

J. M. ... (G. A.)

ON THE

STERILIZATION OF MILK AND FOODS FOR INFANTS.

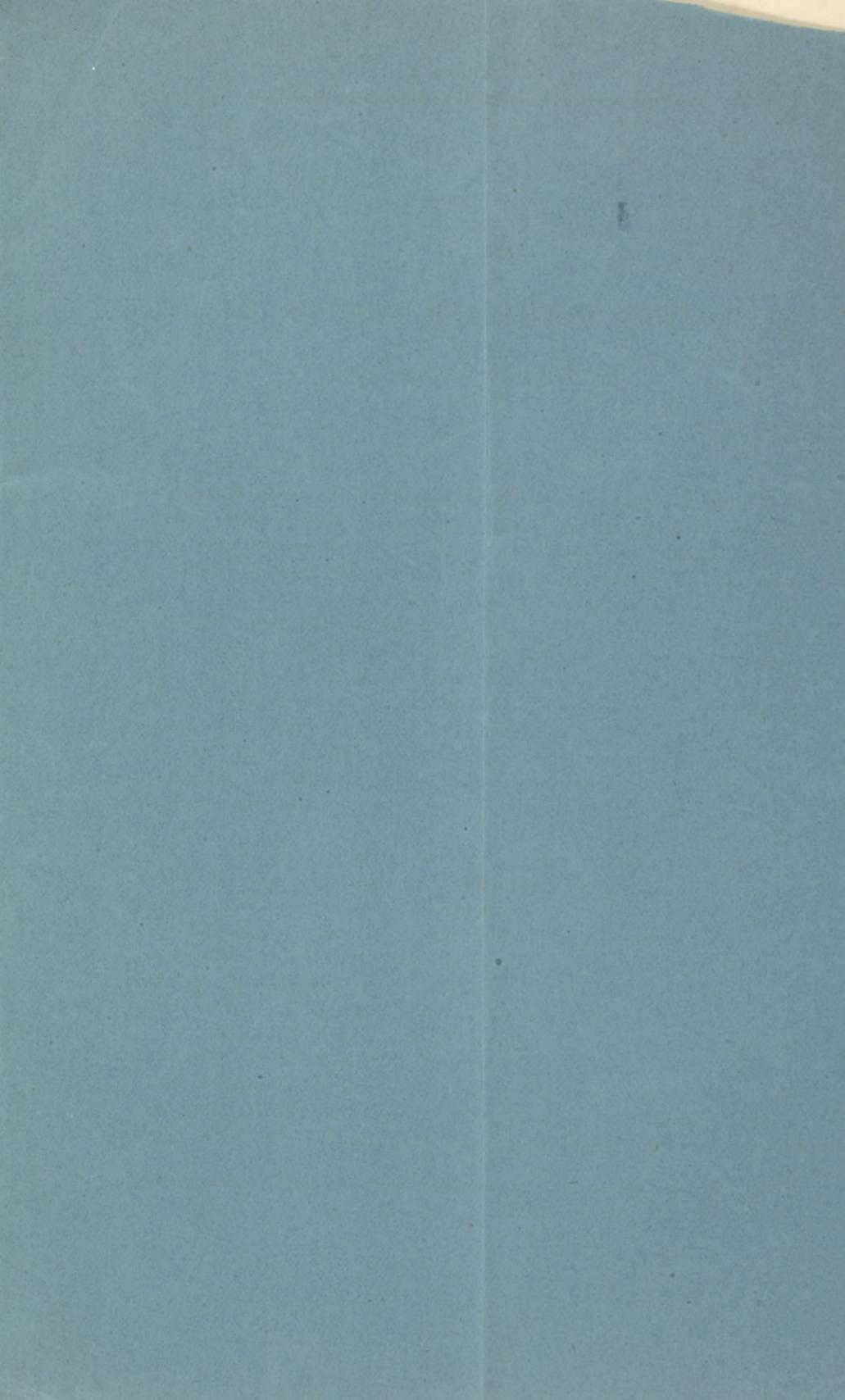
BY

J. AMORY JEFFRIES, M.D.,

OF BOSTON.



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STERILIZATION OF MILK AND FOODS FOR INFANTS.¹

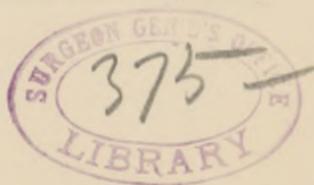
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BY J. AMORY JEFFRIES, M.D.,
OF BOSTON.

DURING last summer's work as District Physician of the Boston Dispensary, my attention was called, by the severity and prevalence of the trouble, to the summer diarrhoeas of infants. The disease was quite prevalent, and in my cases severe, as the milder ones were all treated as out-patients. In most cases it had existed for about a week, and the infant was already collapsed by the time of my first visit. The skin would be found cold, the limbs were blue, the fontanelles sunken, eyes the same, the child either indifferent or curled up and whining. The pulse would be weak, small, and rapid, and the temperature, in the rectum, over 100° F., often higher; convulsions were rare. The bowels were tender and in most of the cases diarrhoea existed; a few, however, were constipated. The tendency of all discharges was to a green color and much mucus. In short, the clinical picture was that with which all physicians are familiar.

Treatment was begun with the ordinary drugs and salicylate of soda, which was then being so much extolled as a germicide, and care of the bottle. Later the treatment was changed to creasote, if vomiting existed, and care of the milk supply. The change was made to bring the treatment more into accord with the generally accepted belief that bacteria are at the bottom of the trouble. Whether special organisms are accepted as probable or not, the belief that changes wrought in the food, inside or outside the body, are the cause of the trouble is held by most.

Long before bacteria were thought of as the cause of the disease the usual routine treatment had a decidedly germicidal tendency. Gray powder probably acts as a mild germicide in the stomach, and lower down in the canal helps to sweep them out; while the care of the bottle

¹ The work for this paper was done in the bacteriological laboratory of the Harvard Medical School, for the freedom of which I am much indebted.



is nothing but an effort to avoid bacteria and their effects. Lastly, a host of patent foods, advertised as germ-free, have come into the market.

It is a curious fact that while all older people are chiefly fed on sterilized food—that is, cooked food—infants are fed on food peculiarly adapted, by its composition and fluid state, to offer a home to bacteria.

Investigation of the milk supply soon showed that this was greatly at fault; though “fresh each day,” it was, as a rule, found to be decidedly acid, often curdling if heated, by the time it was fed to the infant. This the infant, unable to talk and knowing nothing better, was obliged to take or go empty. So, remembering the custom of housewives to scald the milk, directions were given that all milk used for the infants should at once, on receipt, be steamed in a skillet set into the top of the tea-kettle. After this it was kept covered and on ice if possible. The bottles were rarely clean, but were, as a rule, emptied after each feeding. The result was that instead of staying at the point of death, the little patients began to pick up and were soon well, the stools first becoming light, then yellow. I have since undertaken to devise some way by which milk can be practically sterilized—to lay down a rule applicable in any house, by any ordinary nurse.

The ordinary milk supply of a large city is a day or more old, has a slightly acid reaction, and contains many growing bacteria. If kept for a day it is decidedly acid in reaction, has a sour taste, is apt to curdle if heated, and contains a very large number of bacteria, the cause of the changes. Fresh milk sterilized, or collected sterile and protected from organisms, undergoes no changes even after the lapse of indefinite periods except the separation of the fats. If bacteria are present, a great variety of changes may occur according to the species—for instance, the milk sugar may be turned to acids, the fats broken up, or tyrotoxicum formed. As milk affords such a fine medium for growth, all efforts to rid it of bacteria must be governed by the use of poisons—germicides—or some physical condition inimical to their life. The first method is not admissible in foods, while the other offers little chance of success except by heat. Cold simply retards their growth, does not kill. As boiling produces marked changes, this also is undesirable, so our means are narrowed down to the ordinary one of steaming. Fortunately this produces but slight changes in the milk compared to boiling, and, as I have found, is efficient.

Before reporting the experiments a few preliminary statements are necessary. The milk used came from a private source, eight miles from Boston, was either eight or twenty-two hours old, was kept in an ice-chest, and of very good quality. The only precaution, in the way of sterilization, taken was to heat the test-tubes or flasks in an oven before using them. The flasks were also plugged with cotton-wool rather than a stopper, which is liable to be blown out.

The agar-agar tubes, mentioned in the experiments, are the regular ones used by bacteriologists—that is, test-tubes about one-fourth full of a meat-peptone solution, solidified by the addition of agar-agar. These were allowed to cool on an inclined plane to obtain a large surface. The loop is simply a small loop in the end of the platinum wire, used to convey the substance to be tested for bacteria to the surface of the agar-agar. Esmarchs are made by adding the substance to be tested to some meat-peptone gelatine solution, dissolved by warmth, and then rapidly rotating the test-tube containing it on a horizontal plane of ice. By this means the gelatine solidifies in a thin, even coat on the entire inner surface of the tube. Later the bacteria multiply and form colonies easily counted.

In making inoculations from the milk after steaming all precautions against contamination were taken; the fluid being first thoroughly mixed, so as to obtain due proportions of all the constituents in the part used for inoculation. After steaming the flasks were left at the temperature of the room, as ice, by virtue of its cold, would tend to diminish the severity of my tests.

All the experiments are reported, not only those which were favorable.

EXPERIMENT I.—Thirteen test-tubes of fresh morning's milk were placed in the steamer and heated until steamed for fifteen minutes. On the next day six of the above were steamed a second time the same way. Before the first steaming an agar-agar culture was made from the milk; in three days the growth was marked.

10th day. Agar-agar cultures made from the test-tubes of milk, one loop in each case.

13th. All the cultures sterile as yet.

26th. One-half of the cultures of the milk steamed but once, show growth; rest sterile.

EXPERIMENT II.—Agar-agar cultures made from the middle of a freshly opened can of Anglo-Swiss condensed milk. In ten days these developed three colonies. At the same time a 10 per cent. solution of the condensed milk was made with hot water, and steamed as in Experiment I., in all eighteen tubes.

2d day. Nine tubes steamed a second time.

9th. One of the tubes steamed but once has coagulated, all the others have a cream on top, a milky fluid below, and a slight sediment at the bottom. From each tube an agar-agar culture with one loop was made.

24th. Two-thirds of those steamed but once have coagulated, and their cultures show growth; the rest, same as before, and cultures sterile.

EXPERIMENT III.—A mixture was made of Mellin's food as directed on the bottle, of 8.5 grammes of the food and 131 c. cm. of water and milk each. This was then placed in eighteen sterile test-tubes, divided into two lots: (A) steamed once; (B) steamed twice, as in I.

10th day. Both A and B have a brownish cream, fluid, and sediment, but show no signs of coagulation. Agar-agar cultures made with one loop from each.

20th. All the cultures from A show a growth, while those from B are sterile.

EXPERIMENT IV.—A mixture was made of cream 50 c. cm., milk 25 c. cm., lime water 50 c. cm., and milk sugar solution¹ 75 c. cm.; this was divided into two lots, thirteen test-tubes in all, and treated as in III.

¹ Milk sugar 317½, water Oj.

10th day. Mixture turned brown at once upon steaming, and so remained; no other visible change. Agar-agar cultures, with one loop made from each.

20th. No change in test-tubes; cultures both A and B sterile. As Dr. T. M. Rotch¹ reports no changes in the cream mixture after steaming, I made the following experiments to discover the source of the brown color in IV.

EXPERIMENT V.—A mixture of one part milk, two cream, and three milk sugar solution was placed in seven test-tubes and steamed for fifteen minutes.

2d day. No brown color, cream very thick.

8th. No visible change; reaction to litmus paper neutral. Agar-agar culture made from each tube.

23d. No changes in the tubes; cultures all sterile.

EXPERIMENT VI.—A mixture of equal parts of cream, milk, and lime water, placed in six test-tubes, and steamed for fifteen minutes.

2d day. No brown color; cream on top.

8th. Agar-agar cultures made.

23d. Tubes all fresh; cultures all sterile.

EXPERIMENT VII.—First boiled lime water and milk sugar solution separately, over a Bunsen burner, and found no change except that lime was left on the side of the test-tube. Next made a mixture of the two, in the proportion of two to three, and divided it up among ten test-tubes. Reaction strongly alkaline. The ten tubes were then put in the steamer. One was taken out in five minutes, another in ten, a third in fifteen, and the rest at the end of a half hour; all were found to be brown, or rather a yellow-brown, the first slightly less so than the rest. They were then tested with litmus paper, and found to show a marked diminution in alkalinity.

No further experiments were made, as the above seemed to show clearly that the brown color was due to the action of the lime on the milk sugar, like that produced by potassic hydrate, in which case brown products are formed. However this may be, the reaction always took place in my experiments, provided the milk sugar had not become decomposed, as it shortly does if fungi get into the solution.

Why my results should thus vary from Dr. Rotch's is not clear, unless it be that his mixtures had been mixed before he saw them. If examined before disturbing, the cream above is quite light, and the thin fluid below distinctly brown, after mixing the cream makes the whole quite opaque, and the color is almost concealed. It will be remembered Dr. Rotch did not report a test of the reaction after steaming.

In the following experiments the flasks were put in the hot steamer, instead of into the cold steamer and heated up. This was done in order to adopt as much as possible the principle of Pasteurisation; a rapid being more fatal than a gradual change of temperature of the same extent.

EXPERIMENT VIII.—Cream mixture of the same proportions as in IV. was put in eighteen test-tubes, and steamed for fifteen minutes. On the following day nine of them (B) were steamed again for fifteen minutes. All of the tubes, both A and B, became brown during the steaming, and, as was later found, lost much of their alkalinity.

5th day. Agar-agar cultures made from three of A and three of B; milk tested with litmus paper; B found neutral, A faintly alkaline.

9th. One of the agar-agar cultures from A shows a growth.

15th. Another from A shows growth, all B are sterile.

EXPERIMENT IX.—A mixture of Anglo-Swiss condensed milk one part, hot water nine parts, was put in thirteen test-tubes and placed in the hot steamer for fifteen minutes; on the next day seven of these (B) were again steamed for fifteen minutes.

4th day. Cream on top, milky fluid below and slight sediment at the bottom, but no visible signs of decomposition. Three agar-agar cultures made from each A and B.

20th. All the agar-agar tubes sterile.

EXPERIMENT X.—To a mixture of Anglo-Swiss condensed milk like the last was added an old culture of a bacillus producing putrefaction. All twenty tubes were then placed in the hot steamer. Four were removed in five minutes (A), four in ten (B), four in fifteen (C), and the remaining eight in twenty (D).

3d day. Agar-agar tubes inoculated from two tubes of each lot of milk, making eight in all.

8th. One of A is negative, the other shows a good growth; B, C, and D, sterile.

16th. The other A and one of the C tubes have taken, rest sterile. Ultimately all the milk tubes but one steamed for twenty minutes decomposed.

EXPERIMENT XI.—Fifteen test-tubes were filled with milk and put in the hot steamer, they were removed in lots of five at the end of five, ten, and fifteen minutes. At the same time three gelatine Esmarch tube cultures were made, each containing two drops of the fresh milk.

2d day. Agar-agar cultures made with one loop from each of the tubes of milk.

3d. The Esmarchs contain about 250 colonies each.

14th. All the agar-agar tubes are sterile, but the milk has coagulated in all but three tubes.

EXPERIMENT XII.—This experiment was the same as the last, except that the agar-agar tubes were inoculated from the milk four days after steaming instead of one day.

8th day. All five of those steamed for five minutes show growth, also one of those steamed for ten.

12th. Three more of those steamed for ten minutes show growth. All the milk tubes steamed for five or ten minutes have coagulated, also one of those steamed for fifteen minutes. No further changes occurred.

EXPERIMENT XIII.—Fifteen test-tubes were steamed as in the last two experiments and stood aside to be tested for their bacterial contents at the end of fourteen days. At the end of this time all of the tubes but one of those steamed for fifteen minutes had clotted, so no cultures were made.

EXPERIMENT XIV.—Three flasks each containing 100 c. cm. of milk were put in the hot steamer for fifteen minutes.

2d day. Agar-agar cultures were made from the flasks.

32d. Agar-agar tubes still sterile.

EXPERIMENT XV.—This experiment was the exact counterpart of Experiment XIV. and gave the same results.

EXPERIMENT XVI.—One flask containing 200 c. cm. of milk was put in the hot steamer for fifteen minutes.

2d day. Agar-agar tubes inoculated with one loop from the flask.

30th. Agar-agar tubes sterile.

EXPERIMENT XVII.—Four tubes each containing 100 c. cm. of milk were steamed for fifteen minutes.

7th day. Milk acid in reaction, but shows no visible change. Agar-agar tube inoculated from each flask by a loop.

12th. One of the agar-agar tubes shows a good growth.

20th. Another of the agar-agar tubes has taken.

30th. The other two agar-agar tubes are still sterile.

EXPERIMENT XVIII.—Three flasks each with 100 c. cm. of milk were steamed for fifteen minutes.

2d day. Three agar-agar tubes inoculated, with a loop, from the three flasks; milk also tested with litmus paper and found to be faintly acid.

15th. The three agar-agar tubes are sterile.

EXPERIMENT XIX.—A test-tube of the lot of milk used in the last was set aside for a day, and then three agar-agar tubes inoculated, each with one loop.

4th day. The agar-agar tubes are simply swarming with bacteria.

EXPERIMENT XX.—Five agar-agar tubes were inoculated with one loop each from the lot of fresh milk used in Experiment XVIII.

5th day. All show good growth with isolated colonies on the edge.

If we stop to review the results of the above experiments it is at once seen that milk cannot often be sterilized by one steaming. Of the one hundred and twenty odd lots of milk steamed but once, all but four or five showed distinct signs of change within a month. Two which appear sterile are, however, still in my possession after twice that lapse of time. How it happened that these few are sterile will be explained later on. On the other hand, the majority of those steamed twice did not change at all; those which did change, it may be added, coagulated at about the same time as those steamed but once.

But if we look over the data of the agar-agar tubes inoculated by the loop, we see that such may be sterile even if made from milk which has stood for a long period. This is shown by Experiments I., II., III., and V., where the milk had stood from seven to ten days after being steamed before the culture was made. That the loop was sufficiently large to carry enough milk to contaminate the agar-agar is shown by XX. No more such experiments are reported, though many were made in the course of other work, as all showed the loop to contain quite a number of bacteria.

Turning to the twenty agar-agar tubes inoculated from milk which had stood one day, we find that all failed to show any growth. It was evident, therefore, that steaming for fifteen minutes offered good prospects of success.

Before passing to my final experiments to elaborate this point, it must be noted that on several occasions the growth of bacteria on the agar-agar had not become distinctly visible until the tenth day.

The following experiments go in threes: a gelatine Esmarch culture was made with one drop of milk or mixture used, then the flasks, each containing 100 c. cm. of the substance, were steamed for fifteen minutes; and lastly, a part was set aside stoppered in the room. As soon as the flasks were steamed they were put beside the one not steamed. At the end of twenty-four hours Esmarchs were made from all, one drop being taken by a sterile pipette. By this means it was possible to count the number of bacteria in a drop of the substance, a large quantity, before steaming and a day after it had been steamed, and to gather an idea of what the number would have been if it had not been steamed.

EXPERIMENT XXI.—Four flasks were filled, each with 100 c. cm. of milk, and then steamed at once for fifteen minutes, after which they were stood away for a day. At the end of this time four Esmarchs were made from the four flasks, with one drop each.

3d day. No signs of growth in the Esmarchs.

11th. The Esmarchs show 0, 1, 3, and 10 colonies respectively, all of one kind.

EXPERIMENT XXII.—Two Esmarchs were made with one drop each from the fresh lot of milk used in the last.

7th day. Calculations made in the usual way by counting the colonies in a given area, and multiplying by the total area give 1644 and 1391 colonies.

EXPERIMENT XXIII.—Steamed three flasks, each with 100 c. cm. of milk for fifteen minutes.

2d day. Made Esmarchs with one drop from each of the three flasks.

9th. All sterile.

29th. All sterile.

EXPERIMENT XXIV.—A test-tube filled from the lot of milk used in the last was set aside till the following day, when two Esmarchs, with a drop each, were made at the same time as those of XXIII.

4th day. Esmarchs entirely dissolved by the minute colonies, thus showing the presence of innumerable bacteria in the milk.

EXPERIMENT XXV.—One gelatine test-tube was inoculated with one drop of the fresh milk, and should have been rolled out into an Esmarch but was forgotten.

4th day. Full of colonies, but it is impossible to count them in the mass of gelatine.

9th. Gelatine all dissolved for some time.

EXPERIMENT XXVI.—Mixture made of 7 grm. Mellin's food and 150 c. cm. of hot water, after the food was dissolved, 150 c. cm. of milk were added, and the whole steamed. Two flasks were then filled with 100 c. cm. each, and steamed for fifteen minutes.

2d day. Esmarchs, one drop made from each.

5th. Each Esmarch contains one colony.

19th. No change.

EXPERIMENT XXVII.—Two Esmarchs made, with one drop each, from the fresh lot of Mellin's food used in the last experiment.

3d day. One Esmarch shows 18, the other 20 colonies.

8th. They now show 30 and 34 colonies.

15th. No change in the numbers.

EXPERIMENT XXVIII.—Sample from the mixture used in Exp. XXVI. set aside until the next day, when an Esmarch with one drop was made.

3d day. Esmarchs contain so many minute colonies it is impossible to count them; the whole shortly dissolved.

EXPERIMENT XXIX.—A mixture was made of one part Anglo-Swiss condensed milk and ten parts hot water. From this two flasks, 100 c. cm. each, were filled and steamed for fifteen minutes.

2d day. Esmarch, with one drop, made from each.

5th. No colonies visible.

12th. One Esmarch is sterile, the other has one colony.

16th. No new colonies.

EXPERIMENT XXX.—Two Esmarchs were made from the fresh mixture used in the last experiment, each with one drop.

5th day. The Esmarchs show 646 and 612 colonies, according to calculation; these shortly dissolved the gelatine.

EXPERIMENT XXXI.—A test-tube full of the condensed milk solution used in Experiment XXIX. was set aside for a day, when an Esmarch with one drop from it was made.

5th day. The fourth day of the Esmarch, calculation derived from counting the colonies in a small square with a strong lens gave 9750.

EXPERIMENT XXXII.—A mixture of seven grms. Mellin's food, hot

water, and milk, each 150 c. cm., was carefully made and steamed. Two flasks were then filled with 100 c. cm. each and steamed for fifteen minutes.

2d day. Esmarchs, one drop, made from each.

4th. One Esmarch shows one colony, other none.

15th. No new colonies.

EXPERIMENT XXXIII.—Esmarch made with one drop of the fresh mixture used in the last experiment.

4th day. Thirty colonies.

10th. Forty colonies. No new colonies occurred later.

EXPERIMENT XXXIV.—Esmarch with one drop of the mixture used in the last two experiments, after standing for a day. By this time the top was brown and dirty looking.

2d day. The whole is dissolved.

EXPERIMENT XXXV.—One flask was filled with 100 c. cm. of milk and steamed for five minutes.

2d day. Esmarch with one drop made.

13th. Two colonies.

EXPERIMENT XXXVI.—An Esmarch was made with one drop of the fresh milk used in the last experiment.

4th day. Sixty colonies by count.

Shortly dissolved in places, so no later count could be made.

EXPERIMENT XXXVII.—A sample of the milk used in the last two experiments was set aside for a day; then an Esmarch made with one drop.

3d day. Esmarch all dissolved.

EXPERIMENT XXXVIII.—Two flasks of milk, each 100 c. cm., were steamed for ten minutes.

2d day. Made an Esmarch with one drop from each.

4th. No colonies in the Esmarchs.

18th. No colonies.

EXPERIMENT XXXIX.—Esmarch with one drop of the fresh milk used in the last experiment.

4th day. Careful count gave 84 colonies. All dissolved in a few days.

EXPERIMENT XL.—A sample of the milk used in the last two experiments was set aside for a day, when an Esmarch was made with one drop from it.

4th day. Esmarch dissolved.

EXPERIMENT XLI.—A mixture of cream 70 c. cm., milk 35 c. cm., lime water 70 c. cm., sugar and lime water 105 c. cm. made. From this, two flasks were filled with 100 c. cm. each, and steamed for fifteen minutes.

2d day. Esmarchs made with one drop from each.

9th. No colonies.

17th. Esmarchs sterile.

EXPERIMENT XLII.—Esmarch made with one drop of the fresh mixture used in the last experiment

3d day. About 150 colonies.

7th day. Gelatine dissolved.

EXPERIMENT XLIII.—A sample of cream mixture set aside.

2d day. Esmarch with one drop made.

3d. Looks to be crowded with colonies.

7th. All dissolved.

EXPERIMENT XLIV.—From a mixture of one part Anglo-Swiss condensed milk and ten parts water, two flasks were filled with 100 c. cm. each and steamed for fifteen minutes.

2d day. Esmarch with one drop made from each.

17th. Both Esmarchs are still sterile.

EXPERIMENT XLV.—Esmarch with one drop made from the fresh mixture used in the last experiment.

3d day. Nothing visible yet.

13th. About 200 small and 2 large colonies.

EXPERIMENT XLVI.—A sample of the mixture, used in the last two, set aside for a day, when the customary Esmarch was made.

9th day. Two-thirds dissolved by about forty large colonies, solid parts stippled with pin-point colonies.

EXPERIMENT XLVII.—A cream mixture was made in the same proportions as before, and two flasks, 100 c. cm. each, filled from it; the flasks were then steamed for fifteen minutes.

2d day. Esmarch made as usual.

8th. No colonies to be seen.

16th. Both Esmarchs sterile.

EXPERIMENT XLVIII.—An Esmarch with one drop of the fresh cream mixture was made.

2d day. Several minute colonies.

8th. Esmarch dissolved.

EXPERIMENT XLIX.—A sample of the cream mixture used in the last two was stood aside for a day, when an Esmarch with one drop was made.

8th day. Dissolved.

I have put the results of the later experiments in a table, to help comparison. The *a* sign indicates that a large number of colonies developed and dissolved the gelatine before they had grown large enough to count.

Experiment, and substance used.	Quantity.	Time steamed.	Time stood.	No. of bacteria.	Experiment, and substance used.	Quantity.	Time steamed.	Time stood.	No. of bacteria.
XXI.	c. m.	seconds.			XXXIII.	c. m.	seconds.		
Milk.	100	15	1 day.	0	Mellin's.	.....	.....	.....	40
Milk.	100	15	1 "	1	XXXIV.	.....	.....	1 day.	<i>a</i>
Milk.	100	15	1 "	3	Mellin's.	.....	.....	1 "	2
Milk.	100	15	1 "	10	XXXV.	100	5	1 "	2
XXII.	.....	.....	.....	1644	Milk.	.....	.....	.....	60
Milk.	.....	.....	.....	1391	XXXVI.	.....	.....	.....	60
XXIII.	100	15	1 day.	0	Milk.	.....	.....	1 day.	<i>a</i>
Milk.	100	15	1 "	0	XXXVII.	.....	.....	1 "	0
Milk.	100	15	1 "	0	Milk.	100	10	1 "	0
XXIV.	100	15	1 "	0	XXXVIII.	.....	.....	1 "	0
Milk.	.....	.....	1 "	<i>a</i>	Milk.	100	10	1 "	0
Milk.	.....	.....	1 "	<i>a</i>	XXXIX.	.....	.....	.....	84
XXV.	100	15	1 "	1	Milk.	.....	.....	1 day.	<i>a</i>
Mellin's.	100	15	1 "	1	XL.	.....	.....	1 "	0
XXVI.	.....	.....	1 "	<i>a</i>	Milk.	.....	.....	1 day.	<i>a</i>
Mellin's.	100	15	1 "	1	XXI.	100	15	1 "	0
XXVII.	.....	.....	.....	30	Cream milk	100	15	1 "	0
Mellin's.	.....	.....	.....	34	Cream milk.	100	15	1 "	0
XXVIII.	.....	.....	1 day.	<i>a</i>	XLII.	.....	.....	.....	150
Mellin's.	.....	.....	1 "	1	Cream milk.	.....	.....	.....	150
Cond. milk	100	15	1 "	1	XLIII.	.....	.....	1 day.	<i>a</i>
Cond. milk.	100	15	1 "	0	Cream milk.	.....	.....	1 "	0
XXX.	.....	.....	.....	646	XLIV.	100	15	1 "	0
Cond. milk.	.....	.....	.....	612	Cond. milk.	100	15	1 "	0
XXXI.	.....	.....	1 day.	9750	XLV.	.....	.....	.....	202
Mellin's.	100	15	1 "	1	Cond. milk.	.....	.....	1 day.	<i>a</i>
Mellin's.	100	15	1 "	0	XLVI.	.....	.....	1 "	0
					Cond. milk.	.....	.....	1 "	0
					XLVII.	100	15	1 "	0
					Cream milk.	100	15	1 "	0
					Cream milk.	100	15	1 "	0
					XLVIII.	.....	.....	.....	<i>a</i>
					Cream milk.	.....	.....	.....	<i>a</i>
					XLIX.	.....	.....	1 day.	<i>a</i>
					Cream milk.	.....	.....	1 "	<i>a</i>

In looking over the table it is at once seen that very few or no colonies developed from the material steamed. Out of twenty-two trials, in eight bacteria were found, in fourteen none was found. Of the eight cases, only one colony each was found in five.

The calculations from the fresh mixture before steaming show from 30, in a mixture of Mellin's food, to 1644, in a sample of milk; the average for the milk being about 75. In the one case where a count was secured from the mixture after standing a day we found 9750. Very likely the others contained more.

It is, therefore, clear that the method followed has been very successful in killing bacteria, and keeping the milk for a long period. We may thus lay down the following rules in answer to our problem: Stopper the flasks with cotton-wool and heat them in the oven for thirty minutes, at a mild baking heat, or until the wool becomes brown. Pour the requisite quantity of food into the flask and then place in the heated steamer for fifteen minutes.

The first rule is an advantage, and easily done, but not of great importance. The second is both easily done and goes to the root of the subject. Any cooking steamer with a perforated false bottom and a snug cover will do; or the lower part of a Chamberlin's steamer; the heat must be sufficient to keep the water in active ebullition.

For the benefit of those who are not familiar with the technique of bacteriology, or familiar with steamers, a diagram of a section is given, showing the principles and essential elements of construction. The vessel should be of good size, at least eight inches across the bottom—better a foot, and sixteen inches high. Inside, four inches from the bottom, there should be a projecting rim, on which should rest a metal plate perforated with numerous holes a half inch in diameter. The



cover should be tight so as to hold in the steam and prevent the ingress of air. For use, two or three inches of water should be placed in the bottom and brought to a fast boil, when the flasks should be set as near the centre of the diaphragm as possible, the cover replaced, and the whole allowed to steam for fifteen minutes. The flasks should then be taken out and stood in the cold; of course, to be brought up to the body temperature before feeding.

The chief source of failure lies in an insufficient supply of steam to keep the upper chamber full; the heat must be ample, that of a range or Bunsen burner. Where the additional expense can be borne, it is better to cover the outside of the steamer with a thick jacket of felt, extending to within two inches of the bottom.

The milk should be steamed when *first* received, preferably in the flasks from which it is fed to the infants. This requires a few more bottles, as many as the infant is fed times during the day, but will well repay for the trouble. If the milk is allowed to stand before steaming, the advantages of the method are done away with in great part. The milk may be sweet, but has already been acted upon by bacteria, and is certainly unhealthy. In case a sufficient number of flasks cannot be afforded, the milk should be steamed in a few larger ones, kept stoppered with cotton-wool, and drawn from as needed. This is the best method to employ in hospitals, where the contents of a large flask will be used up in a short time.

The secret of the success of this method lies in the well-known fact that the vegetative forms of bacteria succumb to a moist temperature of 100° C. (212° F.); that spores develop slowly; and lastly, but not least, that in milk, being an excellent medium for growth, spores rarely form, spore-formation among bacteria, like seeding among higher plants, being a phenomenon of impaired growth. The dearth of spores in ordinary milk can be demonstrated by the use of the microscope and patience.

Fifteen minutes' steaming is advised rather than five or ten, as some of the earlier experiments reported show the longer period to be more effective. The entire mass of fluid used must be heated up to the boiling-point; for this time is requisite; it is not without significance that the fifteen minutes' steaming is that employed by bacteriologists to sterilize their media.

The preservation of some of the milk steamed but once is explained by the absence of any enduring spores from the start.

