "preservative period" is entered upon. During this time the quantity of ration previously determined is given without variation, except in case of sickness or some unavoidable condition, and to this ration a certain quantity of the preservative to be studied is added.

Borax was selected as the first preservative to be experimented with, both because it is probably the most important of the commonly used preservatives and also because it lends itself to purposes of demonstration the most readily. The preservative was exhibited in two forms, namely, borax and boric acid, as it was thought possible that the soda entering into the former might produce some modification of the results.

During the first part of the experiments here described, the borax or boric acid was mixed with the butter. In later periods of the study it was deemed advisable, for many reasons, to administer the preservative in capsules. When it was realized that a certain article of food contained the preservative a natural distaste for this article was developed, due largely, perhaps, to mental attitude. Since it was known by all that preservatives were administered, there seemed to be no valid reason why they should not be given in capsules in order that the prejudice against any particular article of food might be avoided. It is true that objection might be made to this method because it is so different from the actual method of consuming preservatives when added to foods in the ordinary way. Preliminary experiments with the gelatine of the capsules showed that it dissolved in a very few moments in the digestive ferments. This having been established, it is evident that in a few minutes after the administration of a capsule containing borax its gelatinous envelope would be dissolved, and by the peristaltic action of the stomach the contents of the capsule would be mixed with that of the stomach. It is hardly necessary to add that the food value of the capsule in each case was determined and allowed for in making the balance of the daily rations.

In the administration of the preservative, small quantities were first given, approximately as much as would be consumed in eating foods preserved with borax, such as butter and meat. These quantities were progressively increased for the purpose of reaching, if possible, the limit of toleration of the preservative by each individual. For each variation of the quantity given a separate study of the digestive processes as influenced by the preservative was made.

At the end of the preservative period, the after period began. During the after period practically the same quantities of food were given as in the preservative period, the preservative, however, being omitted. The object of this after period was to restore the individual as nearly as possible, if there had been any disturbance of his physical state, to the condition precedent to the beginning of the experimental period.

During the entire time from the beginning of the fore period to the end of the after period the foods were weighed or measured and analyzed, and the excreta collected and analyzed.

MEDICAL SUPERVISION.

It was deemed important to have competent medical supervision of the members of the experimental class in order that the results of the investigations might be studied also from the point of view of the physician. It was also thought best that this supervision should come for this purpose from an official source. To this end the Secretary of Agriculture addressed the following communication to the Secretary of the Treasury:

I have the honor to ask that you request the Surgeon-General of the Public Health and Marine Hospital Service to detail a physician from his staff to make physical and medical examinations of the young men employed in this Department in testing the effect of preservatives upon the health of the consumer.

There will not be any very great drain upon the time of this expert, since the examinations are to be made only about once in ten days, on six young men, and will not consume, probably, over two hours, making a total of not to exceed six hours' service per month.

In this connection I beg to suggest that the Surgeon-General arrange with Dr. H. W. Wiley, the Chief of the Bureau of Chemistry, for the details of these examinations.

The following reply was received to the above communication:

I have the honor to acknowledge the receipt of your communication of January 28, 1903, requesting that the Surgeon-General of the Public Health and Marine Hospital Service be asked to detail a physician from his staff to make physical and medical examinations of the young men employed in your department in testing the effect of preservatives upon the health of the consumer.

In reply I have to inform you that your communication has been forwarded to the Surgeon-General of the Public Health and Marine Hospital Service, who informs me that he will detail Assistant Surgeon-General H. D. Geddings to make the desired examinations.

The Surgeon-General further informs me that he has communicated with Prof. H. W. Wiley, the Chief of the Bureau of Chemistry of your Department, and that Doctor Geddings has been instructed to arrange details with Professor Wiley in the matter.

In harmony with the above arrangement, Dr. Geddings regularly visited the young men under experiment once a week, giving them a careful physical examination, inquiring in regard to symptoms of any disturbances in their physical state, and prescribing for them when they fell ill, either incidentally to their work or independently thereof. Unfortunately, in several cases, the members of the training table suffered severely from colds, influenza, and grippe to such an extent as often to lose the value of their services during a whole period. These cases of illness, not due to the action of the preservatives, are duly noted in the proper places in the details of the experimental work.

EXAMINATION OF THE BLOOD.

Any changes which might take place in the relative number of corpuscles in the blood, or in the blood coloring matter, are of value in determining the general effect of the added preservatives upon health and digestion. To study this, the ordinary methods of counting the blood corpuscles and measuring the coloring matter in the blood were followed. Valuable help in the initiation of this work was obtained from Dr. Wm. B. French and Dr. E. B. Behrends. The actual examination of blood, for the purposes mentioned, was conducted by Messrs. B. J. Howard and C. P. Knight. The work on the examination of the blood was not commenced at the beginning of the experiment, and so it does not cover the whole time of the experimental work.

DETERMINATION OF TEMPERATURE.

The temperature of the blood was taken *sub lingua* before and after dinner each day. This method is probably the least accurate of any in common use. It is, however, convenient and easy. Since the chief object of the determination was to disclose any notable departures from the normal the method was considered fairly reliable.

Standard clinical thermometers of maximum registration were used for this purpose, each subject being supplied with a separate thermometer. These thermometers were all graduated through the courtesy of the Bureau of Standards.

The rate of pulse was also determined in connection with the determination of the temperature. This is, however, not a matter of so very much importance because of the ease with which the rate of pulse is varied by exercise and emotional influences.

In general, an attempt was made to control as fully as possible all the avenues which might lead to any useful information concerning changes, even of a minute character, in the functional activities of the body during the period of observation. As has already been intimated, the final verification of any small changes of an organic nature, especially of incipient lesions which may take place, is denied in experiment upon human beings, but, in so far as possible, any intimations of such changes, which could have been secured by any of the ordinary methods of study, were noted.

In data of this kind, namely the determination of the temperature, pulse beat, etc., where dependence is placed upon the subject himself, there are doubtless errors of observation which are undetected. Instructions, however, were given, and in so far as possible carried out, to the effect that any variation of a marked character must be verified by a second observer. This rule applied, not only to the variations in the body weight from day to day, but also to the departure of the temperature from the normal, and to the variations in the rate of pulsation of the heart. Thus, whenever one individual in the class noted any marked variation from the normal he called upon either one of the superintendents or one of his fellows to verify the numbers which he had observed. By taking this precaution many errors which otherwise would have crept into the reports were avoided.

BODY WEIGHTS.

The weights of the body were ascertained by means of a platform scale with agate bearings, and of a delicacy sufficient to register easily differences of weight of 10 grams when carrying a man of average weight. The subjects were weighed naked, as it is not safe to assume that the weight of clothing remains constant, for even if the same kind or character of clothing be worn, the variation in weight is very great because of changes in the hygroscopic condition of the atmosphere. Thus a given amount of clothing would show very different weights on a dry and on a wet day.

In the general discussion of the influence of weights it is always advisable to take the average weight for a period of days rather than the separate weight for any one day. In the interpretation of the value of the body weight it should not be forgotten that a loss in weight must not be interpreted to mean always defective nutrition, nor a gain in weight be attributed always to conditions favorable to health. The accumulation of an excessive amount of fat is not an evidence of excellent digestion or normal increase. It may be due to a perversion, to some extent, of the processes of assimilation. On the other hand a loss of weight is not always to be interpreted as indicating an unfavorable condition of nutrition, because in persons who indulge in over-feeding, or who have accumulated excessive fat for other reasons, a diminution of weight may be distinctly favorable to better digestion and health. Nevertheless, in a state of normal equilibrium when the food supply remains constant, any marked variations in weight can not be regarded as wholly normal.

DIFFICULTIES CONNECTED WITH THE WORK.

COLLECTION OF EXCRETA.

Aside from the usual difficulties connected with analytical practice, which must always be taken into consideration, there are some special points in connection with a work of this kind which must be mentioned. These difficulties are connected chiefly with the collection and analysis of the excreta. The principal object in the analysis of the excreta, as is evident, is to establish the relation between certain ingested elements and those which appear in the excreta. Certain forms of food are more or less completely changed in passing through the body, and are oxidized and manifested as heat and energy. The fats and carbohydrates are types of food of this kind. Certain other elements in foods, while they undergo marked changes of combination during digestion, assimilation, and excretion, appear in the excreta in practically the same quantity in which they are found in the food. Among these substances may be particularly mentioned nitrogen, sulphur, and phosphorus.

In a state of equilibrium, where the body is exercising all of its functions in a normal manner, and where there is neither increase nor decrease in body weight, the quantities of nitrogen, sulphur, and phosphorus which are excreted should be the same as those which are ingested in the food. This should not be construed to imply that the actual elements eaten on one day appear in the excreta of the next day. This is far from being the case. It may require many days, weeks, or even months, for a given particle of nitrogen, sulphur, or phosphorus ingested in the food to reappear in the excreta. It is sufficient, however, for the purpose of establishing the balance between these ingested substances and those which are recovered in the excreta to assume that the quantities forced out of the body each day when in a normal state are equivalent in all respects to those which are introduced. As an illustration, the case of a tube long enough to hold a hundred marbles may be cited. If an additional marble be forced in at one end of the tube, a marble of equal magnitude will be forced out at the other, and thus the balance will be maintained in the tube. So in a state of equilibrium each molecule or atom of nitrogen, phosphorus, or sulphur entering the body will be represented by a similar molecule or atom of these respective substances forced out of the body.

Were it practicable in experiments such as these to collect absolutely every particle of emergent nitrogen, for instance, the balance between the entering and departing nitrogen should be complete. In these experiments, however, no attempt was made to collect any of the nitrogen except that removed from the body in the urine and feces. This, of course, represents nearly all of the nitrogen excreted, but not quite all. Small amounts of nitrogen are separated from the body in the hair, the nails, and the desquamations from the surface of the body. Thus in a perfectly normal state of the body the sum of the nitrogen excreted in the urine and feces would not represent the total amount ingested in the food. On the other hand, in abnormal states of the body, where the breaking down of the tissues is going on more rapidly than their building up, just the reverse condition would prove true. The same statements may be made with reference to the sulphur and phosphorus.

It is evident, however, that, if a relation can be established between the total amount of these substances entering the food and that leaving the body in the urine and feces, any disturbance of that relation by the addition of an abnormal constituent to the food, such as a preservative, can be easily detected. Therefore, for the purposes of these investigations, the fact that complete collection of these elements from the body is not secured is not a valid objection to the deductions which are made from the data. Nevertheless, it should be pointed out with clearness and frankness that in the conditions in which these experiments were made there are possibilities of error which must not be overlooked. Carelessness on the part of the observer himself in the collection of the excreta, a violation of the pledge in regard to the conduct of life, or an error in analysis would each tend to render the results of less value.

That such errors have been wholly excluded from the data submitted is not likely. On the other hand, errors of this kind which may have been introduced could not have been purposely made in order to modify the final results of the investigation. Hence it is fair to assume that such errors are to a certain extent compensatory, and that they do not affect seriously the conclusions based upon the data as a whole. Those who have worked in investigations of this kind, however, will understand the great difficulties which attend them, as well as the care which has to be exercised in their conduct, and will be the more ready to excuse any unavoidable error which may have crept in, either in the conduct of the work or the morale of those who were subjected to the experiment.

EFFECTS OF REGULAR HABITS OF LIFE.

Another important factor must be considered in the interpretation of the data which have been obtained in these experiments, namely, the effect of regular habits of living, uniform quantity of diet, and general control of the appetite upon the physical well being of the subject.

It is usually considered by physiologists and physicians that regular habits of life conduce to health and strength. This theory has been corroborated by the results of the experimental work here detailed. While it is true that in many instances during the progress of the investigation the members of the table were made temporarily ill by the quantities of the preservatives administered, it is, nevertheless, an interesting fact to note that at the end of the year after the final "after period" had been passed, they appeared to be, and declared themselves to be, in better physical condition than when they entered upon the experimental work seven months before.

This fact, as has already been stated, must not be neglected, since it is evident that the tendency toward a good physical state and good health produced by the regular habits of life might counteract the unfavorable tendency of any exhibited preservative, so that at the end of the observation, if the results were judged only by the condition of the subject at that time, they might be pronounced negative or even helpful, whereas in point of fact, the preservative might have produced injurious effects. Self-restraint, temperance, regularity of exercise, regularity in hours of sleep and hours of work are believed to have favorable effects, and these were manifested in a marked degree throughout the whole of the experimental work.

MENTAL ATTITUDE.

That the personal attitude of the individual experimented upon influences, to a certain degree, the progress of digestion is undoubtedly true. Every physician and physiologist is familiar with the marked effect which mental states produce upon the bodily functions. These effects may be either favorable or unfavorable. Cheerful surroundings, good company, and, in general, an agreeable environment tend to promote the favorable progress of digestion. A reversal of the conditions of environment to the disagreeable, combined with mental depression, bad news, and other unfavorable conditions, have exactly the opposite effect.

The question, therefore, arose in connection with the experimental work as to the advisability and possibility of preventing the mental attitude from producing any effect. A careful consideration of all the conditions of the problem made it clear that it would be impossible to conduct the experiments in any way which would exclude from the knowledge of the participant the fact that preservatives were added to the food. It was fully understood that he was employed for this purpose, and the very moment that the observation began upon his daily life, by weighing the food and collecting the excreta, he would be aware of the fact that he was under observation and was probably partaking of preservatives.

The question also arose whether or not the preservatives should be given in capsules openly or whether they should be concealed in the food itself. Both of these methods received a thorough experimental trial. When the preservative was mixed with the food in such a way as to conceal its physical appearance, a certain dislike of the food in which it was supposed to be was manifested by some of the members of the table. Those who thought the preservative was concealed in the butter were disposed to find the butter unpalatable. and the same was true with those who thought it might be in the milk or the coffee. When, on the other hand, the preservative was given in the capsules with the full knowledge of the subject, much less disturbance was created. In fact, after a day or two, when the subject became used to the fact that he was taking a preservative, it was apparent that the effect of the mental attitude was not at all noticeable. All the foods offered were relished because they were known to contain no preservative, while the preservative, itself, exhibited in the form of a capsule, imparted no bad taste or other disagreeable effect.

If an experiment of this kind were to be continued only a few days it is evident that the mental attitude of the subject would be a matter of much concern, but when from 30 to 70 days are employed in one series of observations, and especially when the observations are continued for many months, this effect rapidly wears away, and probably does not influence the final results in any appreciable manner.

The young men were cautioned to avoid discussing the development of any symptoms which they might notice among themselves and were urged not to dwell upon any indications of abnormal conditions which they might experience, but to keep their minds employed on their usual vocations and to avoid thinking, as much as possible, about the experiments which they were undergoing. In most cases this course of procedure had its desired effect, and from the general deportment of those upon whom the experiments were made it may be stated, with a considerable degree of confidence, that the mental state as a whole had very little influence upon the course and progress of digestion.

It is in this particular, namely, the mental attitude, that experiments conducted with artificial digestion and experiments conducted upon the lower animals have decided advantages. Yet it must be admitted that in the latter case the confinement to which the animals are subjected probably produces a mental attitude more prejudicial to normal physiological processes than that produced in the case of the man who understands fully the conditions which surround him.

CLASSIFICATION AND INTERPRETATION OF THE DATA.

The great difficulties of correctly studying the extensive data which these experiments have given and drawing therefrom the proper conclusions are fully realized. The utmost care must be exercised in these cases to remove all possible personal bias and to free oneself, in so far as possible, from the weight of authorities which have been consulted. Public opinion, also, must not be forgotten in this respect, especially when it is considered that it is almost universally believed by the great majority of our people that added preservatives are always injurious and in many instances poisonous. But even when personal bias, weight of authority, and public opinion are eliminated from the problem, it is still a most difficult one. So many elements enter into its study, so many conditions difficult to control, so many idiosyncrasies are to be reckoned with, so many external causes influencing health are beyond control, that it is difficult in many cases to decide, where variations are noticed, as to the exact or even the apparent cause which has produced them.

The problem, therefore, has been attacked with a full knowledge of its difficulty and with the desire to be conservative and free from dogmatism. It would probably be better if all the detailed data which have been secured could be printed in connection with this discussion, so that the critical reader might be able in every instance to refer to the original figures. Enormous space, however, would be occupied by the data, and the fact that in most cases they would be of little use in detail has led to the decision to publish only summaries, with such detail as may be necessary to point out the way in which the general data have been obtained. If, as may appear later on, all points of the problem have not been elucidated, the failure has not arisen either from lack of desire or from want of industry in the conduct of the experiment. It is to be attributed rather to the limitations placed upon the observers, either by lack of experience or by lack of knowledge how to properly classify, digest, and study the data at their disposition. A serious attempt has been made to present these data in their full significance, and in no case has any tampering therewith been counseled, desired, or permitted. The unfortunate fact that many of the data are contradictory must be accepted without question. As the judge and the jury in the light of contradictory evidence seek to decide which is the more trustworthy, so have the data herein contained been interpreted with a view, if possible, to give the greater weight to those which deserve the greater credit.

To give an idea of the volume of work involved in this investigation the following approximate estimate is given of the number of samples analyzed and the number of record and calculation forms used, though this but inadequately represents the detail of the work in all its phases.

Number of samples analyzed, etc.

[Number of days of observation, 196.]

Food samples	2,550
Urine samples	1,175
Feces samples	1,175
Microscopical examinations:	
Urine	125
Blood	60
Total	5,085

Number of record sheets, balances, etc.

Menu sheets	3,618
Daily sheets	1,206
Amount and composition of food	1,206
Food calculation sheets	75
Feces:	
Amount and composition	35
Calculation sheets	65
Urine sheets	20
Balance tables	200
Total	6,425

Each one of these analyses, forms, and tabulations was used in preparing the summaries and conclusions which follow.

SUMMARY OF RESULTS.

RATIO OF FOOD CONSUMED TO BODY WEIGHT.

Of interest in connection with the other purposes of this investigation is a study of the relation of the weight of food consumed to the body weight which was made in detail during the first series of observation. This study was made of each individual article of diet, and included a statement of the ratio of the weight of food, including the water consumed, and the ratio of the weight of the dry matter in the food to the body weight. During the fore period, first series of observations, the average daily weight of the moist food, including water drunk, was 4.20 per cent of the total weight of the body; during the preservative period

4.22 per cent, and for the after period 4.21 per cent. That is, in about twenty-four days the average healthy young man would consume a quantiity of moist food, including water drunk, equal to his own weight.

It is seen by the above that the administration of the preservative caused very little variation in the weight of food consumed compared with the weight of the body.

Reduced to water-free basis, the quantity of food consumed in relation to the weight of the body is as follows:

	Per cent.
Fore period	0.96
Preservation period	0.99
After period	1.01

These data show that there is very little difference between the total quantity of dry matter in the food during the three periods. The total quantity of dry matter in the food consumed daily is in round numbers 1 per cent of the weight of the body. For a man weighing 150 pounds, therefore, the quantity of dry matter daily consumed in the food is about 1.5 pounds. It is also interesting to note that the daily ratio of the moist food, including the water drunk, is a little more than four times as great as that of the dry food.

Similar data for the other series of observations are recorded, but the further discussion of the problem is not deemed necessary.

INFLUENCE OF THE PRESERVATIVE UPON THE WEIGHT OF THE BODY.

In every series there was a marked tendency on the part of boric acid and borax to diminish slightly the weight of the body, although this tendency was in some instances checked during the after periods and a portion of the loss of weight was regained. In general, however, there was a tendency to continue the loss of weight during the after periods.

EXCRETION OF THE ADDED PRESERVATIVES.

The borax and boric acid taken into the stomach during the progress of these experiments were excreted almost entirely by the kidneys. In the first series of experiments 83.05 per cent were thus excreted, in the second series 82.85 per cent, in the third series 63.87 per cent, in the fourth series 82.96 per cent, and in the fifth series 75.17 per cent. During the course of observation 607.4 grams of preservative were given either in the form of boric acid or the equivalent in borax, of which 468.69 grams were excreted in the urine, or 77.16 per cent of the whole. These numbers include the data for Series III where the quantity of the preservative recovered in the urine appears to be abnormally low. In round numbers it may be said that 80 per cent of the boric acid and borax taken into the system in foods is excreted in the urine. It is probable that the rest is chiefly excreted with the perspiration. Only small quantities are found in the feces.

EFFECT OF THE PRESERVATIVES UPON THE COMPOSITION OF THE FECES.

A careful study of the effect of the preservative administered upon the composition of the feces shows a slight tendency to increase the amount of water therein. There is, however, no tendency of any marked nature, even when the preservatives are given in large quantities, to excite diarrhea. The administration of the preservative produces a slight increase in the weight of dry matter in the feces.

INFLUENCE OF THE PRESERVATIVE UPON THE METABOLISM OF NITROGEN.

There is only a slight effect produced as a whole, as determined by the data of experiment, upon the excretion of nitrogen. The individual variations are somewhat marked, showing the danger of depending too positively upon data from only one or two persons. A slight tendency is shown, however, on the part of the preservative to decrease the excretion of nitrogen, which tendency becomes more marked after the withdrawal of the preservatives. For instance, the average nitrogen balance of the four series of observation (excluding Series II), during the fore periods is 1.009, during the preservative periods 1.12, and during the after periods 1.74 grams per day. Expressed as a percentage the combined data show an excretion of 94.2 per cent of nitrogen taken in the food during the fore periods, 93.6 per cent in the preservative periods, and 90.1 in the after periods.

The general summary of all the experiments with borax and boric acid indicates the largest elimination of nitrogen in the fore periods, an intermediate amount in the preservative periods, and the smallest elimination in the after periods.

This relation is either produced by causes other than the administration of the preservative or the effect of the preservative continues after its administration has ceased and even after the preservative itself has ceased to be excreted from the body. It is not impossible that such an influence may be exerted. The retarding influence of the preservaative probably increases with the length of the experiment, especially in those cases in which the amount of preservative administered is progressively increased. When the administration of the preservative is discontinued, the elimination of nitrogen is probably at the lowest point (if depressed by the preservative), and yet during the first days of the after period (at least while the preservative is still in the system) the amount of nitrogen eliminated is probably as low as on the preceding days. There may be a tendency of the preservative in the large amounts in which it is administered to increase the formation of difficultly soluble compounds of nitrogen, and by that means, if no other, retard its elimination from the body.

THE EFFECT OF THE PRESERVATIVE UPON THE METABOLISM OF PHOSPHORIC ACID.

A study of the data relative to the influence of boric acid and borax upon the metabolism of phosphorus reveals many contradictory results. When, however, all the data are collected into one expression it is found that the influence of these bodies added to the food is distinctly marked on the metabolism of phosphorus and phosphoric acid. There is a distinct tendency shown by them to increase the quantity of phosphoric acid excreted during the period of the administration of the preservative. In the combined data of Series I, III, IV, and V the average per cent of phosphoric acid, taken in the food, eliminated during the fore periods of observation is 97.3, during the preservative periods 103.1 per cent, and during the after periods 97.0 per cent.

INFLUENCE OF THE PRESERVATIVE UPON THE ELIMINATION OF FAT.

The influence of boric acid and borax upon the metabolism of fat is not very marked. There is a slight tendency shown to decrease the elimination of fat in the feces during the administration of the preservative, and a tendency to recover is shown during the after periods. The percentage of fat ingested in the food, eliminated during the fore periods is 4.1, during the preservative period 4.0 per cent, and during the after periods 4.2 per cent. These data show that almost no disturbance in the metabolism of fat is caused by the administration of the preservative.

INFLUENCE OF BORIC ACID AND BORAX UPON THE OXIDATION OF THE COMBUSTIBLE MATTER IN THE FOOD.

The collected data of all the series (except Series II) show that 6.4 per cent of the combustible matter in the food is eliminated, unburned, during the fore periods, 6.6 per cent during the preservative periods, and 7.0 per cent during the after periods. These data show a slight tendency on the part of the preservative to interfere with the combustion of the food in the body, and this tendency is continued in even a more marked manner during the after periods.

INFLUENCE OF THE PRESERVATIVE UPON THE SOLIDS EXCRETED.

The solids summary for all of the series (except Series II) shows that the average quantity of solids in the food during the fore periods is 631.5 grams, during the preservative periods 627.6 grams, and during the after periods 614.1 grams. The average daily quantity of solids appearing in the feces in the fore periods is 25.6 grams, in the preservative periods 28.6 grams, and in the after periods 28.3 grams. The average quantity appearing in the urine during the fore periods is 64.48 grams, during the preservative periods 59.37 grams, and in the after periods 56.20 grams. The average balance of total solids during the fore periods is

544.701 grams, during the preservative periods 539.875 grams, and during the after periods 530.123 grams. These data show a marked tendency on the part of the preservative to increase the total solids excreted in the feces and to decrease the total solids excreted by the urine. There is a distinct tendency manifested by the preservative to interfere with the processes of digestion and absorption. Inasmuch, however, as the total quantity of solids administered in the food varied slightly in the different periods, a fairer interpretation is obtained by comparing the percentages of the total solids exhibited in the food eliminated by the feces and urine respectively. In this comparison it is found that the total percentage of solids in the food eliminated in the feces during the fore periods is 4.1, during the preservative periods 4.6, and during the after periods is 4.6. The percentage of solids in the food eliminated in the urine during the fore periods is 10.2, during the preservative periods 9.5, and during the after periods 9.1. These percentages indicate also very strongly the influence exerted by the preservative mentioned above. It must be remembered, also, in this connection that practically 80 per cent of the preservative administered is recovered in the urine, increasing to that extent the total solids thus eliminated. In spite of this, however, there is a marked decrease in the total solids in the urine and a marked increase in the total solids in the feces.

EFFECT OF BORIC ACID AND BORAX UPON THE URINE.

Elimination of nitrogen.—The combined data of the four series (excluding Series II) show that the percentage of nitrogen ingested in the food eliminated in the urine during the fore periods is 85.7, during the preservative periods 85.1, and during the after periods 81.1 This shows a tendency on the part of the preservative to diminish the percentage of nitrogen excreted in the urine, and this tendency is continued in a very marked manner in the after periods.

Reaction.—The data of Series II, III, and V show a marked tendency on the part of boric acid to increase the acidity of the urine. In no case during the administration of boric acid was an alkaline reaction observed. In the case of the urine the marked acidity imparted to it by boric acid is continued in most cases throughout the after periods. The data of Series IV and V on the contrary show a marked tendency on the part of borax to diminish the acidity of the urine and in several instances this substance imparted to the urine an alkaline reaction. These facts indicate that a large part of the borax and boric acid administered is excreted unchanged in chemical composition.

Quantity.—Very little effect is produced by these preservatives upon the volume of urine, although there is a slight tendency manifest to decrease the amount. There is a slight tendency also manifested during the administration of the preservatives to decrease the total solids in the urine. In this connection, however, it must be considered that the season of the year has a marked effect upon the amount of urine secreted, the tendency being to secrete larger quantities in cold weather than in warm. Combining the data of Series I, III, IV, and V for those members completing the series we find that the average daily amount of urine secreted during the fore periods, per individual, is 969 cc, during the preservative periods 960 cc, and during the after periods 952 cc. These data show almost no effect of the preservatives on the quantity of urine secreted, but there seems to be a slight tendency to decrease the amount secreted in the preservative and after periods.

Albumin.—In those few cases where there was normally a mere trace of albumin in the urine it is shown by the data that the general tendency of the preservative used is to increase the trace of albumin in the urine, and this increase is manifested also during the after periods.

Microscopic bodies.—Microscopical examinations of the urine were made for the following substances:

Uric acid crystals; Urates; Oxalate of lime; Phosphates: (a) Crystalline phosphates, (b) Amorphous phosphates; Epithelium cells of all kinds; Leucocytes; Red blood cells; Casts: (a) Hyaline, (b) Finely granular, (c) Coarsely granular, (d) Epithelial, (e) Other forms; Mucous cylindroids; Mucous strands.

The microscopic examinations were made at three periods during each series except in Series I, during which time the microscopic supervision of the urine had not been instituted. The examinations were made once during the fore period, once or more during the preservative period, and once near the close of the after period.

Reviewing the data as a whole in regard to the appearance of these microscopical bodies in the urine the facts which appear prominently are the great variations in the number and character of these microchemical bodies. They occur constantly in some cases in very much greater abundance than in others. There are a few cases, in fact, quite a number, where the relative abundance of these bodies seems to be increased during the administration of the preservative. There is a smaller number of cases in which the contrary fact occurs. In the greater number of cases, however, the administration of the preservative appears to have had no influence upon the relative abundance of these bodies. The data, therefore, as a whole, can not be regarded as conclusive respecting the influence of the preservative upon the number or kind of microchemical bodies occurring in the urine.

THE EFFECT OF THE PRESERVATIVE UPON THE NUMBER OF CORPUSCLES AND UPON THE HEMOGLOBIN IN THE BLOOD.

There was no regular influence established relating to the effect of the preservative in increasing or decreasing the number of corpuscles in the blood. The data in individual cases are often contradictory and a general summary of them leads to no conclusive result. The fina deduction can only be drawn that if the preservative affects the number of corpuscles and the amount of hemoglobin at all, it does so in very irregular manner, differing in different individuals and in a way which can not be used as a basis of any definite conclusion.

CONCLUSIONS.

NECESSITY OF MINERAL SUBSTANCES IN THE BLOOD.

In the consideration of the action of preservatives of a mineral nature, such as borax and boric acid, it must be remembered that the animal as well as the plant possesses a certain mineral hunger. In other words, mineral substances play a double rôle in animal and plant nutrition. First, they may serve as real foods, necessary to the formation and nutrition of the tissues. In the second place they are necessary to the functional activity of the various organs of the body, irrespective of any part they may take in direct nutrition.

The necessity of saline solutions in the blood is known to every physician and physiologist. If the blood were deprived of all of its saline constituents, the circulation would be impeded, restricted, or stopped, and death would result. In cases of collapse in disease saline injections in the blood are often used as a restorative measure. These salts in solution stimulate the heart's action and undoubtedly are active in the osmotic operations of the cells. This is one of the facts which show the intimate relation existing between physical chemistry and physiology.

Common salt is the most frequent and most abundant of the saline constituents of the blood, but the alkalinity of the blood is not due, of course, to common salt, which is a neutral substance. The existence of alkaline carbonates or other alkaline salts is necessary to the vital functions. While it is true that the digestion in the stomach takes place in an acid solution, it is likewise true that any excessive acid must be neutralized and enough of alkali added in the small intestine, in order that the further digestion of the food may properly take place. That saline bodies other than common salt or the alkaline carbonates may be useful, however, in the performance of the vital functions can not be denied, though it might be difficult to demonstrate their absolute necessity. Hence the introduction of saline bodies, which may or may not be of an antiseptic character, may, within certain limits, have a favorable influence upon health and digestion. At the same time it should not be forgotten that all excess of such bodies imposes upon the excretory organs an additional burden, which, while it might not impair their efficiency even for a number of years, might finally produce a condition of exhaustion which would be followed by serious consequences. Especially is this remark true of the kidneys, which appear to be a general clearing house for all the surplus of saline matters ingested in the foods.

ARE MINIMAL QUANTITIES OF PRESERVATIVES PERMISSIBLE?

It is admitted by all who have examined the subject in a critical way, even by the users of preservatives, that in certain maximum quantities the limit of toleration is reached in each individual and positive injury is done. But it is also well recognized that many, if not all, of the usual foods when used in large excess produce injurious results. The many cases of disease produced by overeating, or by eating improperly prepared or poorly cooked foods, or by eating at unusual times, are illustrations of this fact. Upon this basis and upon the further statement that when used in extremely small quantities the preservatives in question can not be regarded as harmful, is founded the principal argument in favor of the use of the preservatives, aside from the fact that the foods themselves are kept in a better and more wholesome state.

It is only proper to give to this argument full consideration and not to brush it aside as illogical and irrelevant. It is evident that any attempt to determine experimentally the effect of extremely minute quantities of any preservative, even when used continuously, would not be likely to lead to any definite result. In the foregoing data we have illustrations of the fact that even large quantities of the preservative employed—larger by far than would probably ever be found in any food product—do not always act in such a way as to permit of definite interpretation. The claim, therefore, that the use of such preservatives is justified when the amount is extremely small, and when even these small amounts are used only at intervals and not continuously, is worthy of careful consideration.

An illustration which is pertinent may be taken from the particular preservatives with which the foregoing experiments have been made, namely, boric acid and borax. One of the food products to which these preservatives are very commonly added is butter. This statement should not be taken to imply that in butter prepared for domestic use in this country borax is found to any considerable extent. When butter, however, is to be transported over long distances, and necessarily kept a long while, the addition of borax is very frequently practiced.

The dietetic data which have been accumulated in the course of this experiment show that the quantity of butter consumed daily varies from 30 to 70 grams. Suppose, as a maximum, we say that the quantity of butter consumed in any one case daily is 100 grams, and that it contains 1 gram of boric acid or an amount of borax equivalent thereto. The maximum quantity of boric acid used in a day in this case would be 1 gram. In point of fact, however, it would rarely, if ever, reach this amount, but even in those cases where butter is eaten freely probably half a gram would be about the maximum quantity consumed. Further than this, 1 per cent of boric acid, or its equivalent in borax, in butter is a very large quantity. Probably, as a rule, not more than one-half of 1 per cent is employed. In this case the quantity of boric acid likely to be consumed by any one individual in a day would be reduced to one-quarter of a gram.

In the case of meats preserved by borax, although larger quantities are eaten than of butter, it is not likely that any larger quantities of borax would be consumed. Thus it appears that those who habitually eat butter and meat preserved with borax might be consuming a half a gram or a little more of boric acid per day. But preserved meats are not regularly eaten, and hence the quantity mentioned is likely to be overestimated. It would be unwise to affirm in a case of this kind, in the light of the data obtained by the experiments, that such a minimum consumption of borax, and especially when not a continuous one, would prove deleterious within any reasonable time of observation. The question then arises, Does the absence of such proof or the impracticability of obtaining it serve as a justifiable excuse for the use of this preservative?

This question ought not to be decided alone, because the principle of the decision must stand, not only for boric acid and borax, but for every preservative used in foods. In other words, whatever principle is established for judgment as to the use of boric acid in small portions must also be applied to the use of every other preservative used in foods. The principle must also be still further extended so that whatever may be established as regards butter or meat must be admitted in respect of every other substance used in food. Hence before admitting the full force of the argument based on minimal quantities the full significance of such an admission must be considered and the practically unlimited extent of its application acknowledged.

This leads to the discussion of the fact that in the majority of cases the labor of freeing the system from added preservatives falls principally upon the kidneys. In the method of life in vogue in this country the kidneys are already hard-worked organs. Americans probably eat more freely than the citizens of almost any other country, with the possible exception of England. Large quantities of nitrogenous foods are consumed. In the breaking down of the nitrogenous tissues the kidneys are the chief organs for the excretion of the debris. The addition of any further burden, therefore, no matter how minute, is to be deplored. If, however, the principle be admitted that injurious substances may be used in such small quantities as to be practically harmless, then we find the way open for loading upon the kidneys many different functions in addition to those which they now discharge. If they may be justly called upon to eliminate the small quantities of boric acid added in food they can not logically be freed from the necessity of eliminating also minute quantities of salicylic acid, saccharin, sulphurous acids and sulphites, together with the whole list of the remaining preservatives, which are eliminated principally through the kidneys. It would be useless to contend that the occasional consumption of small quantities of boric acid in a sausage, in butter, or in preserved meat would produce even upon delicate stomachs any continuing deleterious effect which could be detected by any of the means at our disposal, but naturally it seems that this admission does not in any way justify the indiscriminate use of this preservative in food products, implying, as it would, the equal right of all other preservatives of a like character to exist in food products without restriction.

It appears, therefore, that there is no convincing force in the argument for the use of small quantities unless it can be established that there is only a single preservative used in foods, that this preservative is used in only a few foods, that it will be consumed in extremely minute quantities, and that the foods in which it is found are consumed at irregular intervals and in small quantities. On the other hand the logical conclusion which seems to follow from the data at our disposal is that boric acid and equivalent amounts of borax in certain quantities should be restricted to those cases where the necessity therefor is clearly manifest, and where it is demonstrable that other methods of food preservation are not applicable and that without the use of such a preservative the deleterious effects produced by the foods themselves, by reason of decomposition, would be far greater than could possibly come from the use of the preservative in minimum quantities. In these cases it would also follow, apparently, as a matter of public information and especially for the protection of the young, the sick, and the debilitated, that each article of food should be plainly labeled and branded in regard to the character and quantity of the preservative employed.

EFFECT OF BORIC ACID AND BORAX UPON GENERAL HEALTH.

The most interesting of the observations which were made during the progress of the experiments was in the study of the direct effect of boric acid and borax, when administered in food, upon the health and digestion. When boric acid, or its equivalent in borax, is taken into the food in small quantities, not exceeding half a gram ($7\frac{1}{2}$ grains) a day, no notable effects are immediately produced. The medical symptoms of the cases in long-continued exhibitions of small doses or in large doses, extending over a shorter period, show in many instances a manifest tendency to diminish the appetite and to produce a feeling of fullness and uneasiness in the stomach, which in some cases results in nausea, with a very general tendency to produce a sense of fullness in the head, which is often manifested as a dull and persistent headache. In addition to the uneasiness produced in the region of the stomach, there appear in some instances sharp and well-located pains which, however, are not persistent. Although the depression in the weight of the body and some of the other symptoms produced persist in the after periods, there is a uniform tendency manifested after the withdrawal of the preservative toward the removal of the unpleasant sensations in the stomach and head above mentioned.

The administration of boric acid to the amount of 4 or 5 grams per day, or borax equivalent thereto, continued for some time results in most cases in loss of appetite and inability to perform work of any kind. In many cases the person becomes ill and unfit for duty. Four grams per day may be regarded then as the limit of exhibition beyond which the normal man may not go. The administration of 3 grams per day produced the same symptoms in many cases, although it appeared that a majority of the men under observation were able to take 3 grams a day for a somewhat protracted period and still perform their duties. They commonly felt injurious effects from the dose, however, and it is certain that the normal man could not long continue to receive 3 grams per day.

In many cases the same results, though less marked, follow the administration of borax to the extent of 2 grams and even of 1 gram per day, although the illness following the administration of borax and boric acid in those proportions may be explained in some cases by other causes, chiefly grippe.

The administration of borax and boric acid to the extent of one-half gram per day yielded results markedly different from those obtained with larger quantities of the preservatives. This experiment, Series V, conducted as it was for a period of fifty days, was a rather severe test, and it appeared that in some instances a somewhat unfavorable result attended its use. On the whole the results show that one-half gram per day is too much for the normal man to receive regularly. On the other hand it is evident that the normal man can receive one-half gram per day of boric acid, or of borax expressed in terms of boric acid, for a limited period of time without much danger of impairment of health.

It is, of course, not to be denied that both borax and boric acid are recognized as valuable remedies in medicine. There are certain diseases in which these remedies are regularly prescribed, both for internal and external use. The value which they possess in these cases does not seem to have any relation to their use in the healthy organism except when properly prescribed as prophylactics. The fact that any remedy is useful in disease does not appear to logically warrant its use at any other time.

It appears, therefore, that both boric acid and borax, when continuously administered in small doses for a long period, or when given in large quantities for a short period, create disturbances of appetite, of digestion and of health.

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