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Right application of Heat to the Conversion of Food Material

1890

THE RIGHT APPLICATION OF HEAT

TO THE CONVERSION OF

FOOD MATERIAL.

A PAPER READ AT THE MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE,

SECTION I.

INDIANAPOLIS, IND., AUGUST, 1890.

WITH REPORTS

BY MRS. ELLEN H. RICHARDS AND MRS. MARY HINMAN ABEL, ON CERTAIN LINES OF INVESTIGATION WITH THE RESULTS.

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The right application of heat to the conversion of food material.

By Edward Atkinson, Boston, Mass.

INTRODUCTION.

In dealing with this question again, I shall be obliged to repeat some part of what I presented at the Toronto Meeting, in order to make this paper a fitting introduction to the reports of Mrs. Richards and Mrs. Abel, which are submitted with it.

At the meeting of the Association held at Ann Arbor in 1885, I presented an address before Section I, which (so far as my own part of the work was concerned) was mainly devoted to the statistics of the Food Supply. To this statistical treatise was added a most valuable paper by Professor Atwater, containing dietaries scientifically prepared, at various prices for a day's ration. After I had given this address and had become very greatly interested in this branch of economic science, it became very evident that one might print and publish treatises upon the subject to an almost indefinite extent but they would fall dead and would be practically useless unless some way could be devised for the conversion of food materials into nutritious food by which the practice of cooking should be practically revolutionized. I began experimenting in a crude way on methods which I had started upon many years before, but my attention being turned in other directions I had then dropped the subject. I succeeded in making what became known as the Aladdin Cooker, a bit of apparatus in which food could be simmered and could be readily converted into a nutritious form at a very low cost. This conception or invention I attempted to give away, thinking that it might be taken up without being forced into use by any organization established for the purpose of making a profit on the manufacture.

But this plan did not work. I had a curious experience in finding out that one cannot give away an idea. I ought to have known this before, from my economic study of the methods of business. I ought to have realized that profit is the incentive to progress, and that giving away is not, in the long run and as a common rule, profitable either to him who gives or to him who receives.

In my experience with this apparatus, however, it also became very apparent that the people of this country would not be converted from their bad methods of cooking by any apparatus in which merely stewing or simmering could be accomplished. I then began in a somewhat empirical way to make experiments upon the effect of dry heat in the conversion of food materials into food; and I presently found out that the science of cooking depended wholly upon the cook being able to measure and control the heat.

Every good cook learns this in practice, but how few good cooks there are; while fewer yet practise the right measure of control, because in practising this fine art, the cook is cooked by the heat about as effectually as the food itself. In other words, in the ordinary practice in the use of the cast-iron stove and range, the degree of heat is controlled mainly by dealing with the food itself when subjected to it, rather than by regulating the heat at the point of combustion. The cast-iron stove and range, especially when worked with anthracite coal, cannot be regulated. The measure of the draft necessary to promote the combustion of the fuel of necessity makes too great a degree of heat in the oven or on the stove to render it possible to deal with the food in a proper way except by constantly watching it, stirring it, changing the position of the pots and pans, and by various other empirical devices known but to few and practised by a less number of those who call themselves cooks.

On further investigation it became quite apparent that the process of converting crude material into nutritious food through the application of heat to it is rather a fine process of "chemical reaction" (if that is the right term—I am not a chemist), and that unless an apparatus could be devised in which it might be nearly impossible to overheat or burn the food, the work would be badly done.

Now what can be expected in the result if we put appliances which are not fit to be used — like our cast-iron stoves and ranges — into the hands of persons of very moderate intelligence, for the purpose of working a rather delicate and fine process of chemical conversion? Could anything else be expected than what we get, namely,— good material converted into the most indigestible form by the most wasteful methods? I should amend the old saying "The Lord sends the meat and the Devil sends the stoves."

I have taken as an example of this fine process of chemical conversion, the common methods of dealing with the coffee berry. If the coffee berry is dried, ground, and made into an infusion, without being subjected to heat, no good results are attained; the liquid infusion is undrinkable. If the berry is subjected to heat so as to be burned or considerably carbonized, or to a heat at too low a degree, then ground and made into an infusion, the result is an acrid, unpleasant liquid. If the berry is subjected to the right degree of heat for the right length of time, then ground and made into an infusion, we get good coffee. The flavor and the other properties of the coffee berry are developed by the right application of heat or by a process of chemical conversion under the influence of heat. Which is it? Will the chemists please tell us what we really do when we apply heat to food material.

Every one knows how difficult it is to roast the coffee berry over a stove or range: the heat being under no control, the berries themselves must be kept from burning and from being irregularly roasted by constant stirring. Few are capable and few are willing to do this work in the right way. When the work is done on a large scale by machinery it is well done only because the heat can be controlled at an absolute measure in the process of doing the work with proper mechanism.

The same rule which affects the coffee berry also affects grain, meat, fish, poultry and vegetables. Unless the heat applied to either can be established at the right point and then be controlled and regulated, the work is not well done: the fats are dissociated and rendered indigestible instead of being converted into a nutritious and digestible form; the fine flavors are wasted and the house is infested with odors. The measure of the waste of material and of flavor may be measured in proportion to the odor generated by the cooking stove and the cooking range.

Having reached these conclusions, I endeavored to make an oven in which I could control combustion and to which I could apply a regulated and measured degree of heat to each kind of food. After many cumbrous and costly experiments in developing this apparatus, I finally reached a very simple method of construction. But from the beginning to the end, although my first apparatus was costly, cumbrous and for a long time unsuitable for common use, I made not a single failure in dealing with any kind of food, because I was working on the basis of a true theory; to wit: the theory of applying a moderate, regulated degree of heat to each kind of food for a sufficient time. This apparatus, known as the Aladdin Oven, I have protected by a patent.

It has taken me two or three years to convince even myself that my plans were established on solid ground and that I had really achieved success. I have made arrangements for the manufacture of the Aladdin Oven in a moderate way, keeping the general supervision of the work in my own hands with the hope and expectation that ere long under the protection of the patent, it will become expedient for some large establishment to begin to manufacture the ovens and to introduce them on a large scale. My experiments have been at considerable cost; it is my intention to recover that cost as soon as may be from the profits of the manufacture of the oven as at present established. When that has been accomplished it is my intention to conduct the manufacture of the oven either under my own supervision or under contract on a strictly commercial basis. But as I do not intend to make this work a part of my own means of subsistence, I shall devote the profits, if any, after I have recovered the cost of my experiments, to the further development of the science of nutrition. In this work I have been greatly aided by the counsel of Professor Atwater; and I have been enabled to coöperate with Mrs. Ellen H. Richards, who with Mrs. Mary H. Abel had established the New England Kitchen in Boston, with a view to diffusing right information in the community as to the kind of food that it would be expedient for them to consume and the right methods of preparing it by the use of the apparatus which is in common use.

It was desirable, however, that Mrs. Richards should have the support necessary to carry on a scientific investigation at the same time that she was conducting this practical work of reform. To the end that this scientific work might be done in connection with, but not necessarily as a part of the main purpose in establishing the New England Kitchen, a grant was made by the Trustees of the Elizabeth Thompson fund; two of my friends also made unsolicited contributions in money. By the use of these funds a certain amount of excellent work has been done on the scientific side. With this introduction I venture to present to the Association a copy of the report of Mrs. Ellen H. Richards to the trustees of the Elizabeth Thompson fund; and also a copy of the report of Mrs. Richards and Mrs. Mary H. Abel on the scientific work accomplished by the aid of the funds which had been placed in my hands. These latter reports are devoted to preparing meat and milk.

A beginning has been made upon the bread question. From my own investigations I have proved that the process of kneading by hand in making bread is entirely superfluous. I have also proved in common practice in my own family and in other places that perfect bread can be made at the minimum of cost without the hand touching the dough. This bread is raised in the Case Bread-Raiser and baked in the Aladdin Oven at the exact temperature required.

A complete treatise on the science of bread making will hereafter be presented; but for the moment, information upon that subject, which would not properly come into this treatise, may be found in a pamphlet upon the Aladdin Oven, which will be sent on application to Messrs. Kenrick Bros., Brookline, Mass.,of which I also transmit copies herewith.

I should not venture to advertise this oven in this way if I had not already declared my purpose to devote the profits, if any, to the further development of the science of nutrition.

REPORT NO. I.—TO THE TRUSTEES OF THE ELIZABETH THOMPSON FUND.

The investigation of certain scientific principles of hygienic and economic cookery in aid of which a grant of $300.00 was made from the Elizabeth Thompson Fund was to cover four points:—

1. The determination of the time and temperature required for the best results in flavor and digestibility of the several classes of food materials, *i.e.*, meat, vegetables, etc.
2. To ascertain the difference, if any existed, in the chemical character of bread quickly baked and that baked for a long time.
3. To endeavor to secure a simple and effective measure of oven heats.
4. To modify the ovens in common use in order to obtain more digestible food and to secure more economical use of food materials.

The study of these points was made by Mrs. Mary Hinman Abel in connection with the work of the New England Kitchen, 142 Pleasant St., thus securing more than mere laboratory results. The analyses were made in the laboratory of sanitary chemistry of the Massachusetts Institute of Technology, by Messrs. G. L. Heath, F. S. Hollis, W. R. Whitney, and Misses Bragg, Day, Sherman and White. The apparatus is being used constantly in further experiments.

The accompanying Report gives in detail the results of the six months' work. It may be briefly summarized as follows:—

Two standard dishes have been perfected which have stood the test of six months daily sale with constantly increasing popularity. The time and temperature necessary for these dishes are known as well as the exact proportions of the necessary ingredients. Meat and vegetables are represented. The two dishes are beef broth for invalids, and pea soup. From the beef broth other soups are made. We believe this to be the first time that standard dishes have ever been prepared on scientific principles with such exactness that they may be duplicated, in every particular, like an apothecary's prescription. Besides these, several dishes have been prepared with, we believe, more careful and intelligent study as to methods and food value than has ever before been bestowed on this class of food in this country.

2. The change in the composition of bread when baked a long time at a moderate temperature has been demonstrated as will be seen by reference to the tables of analytical results. This branch of the subject is still under investigation.

3. The question of an oven thermometer has not been satisfactorily settled, nothing which was obtainable answered the purpose with sufficient exactness and in view of our conclusions in regard to the use of stoves it was not thought best to pursue the investigation further.

4. In regard to the American cook-stove we have come to the conclusion that no general improvement in the character of prepared food can be expected with so crude and unreliable a means. As we have demonstrated that for most substances a long time and a moderate heat is required for the best results, we must find an apparatus to secure this. Nothing which we have seen or heard of, quite meets the ideal requirement. No hotel or restaurant kitchen have we found, in which the apparatus is made with regard to definite scientific principles. All such methods are exceedingly wasteful of heat and of the nutritious properties of the foods.

In our practical experiments we have confined ourselves to the effect of a moderate degree of heat, continued for a considerable time. We have not considered to any extent the methods of broiling or so-called roasting because it is well known that only tender, high-priced cuts of meat can be thus made fit for the table.

We have, however, procured the best type of gas apparatus for this purpose, and later we shall have some results on the subject.

Neither has the cookery of fresh, green vegetables been taken up. Only the points which seemed most vital to the whole question could be covered in the few months at our disposal.

We have also limited ourselves thus far to such apparatus as is applicable to household and hospital uses, and have not considered large steam plant for hotels or coöperative kitchens, although that is the next desirable step to be taken.

ESSENTIALS FOR GOOD COOKING APPARATUS.

For ordinary cooking apparatus the following are essential points :—

1. The degree of heat should be under perfect control, increased, diminished or withdrawn at will, and without loss of time. This can only be perfectly attained with liquid or gaseous fuel. Solid fuel demands constant and equable running, and gives best results in large masses. The

small fire-box of a cook stove, and the urging of the fire for a short time three times a day are fatal objections to the use of anthracite.

2. A tightly closed vessel heated by steam, or hot water, or hot air, offers many advantages over the top of a red-hot stove or the inside of a nearly red-hot cast-iron oven for cooking, except for the broiling and the roasting of meat and for some other methods of cookery which require the quick application of heat.

3. For all purposes of slow cooking the oven should have a non-conducting covering which retains the heat where it is wanted, and also allows of tight closing and of security from the constant watching required by the fitful heat of a stove.

This use of a close oven with a non-evaporative atmosphere, seems to be the secret of the retention of the delicate and volatile flavors which usually flavor the house and street, and not the food as it is brought to the table.

Three kinds of apparatus are now in the market which meet more or less of these requirements, and all may be used with a kerosene lamp. The Arnold Steam Cooker uses steam generated in a sort of flat boiler. For some purposes, such as the cooking of cereals, as mush, and also for the preparation of a few quarts of soup, and for the slow cooking of meat in its own juices, we find this cooker very effective. The liability to leakage and the difficulty of mending are drawbacks, and there is no non-conducting covering.

The Wanzer Cooker we have not been able to purchase as it is held by an English patent. It has a special lamp of some merit and it has good points as the demonstration which the patentees gave us showed. The loss of heat is however very large and the lamp will run only four hours.

Both of these cookers are in the market in rather small sizes but for small families offer a convenient means of securing good cookery.

The Aladdin Oven or Covered Stove. This is a square or oblong box of sheet iron of any desired size, with a non-conducting covering of magnesian cement or wood pulp, and is heated with a kerosene lamp or gas burner. The size in use for these experiments is 18 by 12 by 14 inches, and gives a cooking space at least equal to that of a No. 8 Crawford cook stove, and when empty can be heated to about 300° F. in an hour, and maintain that temperature for eight hours by a single kerosene lamp of the Rochester burner type, with the consumption of one quart of kerosene. When well filled with food materials in small portions the heat is sufficient to heat them in about twice the time allowed by an ordinary cook stove. When the space is completely filled with a vessel containing for instance forty lbs. of meat and bone and fifteen qts. of water, the whole is raised from a temperature of 70° to 180° F. in seven hours, and to 212° in twelve hours. If the lamp is then taken away or allowed to go out the temperature does not fall below 190° for four hours.

For this twelve hours, one and one-half quarts of kerosene are needed, or a gas burner can be used. For simplicity, effective use of heat, economy of fuel and development of flavor in the food cooked, combined with increase of its digestibility, the Aladdin Oven is an apparatus far exceeding in merit any other now in market. It will not meet all the demands that the modern cook now makes of the kitchen stove, and it may be in several respects improved, but in the application of well known and long tried scientific principles to the cookery of food, it is a distinct advance and a most valuable invention.

There has also been designed and put in use a gas table for direct heating of water and other liquids. The great advantage of gaseous fuel, that of perfect control, is here demonstrated.

Certain incidental investigations as that of sterilized milk will be found in the Report. The money has been expended as follows : —

Apparatus	$100.00
Experimental work	50.00
Analyses of the product	150.00

While only a beginning has been made in this line of work we believe that it has been a real beginning, a distinct departure which we hope will be followed up until the food of the household and the means of preparing it shall receive its proportionate share of the time and attention of scientific men, and we desire to express to Mr. Edward Atkinson and to the Trustees our appreciation of the opportunity thus given us to increase the scientific value of our work at the New England Kitchen, and to lay the foundation of what we believe will eventually prove a Kitchen Experiment Station.

Respectfully submitted,

ELLEN H. RICHARDS.

BOSTON, AUGUST, 1890.

REPORT NO. 2. — TO EDWARD ATKINSON AND THE CONTRIBUTORS TO THE FUND MADE USE OF IN THIS INVESTIGATION.

Cookery of meat.

The ideal preparation of a food for human use requires that the nutriment it contains should be utilized to the fullest extent and this implies not only that it shall be in such a state that the digestive juices can best act on it, but that these digestive juices shall be properly stimulated to do their work by the taste or flavor of the food.

Therefore in the cooking of meat we undertook to answer this question: What method can be employed that will yield the most in nutrition and flavor? It was determined to experiment first with beef of the cheapest cuts, as the neck and shin, these cuts although tough being among the richest in nutriment as shown by analysis, and to utilize this nutriment in the form of broth, or as a basis for soups.

In examining a shin of beef we find it to consist, as far as our uses are concerned, of first, muscular fibre; second, connective tissue; third, bone. We have here three distinct food materials which, if treated separately, would require quite different processes.

1. Muscle fibre.

To prepare this for the digestive juices requires only that slight application of heat that develops the flavor which is most agreeable to the civilized palate, and so increases the nutritive value of cooked muscle fibre over raw, at least for the civilized stomach. A familiar example of the most perfect method of cooking the muscle fibre alone, is broiling.

2. The connective tissue and tendons.

We find these intimately connected with the muscle fibre, and their food material is finally obtained mostly in the form of gelatine. To render these substances available for food they must be first hydrated, and then to a greater or less extent dissolved. The length and difficulty of this process differs with the age of the animal, its food, and also on the length of time the meat has been kept after killing, all of which affects the toughness of the enveloping membrane. The connective tissue in a sirloin steak is so tender that the heat necessary to cook the muscle fibre, as in broiling, is sufficient also to hydrate the connective tissue by merely heating the water contained in the steak; that of the tougher cuts like that of the shin needs a much longer application of heat.

3. The bones also contain a substance which yields gelatine, and to extract it requires a long application of heat.

It became evident at this step in the investigation that since muscle fibre, connective tissue, and bone must be cooked by the same process, and that this process must be a long one in order to effect the necessary changes in the connective tissue and the bone, some means must be devised to prevent the over cooking of the muscle fibre from dissipating its flavor.

This settled the first requirement of the cooking vessel to be used, namely, that it must be tightly closed On this account the ordinary iron pot was rejected, but the long famous Papin Soup Digester with its tightly screwed top was given a good trial on the kitchen range.

But other requirements were to be met. The perfect hydration of the gelatine yielding connective tissue of meat and the proper cooking of the albumen would require that the temperature be perfectly under control. It was found to be impossible to regulate the temperature inside the digester; for, added to the ordinary difficulty found in using the variable kitchen range, was the fact that the tightly closed digester gave no sign of the rising temperature till the mischief was done. Placed over the more easily regulated flame of gas or kerosene so large a vessel showed great unevenness in the temperature in the top and bottom, and both of these methods were expensive as to fuel.

We next tried cooking the meat in earthen jars placed in the Aladdin Oven to which the heat of a kerosene lamp was applied, and the results obtained were so good that it became evident that we were on the right track. The meat and bone placed in a jar and covered with cold water rose slowly and steadily without any attention on the part of the cook, to a required temperature and could be held there for any length of time by simply lowering the flame of the lamp. The non-conducting shell of the oven assured nearly the same heat to the bottom, top, and sides of the cooking vessel, and did the work with a minimum amount of fuel.

We had aimed to produce a food that should hold nitrogen compounds in solution with all the flavor available. This would require that the extraction of the food material from the meat should be effected as nearly as possible before that temperature was reached at which the flavor once developed would be dissipated by the escaping steam. It was found by later experiment that the agreeable flavors peculiar to boiling soup were not brought out till the boiling point was nearly reached. This by our present method is twelve hours after the beginning of the cooking, and near the end of the process, so that the least possible quantity of these flavoring substances is lost by further cooking.

We therefore had a tin-lined copper vessel holding thirty quarts made to fit the oven, thus utilizing the entire inside space. Three of them have been in constant use in the kitchen since our early experiments demonstrated their value. By this method only, have we been able to meet our requirements for the proper cooking of meat of the tougher cuts, and at the same time extract from bone and tendon a due amount of gelatine. We consider it quite probable that a steam apparatus might be devised that would do the work on exactly this same principle by surrounding the cooker with a heated medium easily regulated and using low pressure; the steam jacket of the restaurant does not answer the requirements, but to have something of this kind constructed did not come within our means.

Whether the Aladdin Oven is the ultimate best form of a cooker we do not attempt to say, but it certainly deserves a high place because constructed on the principle of holding the heat to its work by a non-conducting covering, and for using an easily regulated fuel. Other contrivances examined by us, however convenient and ingenious, are on the old lines and show no distinct advance toward an application of scientific principles to cooking methods.

The method employed in the Aladdin Oven is the same whether the meat and bone are cooked with a small quantity of water and used in the form of a stew, or with a larger quantity of water, the meat at the end of the process being pressed dry of its juices. This latter method is the one most employed at the Kitchen because of our large consumption of this broth, merely salted as beef broth for invalids, and as a basis for our various soups.

COMPOSITION OF BEEF JUICE, BEEF TEA, ETC.

In view of the unexpected demand for the broth for the sick room we were obliged to study the composition of the various preparations in use and the possibilities of the yield of meat under various kinds of treatment.

"Beef Juice" obtained from the best steak which has been merely warmed through over the coals and then entirely deprived of soluble substance by a screw press is undoubtedly the most concentrated of the liquid foods. If prepared with the most scrupulous care, from the best material, and used at once, it probably leaves nothing to be desired. But in unskilled hands the risks are considerable in using this raw and most easily putrescible material. It is also a slow, laborious and expensive operation.

"Beef Tea," as ordinarily made, is of uncertain composition; it may be only the juice of the meat set free by the coagulation and shrinking of the fibre on heating. Such is the beef extract made by heating chopped steak in a bottle. It may be an aqueous infusion of very variable strength containing chiefly phosphates, kreatin, and certain extractive matters, agreeable to the palate but of little nutritive value.

It occurred to us to prepare on a large scale a broth of constant composition from both meat and bone, in such a manner as to secure a nutritive value at least equal to that of milk (without its fat), and without sacrificing the appetizing flavor. The bone gives a proportion of gelatine which, when flavored with the meat extract, is believed to be of high nutritive value.

The following table gives a comparison of these different preparations.

	% of meat.	Total solids.	Solids, juice filtered before coagulation.	Solids, juice filtered after coagulation.	Coagulable albumen.	Extract, % of meat.	Salts or ash.
"Beef Juice" from meat slightly broiled and pressed, Round.	26.8	11.9	10.8	4.93	6.97	3.90	
ditto, Neck.	21.9	9.9	9.4	4.72	5.18	3.56	1.36
"Beef Tea," chopped beef heated in a bottle without water.	26.4	7.91		5.72	2.19	2.09	
"Beef Tea," New England Hospital, with water.		3.23		2.55	0.68		
"Beef Tea" with equal weight of water 2 hours at 75° C. then boiled 2 hours.						2.15	
"Beef Tea" with twice its weight of water 2 hours at 70° C. then 2 hours at 85° C.						2.62	
"Beef Broth," New England Kitchen, average of 26 analyses.		3.53				4.40	

It will be seen that the yield of lean beef to water is only about two per cent, that is to say, from three pounds of juicy steak only about one ounce of solid matter is obtained. The broth of the Kitchen adds to this two per cent from the meat, two per cent of gelatine from the bones.

The following table gives the analyses in detail which have been made in the past six months, eight-tenths of a per cent of the total solids being salt added for flavor, about 0.2 per cent are phosphates from the meat, and the total nitrogen is about 0.4 per cent.

ANALYSIS OF BEEF BROTH.

DATE.	TOTAL SOLIDS.	ASH.
Jan. 22, 1890,	4.19	1.31
" 24, "	4.85	1.40
" 25, "	3.43	1.34
Feb. 4, "	3.88	1.18
" 5, "	4.13	
" 9, "	4.58	
" 11, "	5.06	
" 12, "	4.93	
Mar. 19, "	3.82	
" 20, "	4.13	
" 21, "	3.60	
" 25, "	4.60	
Apr. 24, "	4.32	
" 30, "	4.79	
May 1, "	4.96	
" 3, "	4.55	
" 13, "	3.29	
July 15, "	3.85	
" 16, "	4.43	
" 17, "	5.01	
" 18, "	4 01	
" 19, "	4.66	
" 22, "	4.45	
" 23, "	4.84	
" 24, "	3.71	
" 25, "	4.77	
Average,	4.33	1.27
Average less 0.8 per cent salt,	3.53	

The complete method now applied daily in the New England Kitchen in the making of this beef broth for invalids is as follows:—forty pounds of *well cleaned meat* and bone in equal quantities, the meat cut in thin slices, the bone broken in pieces, is put into the Aladdin Oven in a cooker as described, fifteen quarts of cold water are added, the lamp under the oven is lighted one hour previous to this and heat is then applied for twelve hours, and three pints of kerosene are used. After the lamp goes out the soup is left untouched for three hours, the cooking being continued by the heat still held in the oven. The broth is now strained from the meat through a collander and made up to twenty-five quarts with boiling water which is poured over the meat and bones and strained through a fine strainer. Six ounces of salt are added.

HOW LONG BROTH MAY BE KEPT.

We have taken some pains to determine how long this broth will keep under different conditions, an investigation in the field of household bacteriology. We have settled for our own practice the great importance of:

1. Sterilizing with boiling water every utensil used in the process.
2. Rapid cooling of the broth as soon as made, to below the temperature most favorable to the growth of bacteria.
3. Keeping the broth at as low temperature as possible.

As a result of several experiments during the hot days of July it was found that broth which spoiled in twelve hours in a cellar where the thermometer stood at 70° F. kept sweet for seven days if placed while still hot in small jars in an ice-chest at 32° F. the cake of fat on the top remaining undisturbed. More complete work in this line is to be done. Canning this broth has been suggested but it seems at present to be impracticable.

The rich but tough meat from the neck of beef is made into an excellent dish by cooking it in its own juice in the Arnold Steam Cooker. This is an application of the same principle of long, slow cooking in a partially non-conducting vessel. The Arnold Cooker is a very good apparatus for small quantities and where no regard is had to economy of fuel.

PEA SOUP.

Of our many experiments in the cooking of cereals and vegetables we consider only one complete and satisfactory enough to report upon. The principles here demonstrated can, however, be applied to many different dishes.

On account of the high food value of the legumes and the general impression that as ordinarily prepared they are indigestible we determined to make careful experiments on methods of cooking them. First we undertook to make what would be a standard soup out of the dried split pea. We found that in this case also the principle of long slow cooking was the secret of success. The ordinary kitchen rule is that the pea and bean is cooked sufficiently when it will mash between the fingers, as the cook says "When it is done it is done and what is the use of cooking it any longer?" But careful examination shows that at this point the vegetable may still be slightly granular and quite lacking in the rich flavor that longer application of heat develops. It was found that not until the split pea was cooked four or five hours, was the result that thick puree of rich and mellow flavor that has been so popular in the New England Kitchen. Here again ordinary methods failed us, for in this length of time the soup was certain to become burned. We again had recourse to the Aladdin Oven and found it to answer our needs. The soup is cooked during the night without any care, the result being always the same in taste and appearance. This soup has not been analyzed.

In the cooking of at least two dishes we have proved that a kitchen may approach a pharmacy in exactness, and we have reason to believe that these methods will in time be adopted in hospitals and diet kitchens, as being exact and veIy economical, both of material and labor, and as furnishing most nutritive food.

The reasons why principles already ascertained in the scienee of nutrition have been so little applied would seem to lie in the fact that cookery is not conducted with accuracy; that scarcely a dish can be named which has in different countries or even in different kitchens of the same country a constant composition. Any discovery in the use of drugs is immediately disseminated among physicians because of the universal and standard pharmacopœia.

The final step in the establishment of standard dietaries seems to wait for standards in cooked food.

The Records of the Kitchen will be available as a basis for future study of food values, and many observations which are not complete enough to be included in this report will be useful in future work.

Respectfully submitted,

MARY HINMAN ABEL.
ELLEN H. RICHARDS.

Boston, Aug., 1890.

REPORT NO. 3.—TO EDWARD ATKINSON ET AL.

MILK.

To explain why we considered it to be of great importance to furnish a safe milk for infants and invalids, and, secondarily, for household use, it will be well to state what we find to be the present condition of the milk supply in our large cities.

An investigation into the milk supply of Boston was made during the spring and summer of 1890 by W. T. Sedgwick and John L. Batchelder, jr., whose results will shortly be published. From advance sheets of their report it appears that milk drawn directly from the healthy cow is ordinarily free from bacteria, or sterile. It is, however, so rapidly contaminated in the act of milking, and is itself so favorable a medium for the growth of bacteria, that even "pure country" milk contains hundreds of bacteria per teaspoonful. The time required before this can be distributed in the city is so great that milk arriving by rail in Boston contains about 300,000 per teaspoonful, while that taken from wagons or sold in groceries is older and shows from one to ten millions.

This account is confirmed by what comes to us from other large cities and from Europe where the subject has received more study than with us. The conclusions forced upon us are these:—

1. That a large per cent of the milk in daily use is liable to contain disease germs which may under favorable conditions be communicated to the consumer.

2. That even healthy milk is a highly putrescible substance, which in its raw state offers a most favorable medium for the culture of many kinds of bacteria which grow in numbers and rapidity, depending principally on the surrounding temperature, and that in the digestive tract, especially of young children, in warm weather this partly decomposed milk leads often to fatal results, without doubt in direct connection with this being the fact that from 50 to 70 per cent of the summer deaths are of children under five years.

Various chemicals have been used to neutralize the acids resulting from the activity of these bacteria, but they have one and all been condemned as injuring the milk or as deleterious to the stomach.

It is at present agreed on all hands that only by the application of heat can all of this germ life be destroyed and the milk made safe without injuring its food value, and numberless experiments have been made to determine how high a degree of heat must be employed and how long it must be continued. This process is known as sterilization.

EXPERIMENTS IN RATE OF ACIDIFICATION UNDER DIFFERENT CONDITIONS.

	RELATIVE ACIDITY EXPRESSED IN C.C H_2SO_4.						
	JUNE.						
	18	19	20	21	24	25	26
Milk from the contractor, uncooked,	1.5	9.8	11.0	10.6	11.6	12.7	11.3
Heated 20 min. at 62° C.	1.5	3.0	4.8	6.2	7.5	9.6	11.1
" 20 " " 70° C.	1.5	1.7	1.3	2.4	8.4	8.9	10.9
" 20 " " 80° C.	1.5	1.5	1.1	1.2	7.1	8.6	10.7
" 20 " " 90° C.	1.5	1.0	1.2	1.8	6.0	9.4	12.4
" 45 " " 70° C.	1.5	1.4	1.8	1.5	9.7	11.3	11.0
" 20 " " 95° C. after 9 days,							12.9
Evaporated milk, 1 week old,							1.6
Milk from the grocery, 2 days old,			10.4				

1 c.c. NaOH = 1 c.c. H_2SO_4
1 c.c. H_2SO_4 = .0031276 grms. Na_2Co_3.
" = .005311 grms. lactic acid.

1. STERILIZATION.

The simple household method of boiling the milk in an open vessel for a long time will kill germs of all kinds, making the milk a safe food and thereby greatly increasing its keeping qualities. But this method has drawbacks, it changes the taste of the milk giving it a flavor disagreeable to many people. This sterilizing is practised to a considerable extent on the continent in an apparatus invented by Dr. Soxhlet. This was described in a paper by August Caille, read at the meeting of the Pædiatric Section of the N. Y. Academy of Medicine, Feb. 22, 1888, and in this paper we find also the valuable suggestion that legal enactment should provide for the transportation of milk in refrigerator cars during the summer months. How far the digestibility of the milk is affected by boiling seems to be still an open question. An article on the subject by R. W. Raudnitz appeared in the Zeit. Physiol. Chem., 14, pp. 325–327.

The changes wrought in the milk by sterilization according to any method yet used being considerable, it has been sought to destroy the bacteria if possible, at a temperature that would leave the milk unchanged in odor, taste and appearance, as Pasteur killed the wine ferments without spoiling the wine.

This principle has been used in a number of experiments and has led to the invention of ingenious apparatus that is used in Germany for this purpose. By these the milk is brought as rapidly as possible to a temperature of 68°–70° C. and there kept for thirty minutes. It is then rapidly cooled and due care is taken to keep it from re-infection. The result bears favorable comparison with raw milk in smell, taste, and appearance, and has been proved by what would seem sufficient experiments on animals to be free from pathogenic germs, such as the bacilli of cholera and tuberculosis, and nearly or quite free from saprophytic bacteria, though not from such spores as may be present or develop later, spore formation being comparatively rare, however, in so good a growth medium as milk. It keeps at summer temperature twice as long as raw milk and at lower degrees three or four times as long.

As clearly stated by H. Bitter in an article in the Zeitschrift fur Hygiene, May, 1890, milk must be sterilized or Pasteurized before it reaches the consumer, and not left to his ignorance or carelessness. Moreover in most cases it is already too late when the milk reaches him, and if a safe milk can be furnished at a price that will compare favorably with raw milk and also be agreeable in taste and appearance, it will be quite likely to obtain in time general acceptance.

EVAPORATED MILK.

In April there came to our notice the evaporated milk made by the Orange County Milk Association. The milk was said to be prepared by simply taking from it seventy-five per cent of its water by evaporation in a vacuum pan at 130° to 150° F., no sugar or other substance being added. By a cursory examination it showed itself when diluted to its original bulk to be in taste and appearance scarcely to be told from the best of fresh milk and its keeping qualities were greatly increased, especially in the undiluted state. We undertook a thorough examination of this milk, applying to it all the tests in our power. A trained bacteriologist was sent to examine the factory and made the following report:

REPORT OF BACTERIOLOGIST.

"The Orange County Milk Association has three factories: at Goshen, Fort Plains and Walton.

Generally the evaporated milk is made at the last two and the superheated or thicker milk is made at Goshen.

Just now (May 27) the market is stocked with milk, so the two more distant factories have been ordered to make their milk into butter and cheese, and the Goshen factory to make alternate lots of evaporated and super-heated milk, which is enough to supply the market.

If evaporated milk is shipped to Boston it probably comes either from Goshen or Fort Plains, as these are the nearer ones.

The milk is brought in every morning by the farmers and consists of the morning's milk which has not been cooled, and that of the previous evening, which has been cooled over night.

If a large amount of evaporated milk is to be made, all is put into the vacuum pan, but if only a part is needed that of the night before is used and the fresh morning's milk is set to cool.

The evaporated milk is taken down 4 1-2 to 1, while the thicker superheated milk is only taken down 4 to 1.

The super-heated milk is subjected to a high temperature before it is put into the vacuum pan by blowing in free steam, while the evaporated is only slightly warmed before taking it into the vacuum pan.

During the evaporation the temperature is carried to 190°–200° F. for super-heated, while for evaporated it cannot go over 140°–150° F. without spoiling the product.

The difference in milk owing to the time of year, kind or amount of feed, makes a slight difference of treatment necessary.

The aim is to carry through large amounts of milk in a short time. The evaporator is of copper, seven or eight feet in diameter, capable of evaporating 1400 quarts per hour. The lot carried through on the first morning that I was there was thirty-two times forty quarts, equals 1280 quarts.

The heating is done by a coil of copper pipe inside, at the bottom. The vacuum is maintained by pumps and a supply of cold water, the whole arrangement is much like an evaporator at a sugar refinery.

The milk to be condensed or evaporated is put into two tanks in the basement and connected by pipes with the evaporator, so that the milk is sucked up as fast as water from that already in the pan is evaporated off.

For super-heated or condensed milk, the milk is heated in these lower tanks by blowing in steam, while for evaporated milk it is only just warmed. Thus that part of the milk drawn up last in the making of evaporated milk has been heated for a much shorter time (perhaps only twenty minutes) than the first taken into the evaporator, and these are all mixed in the final product.

The temperature is determined by means of a long thermometer dipping down into the milk, and by the pressure.

When finished both the super-heated and the evaporated milk are drawn off through a long pipe in the bottom into forty-quart cans which are placed in troughs filled with running artesian well water (temperature 45°–48°) and allowed to cool.

This cooling is hastened by putting in paddles with a number of vanes which are moved by connecting with a shafting above. It seems to me that this is a great source of bacterial contamination and I should not think it would be absolutely necessary for evaporated milk, although it is for super-heated milk.

All of the milk is sold in large stoppered cans for immediate use.

They claim that all of their milk is without artificial sweetening.

The farmers are cautioned to be careful in milking, and in the subsequent keeping of the milk, but no other precautions are taken.

The milk is not analyzed. but its quality is judged by its appearance and by the product which it yields.

The following statement gives the result obtained by planting samples taken directly from the vacuum pan and from the cans after they had been cooled.

The cultures required ten days before they were ready for counting.

Samples taken from the charge of the morning of May 28, taken after about half of the milk had been drawn from the evaporator, showed an average of 1593 colonies per c.c.

Samples of May 29, after drawing off 40 quarts, gave an average of 319 colonies; after 200 quarts, an average of 1048 colonies; after 440 quarts, an average of 865 colonies per c.c.

Samples from cans after cooling to 60° in which paddles had been worked for about half an hour gave an average of 968 colonies."

The milk has been analyzed at various times at the Institute of Technology, and the results are given in the following table:

DATE.	TOTAL SOLIDS.	FAT.
April, ...	48.40	13.50
July 14, ...	47.52 47.35	13.53
July 15, ...	51.58 50.97	
July 16, ...	48.50	
" 18, ...	48.07	
" 19, ...	45.66	13.62
" 22, ...	47.55	14.12
" 24, ...	50.67	13.46
" 25, ...	49.36	

While this form of " thin milk " has been known in New York for years, its especial hygienic significance seems to have escaped notice, namely that by restricting the temperature below 150° F. the caseine is not changed as is the case at 190°. This is proved by the fact that the thick or superheated milk contains a lower percentage of solids than the thin variety, its appearance to the contrary, as well as by the absence of the cooked taste in the thin variety. There seems to us good and sufficient reason for urging a trial of the milk during the hot season.

We have assumed the expense of expressage from New York and of frequent analyses in the interest of sanitary science, and we hope that some investigation will soon be made as to how far the vacuum pan reinforces the temperature. In other words whether a temperature of 130° F. and a low pressure are not as effective in killing germs, if not spores, as a much higher temperature at the ordinary atmospheric pressure. Another point to be investigated is what is the effect of concentration on intercellular osmosis. It is evidently only a question of time when the mode of milk supply for all large cities will be changed.

We placed this milk on sale and asked the coöperation of physicians already interested in our investigations in giving it a thorough trial. As it was well known that we had no pecuniary interest in the milk and only wanted facts, we feel that we have had an unbiassed judgment.

It is now three months since this trial began and the latter part of this time has covered some of the hottest weather known in Boston for years. The Boston Dispensary has prescribed it for all its out-door patients (children) and so far with gratifying results. In many cases the child had not been able to keep on the stomach any other kind of milk, or any of the prepared foods, but on the first trial digested the evaporated milk and continued to do so.

One child who has been using the milk for ten weeks and was at the beginning feeble and sickly, weighing at three months only eleven pounds, after being put on the evaporated milk gained three-fourths of a pound a week for five weeks. Since that time we have not been informed of its gain, but it continues to do finely.

The milk has been used since early in June at the Dimmock street hospital for women and children. The physicians in charge inform us that the children have on the whole done well on it even during the very hot weather, and express the desire that it might be within reach of all the babies in their neighborhood.

That the milk is harmless and also digestible, seems to be quite fully proved. We are told by the physicians that its full nutritional value could not be definitely stated without still further tests, though all looks favorable for it.

In our estimation this milk is the most readily found substitute for mother's milk, and it is a safe, cheap and convenient milk for household use.

Our test has been made under the most unfavorable conditions, in that we have had no control over the manufacture and supply, the milk being probably twenty-four hours on its way to us, and in hot weather. If it were to be introduced as a general supply in large quantities, very careful supervision should be had of its manufacture.

Respectfully submitted,

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Boston, August, 1890.