UNIVERSITY OF IDAHO
AGRICULTURAL EXPERIMENT STATION
Department of Dairy Husbandry

Sterilizing Dairy Utensils On The Farm

By

D. R. THEOPHILUS AND F. W. ATKESON

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Sterilizing Dairy Utensils on the Farm

by

D. R. THEOPHILUS AND F. W. ATKESON

Is It Necessary to Sterilize Dairy Utensils?

STERILIZATION of dairy utensils* is absolutely necessary in the production of highest quality milk or cream. Unsterile utensils are the greatest source of bacteria in milk (1, 14, 17, 19, 20, 21, and 22). Bacteria that cause sour milk, off flavors, and poor quality dairy products are found in great numbers on the surfaces of unsterilized cans, pails, strainers, separator parts, etc. Although utensils may appear to be clean, they are not really clean and safe to use unless they have been sterilized.

Ayers, Cook, and Clemmer (1) showed that milk drawn into sterilized pails had an average of 6,306 bacteria per c. c., while samples of milk from unsterilized pails averaged 73,308 bacteria per c.c. Prucha, Weeter, and Chamber (21) reported that milk handled in sterilized utensils averaged 6,807 bacteria per c.c., while milk handled under similar conditions except that the utensils were not sterilized showed an average of 285,600 bacteria per c.c.

Public health officials through state laws and city ordinances demand that all utensils coming in contact with milk be sterilized. The purpose of these regulatory measures is to establish an additional public safeguard by making more certain a safe, high quality milk supply. Every producer of milk should sterilize all dairy utensils, either because of state or city regulations, or in the interest of a high quality product for which there is always a special demand.

What Is Sterilization?

Sterilization, according to the strict bacteriological interpretation, means destruction of all life. In sterilization of dairy utensils all life is not destroyed, especially the more resistant spore formers, but the bacteria are reduced to an insignificant number. The Bureau of Dairy Industry and the Food, Drug, and Insecticide Administration of the United States Department of Agriculture have both recently discontinued the use of the word "sterilize" in the sense of sanitary

*The word "utensils" as used in this bulletin means all appliances, such as milk pails, strainers, cans, separator parts, milk bottles, etc., which come in contact with milk or cream during production or handling.

treatment of dairy utensils and are instead using the term "treating to kill bacteria."

According to Prucha and Harding (20) it is the common view among dairy authorities that a can is satisfactorily sterilized when it adds to the milk only 100 or less bacteria per c. c. Effectively sterilized utensils contain very few live bacteria.

Heat and chemicals are the two general agencies used in sterilizing utensils. Sterilization by heat depends upon the use of steam, hot water, or hot air. Heat sterilization is best accomplished with steam, particularly if the steam is under pressure. Utensils are sterilized very satisfactorily and efficiently when placed in a steam cabinet and subjected to a temperature of 210°F. for 20 minutes or when inverted over a steam jet for 30 seconds, if the steam is under pressure of 20 to 25 pounds. If a steam jet is used, the utensils must be steamed until they are too hot to handle with the bare hands.

Figure 1.—Electrically Heated Steam Sterilizer No. 1. Alpha Electric Sterilizer No. 2 E, 4-can size. De Laval Pacific Co., San Francisco, Calif.

Hot water may be used, but it must be *boiling* water, and the utensils must be immersed in the water and boiled from 5 to 10 minutes. The practice of scalding the utensils with boiling water from a tea kettle is very unsatisfactory as the amount of hot water is too limited to give efficient sterilization.

When sterilizing rubber parts of milking machines, Burgwald (5) recommends that they be submerged in hot water at a temperature of 160° to 165° F and left until the next milking.

An objection to both steam and hot water sterilization is that utensils are frequently left moist after sterilization. This is conducive to re-contamination and growth of bacteria, as shown by Prucha, Weeter, and Chambers (21) and by Prucha and Harding (19). Moist utensils rust easily. Dry hot air and humidified hot air have been used to prevent moist utensils, but as yet these methods have not been generally adopted.

Chemical sterilization may be used either in place of heat sterilization or in combination with it. Its advantages and limitations are discussed later under "Chemical Sterilization."

Any dairy sterilizer using steam, hot water, or hot air as the sterilizing medium should meet the following requirements:

1. High sterilizing efficiency
2. Low operating cost
3. Sturdy construction
4. Low original cost
5. Easily cleaned and operated
6. Sterilizing process completed quickly
7. Leaves the utensils dry at the end of the sterilization process
8. Produces no undesirable odors or dirt
9. Produces hot water for washing purposes
10. Proper size for amount of equipment to be sterilized.
11. Safe and free from fire hazard.

Sterilization cannot be efficient or satisfactory unless the utensils have first been thoroughly washed and rinsed. Rinse the utensils with cold or lukewarm water, next thoroughly wash and scrub them with a brush (a rag should never be used as it is a source of contamination), using warm water containing dairy washing powder (never use soap because it is more expensive, does not cut the grease and dirt as well, and is not easily rinsed off), and finally, rinse in clean water before sterilizing.

How To Clean and Sterilize Milking Machines

Milking machines are a very important source of bacteria in milk unless properly cleaned and sterilized. The following procedure is recommended:

1. Immediately after milking, rinse the machine by drawing cold or lukewarm water through the machine by vacuum. Break the flow of water occasionally by pulling the teat

cups out of the water and then immediately immersing them again. Do this 10 or 12 times.

2. Repeat the rinsing process, using hot water containing a dairy washing powder. Wash the teat cups and tubing with a brush. At least twice a week take apart the teat cups and tubes and carefully scrub them with hot water and dairy washing powder.

3. Rinse the machine with clean water drawn through by vacuum.

4. Remove the milk tube with claw and teat cups attached and submerge in clean water (preferably in a covered tank).

5. Heat the water, preferably with steam, to 160° to 165°F and allow to cool gradually. Keep the parts in the water until next milking. (If the water is heated on a stove or over a direct flame, do not place the rubber parts in the water until the proper temperature has been reached and the water container removed from the stove or flame).

6. Wash milking machine pail and covers thoroughly in warm water containing a dairy washing powder.

7. Sterilize pails and covers like any other dairy utensil, either in a steam cabinet or in boiling water.

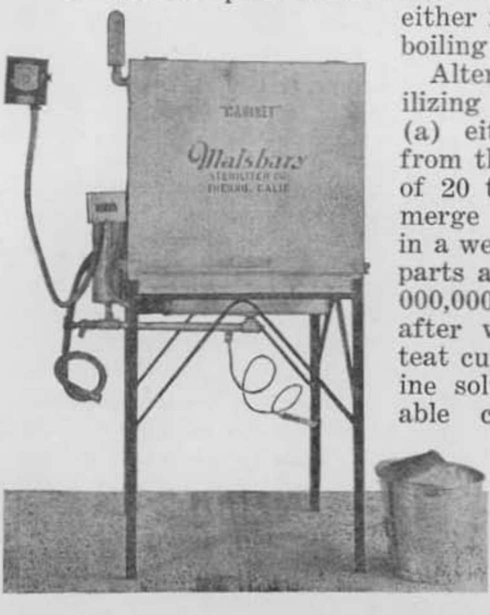

Figure 2.—Electrically Heated Steam Sterilizer No. 3. Malsbary Electric Sterilizer "Cabinet," 4-can size. Malsbary Sterilizer Co., Fresno, Calif.

Alternative methods of sterilizing the rubber parts are: (a) either remove the units from the hot water at the end of 20 to 40 minutes and submerge until the next milking in a weak chlorine solution (50 parts available chlorine per 1,000,000 parts water); or (b) after washing the tubes and teat cups, fill them with chlorine solution (200 parts available chlorine per 1,000,000 parts water) and hang them up until the next milking so they will not drain.

Rubber parts sterilized by these methods have a much longer life than if they had been sterilized with steam or boiling water

Review of Literature

The standard types of heat sterilizers may be grouped as follows: the steam boiler, wood or oil furnace, self-contained kerosene burner, gas burner, gasoline burner, steam electric, and hot air.

A steam boiler connected with a sterilizing cabinet or steam jet is recommended by Posson (17) and is the type of sterilizer used by practically all the larger producers. This type of sterilizer, according to Golding (12) and Ayers and Taylor (3), costs too much for the small producer to install and use.

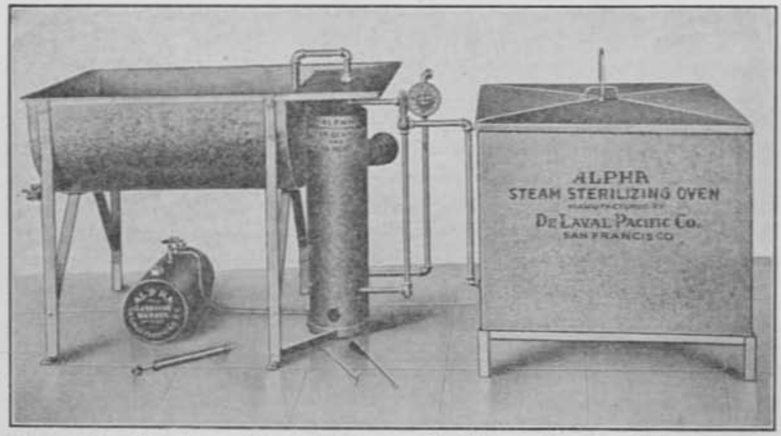

Figure 3.—Gasoline Heated Steam Sterilizer No. 1. Alpha Steam Generator, Water Heater, and Sterilizer No. 1 G. 4-can sterilizing oven. De Laval Pacific Co., San Francisco, Calif.

As a substitute for the steam boiler, wood or oil heated furnaces or tanks have been developed for the small producer. Prominent among this type of sterilizers are the hot water heater and sterilizer developed by the United States Department of Agriculture and described by Posson (17) and Kelly (14), the galvanized iron sterilizing tank described by Roadhouse (22), the steam sterilizer developed by Golding (12), and the tank or wash boiler type described by Mackintosh (15). None of these sterilizers are in general use, apparently due to the general inconvenience in operation.

In an effort to meet the demands of the smaller milk producer who cannot afford expensive types of sterilizers, the United States Department of Agriculture developed a self-contained, kerosene-heated sterilizer, described by Ayers and Taylor (3).

Private companies have placed on the market a number of kerosene-heated sterilizers, and according to Farrall (7) the tank type is economical to operate and gives satisfactory sterilization. However, Farrall et al (9) say that oil or kerosene heated sterilizers have a short life, sooty and unsatisfactory burners, and the cost of operation is excessisve.

No published work is available on the gas and gasoline burner sterilizers.

Electrically heated steam sterilizers have become quite common on the Pacific coast, and, according to Farrall and Moses (10), give satisfactory service if properly designed and operated. Farrall et al (9) list the disadvantages of this type of sterilizer as follows: "The principal difficulties of electrically heated sterilizers are their high first cost, high cost of operation in all except localities where electricity may be had at low prices, and danger of burning out elements with resulting high cost of replacement."

They further state that it is expensive to heat water for washing purposes in the sterilizers and due to the presence of moisture, utensils frequently rust if left in the sterilizer.

In order to offset the disadvantage of moist utensils and the likelihood of an increase in bacterial content and of rusting, some work has been done on an electrically heated dry air sterilizer. Ayers and Mudge (2) recommemnd a temperature of 230° F. for 30 minutes for the dry air sterilizer. Farrall (8) found the dry air sterilizer destroyed bacteria satisfactorily, left the utensils dry, and was less expensive than the electrically heated steam sterilizer, but low temperature air pockets formed within the sterilizer, causing unevenness of heating, which is a distinct disadvantage in any sterilizer.

Farrall and Regan (11) reported on an electrically heated, humidified, hot air sterilizer that possessed all the advantages of the dry hot air sterilizer and minimized the formation of air pockets within the sterilizer, but had no means of heating wash water.

Authorities recommend that cabinet sterilizers, particularly self-contained sterilizers, should be insulated to conserve heat, lower the cost of operation, and increase sterilizing efficiency (6, 7, 8, 9, 10, and 11).

Chemical sterilization is an alternative method of sterilizing dairy utensils. Johns (13), the Bureau of Dairy Industry (16), and Prucha (18) recommend chemical sterilization under farm conditions, provided directions are followed explicitly and intelligently.

A Study of Dairy Utensil Sterilizers For the Small Producer

The number of commercial sterilizers that have been placed on the market in recent years, when compared with their absence from the market a few years ago, indicates a more general recognition and better appreciation of the small producers' sterilizing problems.

The volume of butter fat, considered in the aggregate, that comes from this class of producer makes necessary more consideration of the small producer in any general program of quality improvement of dairy products.

A survey of sterilizing methods used by 264 members of dairy herd improvement associations in Idaho showed that 236, or 89.4 per cent, used hot water; 27, or 10.2 per cent, used steam; while only 1 used chemicals. Of the 236 using hot water for sterilizing purposes, 216 heated the water on kitchen stoves, 10 in electrically heated tanks, 5 on electric plates, 2 on oil stoves, and 3 by means of exhaust pipes of stationary engines. About 4 gallons of boiling water is required to properly sterilize the dairy utensils (3 cans, 2 pails, a strainer, a small cooler, and separator parts) used by a small producer. When the additional quantity of hot water necessary for washing purposes is considered, it appears that even the better dairymen do not have available sufficient hot water, and that certainly the hot water is not provided in a convenient manner.

The small percentage of producers who milk few cows and who use satisfactory methods of sterilization indicates that recommendations proposed in the past have failed to consider the limitations of these producers or the recommendations have not been brought sufficiently to their attention. Therefore, the apparent need for a method of sterilization adapted to the needs of the small producer, together with commercial appliances placed on the market for this purpose in recent years, seemed to justify a study of their utility and efficiency.

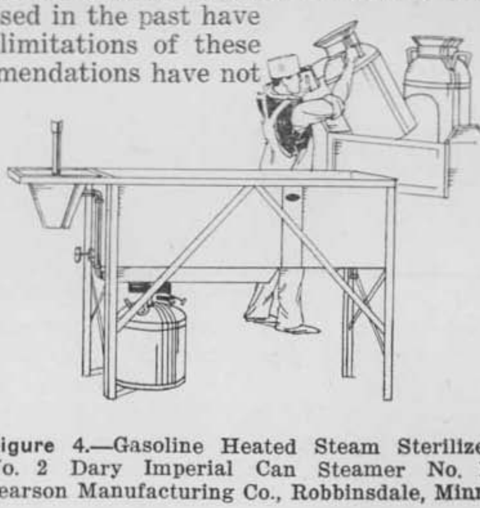

Figure 4.—Gasoline Heated Steam Sterilizer No. 2 Dary Imperial Can Steamer No. 1. Pearson Manufacturing Co., Robbinsdale, Minn.

Seven commercially manufactured combination sterilizers and water heaters, one water heater, and one home-made sterilizer, were included in the investigation. Selection of these was based upon their apparent differences in adaptability and limitations.

The two chief problems of the small producer, namely, sterilization of utensils and a plentiful supply of hot water for washing purposes, were considered when studying each sterilizer. The sterilizers and water heaters studied are grouped for discussion according to source of heat. Those included were:

- A. Electrically heated steam sterilizers
  1. Alpha Electric Sterilizer
  2. Everhot Electric Sterilizer
  3. Malsbary Electric Sterilizer
- B. Gasoline heated steam sterilizers
  1. Alpha Steam Generator, Water Heater and Sterilizer
  2. Dary Imperial Can Steamer
- C. Gas heated steam sterilizer
  1. Malsbary Standard Flamo Sterilizer
- D. Kerosene heated sterilizers
  1. Maanum Foot Pressure Can Washer and Sterilizer
  2. Home-Made Sterilizer
- E. Kerosene Water Heater
  1. Warco Perfection Set

Electrically Heated Steam Sterilizers

The three electrically heated steam sterilizers studied were manufactured and marketed on a commercial scale by different companies. They were considered representative for comparison with other types of sterilizers and with other sources of heat. The sterilizers studied were of the cabinet type, of the same size (4-can size), and similar in construction.

Procedure

Following is a description of the standardized procedure used in studying each sterilizer. The sterilizers were studied from two viewpoints: first, as a means of sterilizing; and second, as a means of heating water for washing purposes. In the first phase of the study four cans (two 10-gallon and two 5-gallon; total weight approximately 60 pounds) used in the University creamery were selected at random and washed, but not sterilized. One of the 10-gallon cans was rinsed with 200 c.c. of sterile water and the bacterial content of this water

TABLE I

Electrically Heated Steam Sterilizers

Sterilizing Efficiency

Sterilizer	No. Trials	Time Held (Minutes)	Ave. Sterilizing Efficiency (Per cent)	No. Trials	Time Held (Minutes)	Ave. Sterilizing Efficiency (Per cent)	No. Trials	Time Held (Minutes)	Ave. Sterilizing Efficiency (Per cent)
1	7	20	99.9	3	15	99.9	3	5	99.5
2	7	20	99.9	3	15	99.9	3	5	99.1
3	7	20	99.9	3	15	99.9	3	5	99.9

Cost of Sterilizing and Heating Water

Sterilizer	No. Trials	Ave. Amt. Water in Sterilizer (Lbs.)	Ave. Amt. Elec. Used to Sterilize 60 lbs. Utensils (Kw-Hr.)	Ave. Cost at 3.0 cents per Kw-Hr. (Cents)	Ave. Time to Ht. 70 lbs. Water to 140° F. (Minutes)	Ave. Amt. Electricity Used (Kw-Hr.)	Ave. Cost at 3.0 cents per Kw-Hr. (Cents)
1	10	8	1.74	5.22	31	2.5	7.5
2	10	16.5	1.94	5.82	30	2.3	6.9
3	10	18.0	2.47	7.41	25	2.04	6.12

Time and Temperature for Thermostatic Cut-Off

Sterilizer	No. Trials	Ave. Time (Minutes)	Ave. Temp. (Degrees)	Sterilizer	No. Trials	Ave. Time (Minutes)	Ave. Temp. (Degrees)	Sterilizer	No. Trials	Ave. Time (Minutes)	Ave. Temp. (Degrees)
1	11	22.7	190	2	11	25.0	193	3	11	31.1	197

determined by the standard plate method. The sterilizer was then operated according to directions of the manufacturer. After sterilization, the can previously checked for bacterial contamination was again checked by the same method. Sterilizing efficiency was expressed as the percentage of bacteria destroyed.

In 7 of 13 trials with each electrically heated steam sterilizer the utensils were held in the sterilizer 20 minutes after the electric heat was automatically cut off by the thermostatic control. In three trials the utensils were held 15 minutes and in three other trials they were held five minutes.

In the second phase of the study, that of heating water for washing purposes, 70 pounds of water with an average temperature of 53° F., were placed in the sterilizing cabinet and heated to 140° F.

The electric energy used in all trials of either the first or second phase of the study was measured in kilowatt hours by an electric meter. In the sterilizing study the temperature of the cabinet was measured by an accurate, long stem thermometer, the bulb of which was at the uppermost portion of the can. In the water heating phase of the study the water temperature was measured by a thermometer, the bulb of which was immersed about an inch below the surface of the water.

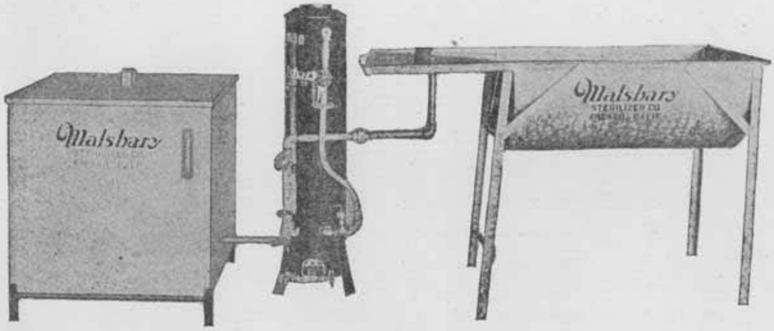

Figure 5.—Gas Heated Steam Sterilizer No. 1. Malsbary Standard Flamo Sterilizer, 4-can sterilizng oven. Malsbary Sterilizer Co., Fresno, Calif.

Sterilizing Efficiency

The averages of the results of sterilizing efficiency of the cabinet type steam sterilizers heated by electricity are shown in Table I. The average of seven trials, when the utensils were held in the sterilizer 20 minutes after the maximum temperature was reached, showed each of the sterilizers to be

99.9 per cent efficient. An average efficiency of 99.9 per cent was again obtained in three trials when the utensils were held in the sterilizer 15 minutes. Sterilizers numbers 1, 2, and 3 showed a sterilizing efficiency of 99.5 per cent, 99.1 per cent, and 99.9 per cent respectively, in three trials when the utensils were held in the sterilizer five minutes. Not only do the averages of the different trials show a high degree of efficiency, but in no instance in any of these trials with any of the sterilizers did the sterilizing efficiency drop below 99.0 per cent. The bacterial contamination of the cans, measured as previously outlined, varied greatly, extending to an upper limit of over 14 million per c.c. After sterilization, however, the highest bacterial count obtained in the 39 trials was 31 bacteria per c.c.

These results prove: first, that the cabinet type electrically heated steam sterilizer has a high degree of sterilizing efficiency; second, that there is practically no difference in this respect among the three sterilizers studied; and third, that leaving the utensils in the cabinet longer than five minutes after the maximum temperature is reached is not necessary. The third point is of particular importance when time is a factor in the sterilizing process, especially when more than one run of the sterilizer is necessary to handle all the utensils.

Time Required for Sterilization

Eleven trials with each of the sterilizers numbers 1, 2, and 3 averaged 22.7 minutes, 25 minutes, and 31.1 minutes respectively from the time the electricity was turned on until the thermostatic control cut off the heat. Table I also shows that sterilizers numbers 1, 2, and 3 required 8, 16.5, and 18.0 pounds of water respectively for sterilization, and that the thermostatic control operated at 190°, 193°, and 197° F. Thus it is apparent that the time of operation is related to the amount of water heated for steam and the cut-off temperature. Therefore, when the utensils are held in the cabinet for five minutes the complete sterilizing process varies from 28 to 36 minutes with the three sterilizers studied.

Cost of Sterilization

Table I shows that the average electric energy required for the sterilizing process with sterilizers numbers 1, 2, and 3, was 1.74, 1.94, and 2.47 kilowatt hours respectively, which, at the rate of 3.0 cents per kilowatt hour, cost 5.22 cents, 5.82 cents, and 7.41 cents. The energy required, or the cost of sterilization, (as in the case of time required for sterilization) is related to the amount of water heated to produce steam and to the thermostatically controlled cut-off temperature.

The range in kilowatt hours used was 1.5 to 1.9 for sterilizer No. 1, 1.8 to 2.0 for sterilizer No. 2, and 2.3 to 2.6 for sterilizer No. 3. The range in temperature for the three sterilizers in the same order was 188° to 192° F., 191° to 195 F°., and 195° to 200° F. Based on the above average figures, if the sterilizer is operated twice daily the yearly cost for electricity would range from $38 to $54.

Time and Cost of Heating Water

A study of the efficiency of heating wash water in the cabinet type steam sterilizer with electricity showed that the time required to raise the temperature of 70 pounds of water (about 8½ gallons) from 53° F. to 140° F. was 31, 30, and 25 minutes for sterilizers numbers 1, 2, and 3, respectively. Table I shows that the electrical energy required by the three sterilizers in the same order was 2.5 kilowatt hours, 2.3 kilowatt hours, and 2.04 kilowatt hours, which at 3.0 cents per kilowatt hour, costs 7.5 cents 6.9 cents, and 6.1 cents. Analyses of the individual trials showed practically no variations from these average figures. Heating the above mentioned amount of water twice daily for washing purposes would cost from $45 to $55 per yer for electric energy.

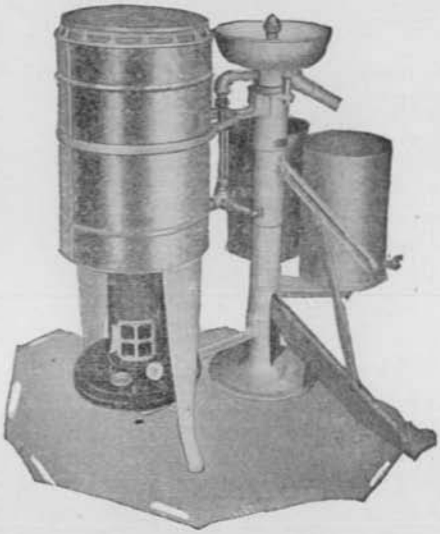

Figure 6.—Kerosene Heated Sterilizer No. 1. Maanum Foot Pressure Can Washer and Sterilizer, Model 200. Cherry-Burrell Corporation, Chicago, Ill.

Therefore, the combined yearly cost of electricity for sterilization and heating of water for washing utensils would vary from $83 to $109. In some instances it would probably be cheaper to heat water by means of a heating element on a hot water tank, provided a relatively low flat rate is allowed.

Gasoline Heated Steam Sterilizers

Two gasoline heated steam sterilizers manufactured on a commercial scale were studied. Sterilizer No. 1 was of the steam cabinet type, 4-can size, and the steam was generated outside the cabinet in a gasoline heated coil containing slowly circulating water. It was also equipped with an open steam jet. Sterilizer No. 2 was of the steam jet sterilizing type. Steam was generated in a gasoline heated core-casting into which water flowed by gravity from the water supply tank. The burner and core-casting were directly under the water supply tank and were so arranged that the flame heated the bottom of the tank, thereby heating the water supply simultaneously with the production of steam.

The same number of utensils was sterilized and the same general plan of procedure followed as described under electrically heated steam sterilizers.

In sterilizer No. 1 the time required for sterilization included the period from the time preparations were made to light the burner until a temperature of 200° F. was reached in the cabinet (at which point the burner was turned off), plus a period of five minutes in which the utensils were left exposed to the heat. The time required for the sterilizing process in sterilizer No. 2 included the period from the time preparations were made to light the burner until sterilizing steam was produced, plus a sterilizing period of two minutes for each can.

Sterilizing Efficiency

Table II shows the average results obtained in six trials with each sterilizer. Sterilizing efficiency of sterilizer No. 1 was 99.9 per cent in all trials. These results, as would be expected, are similar to those obtained with electrically heated steam sterilizers since all conditions were quite alike. Sterilizing efficiency of sterilizer No. 2 gave uniform results and averaged 99.3 per cent in six trials. Therefore, the open steam jet proved to be just as efficient, within the limits of experimental error, as the cabinet type sterilizer when the cans were exposed to direct steam for two minutes each.

Time Required for Sterilization

The time required for sterilizing four cans was 25 minutes for both sterilizers. However, No. 2 has the advantage in that when steam is generated the process may be continuous for a large number of cans. The more cans sterilized the shorter the time required for each can, including the steam generating period. The disadvantage of sterilizer No. 2 is that it is not well adapted for such utensils as strainers, separator parts, etc., that are difficult to sterilize except in enclosed sterilizers. Although sterilizer No. 1 has the same disadvantage as all cabinet types in that it is not continuous in operation, nevertheless, being an enclosed cabinet it is well adapted for sterilizing all types of utensils. No. 1 may be used

TABLE II

Gasoline Heated Steam Sterilizers

Sterilizing Efficiency and Time and Cost of Sterilizing and Heating Water

Sterilizer	No. Trials	Ave. Sterilizing Efficiency (Per cent)	Ave. Time to Sterilize 60 lbs. Utensils (Minutes)	Ave. Amt. of Fuel Used (Pints)	Ave. Cost at 25 cents per gal. (Cents)	Av. Time to Ht. 10 gal. Water to 140° F. (Minutes)	Ave. Amt. of Fuel Used (Pints)	Ave. Cost at 25 cents per gallon (Cents)
1	6	99.9	25	0.5	1.55	13	0.5	1.55
2	6	99.3	25	0.5	1.55	88	2.5	7.75

TABLE III

Gas Heated Steam Sterilizer

Sterilizing Efficiency and Time and Cost of Sterilizing and Heating Water

Sterilizer	No. Trials	Ave. Sterilizing Efficiency (Per cent)	Ave. Time to Sterilize 25 lbs. Utensils (Minutes)	Ave. Amt. of Fuel Used (Ounces)	Ave. Cost at 13.5 cents per lb. (Cents)	Av. Time to Ht. 10 gal. Water to 140° F. (Minutes)	Ave. Amt. of Fuel Used (Ounces)	Ave. Cost at 13.5 cents per lb. (Cents)
1	6	99.9	10	2.04	1.72	10	4.08	3.44

as a continuous or steam jet sterilizer for cans in addition to being used as a steam box or cabinet for sterilizing strainers, separator parts, etc.

Cost of Sterilization

Fuel consumption required in sterilizing four cans was very uniform and averaged one-half pint for each sterilizer, indicating that the burners and heating arrangement on the two sterilizers were equally efficient. Fuel used was high test gasoline, which at 25 cents a gallon cost 1.55 cents per operation for each sterilizer. As in the case of time of operation, the continuous feature of sterilizer No. 2 would be of some advantage in fuel consumption when sterilizing a large number of cans, but with the same limitations.

Time and Cost of Heating Water

Differences in construction of the two sterilizers resulted in considerable difference in efficiency of heating wash water. In six trials with sterilizer No. 1, water at 53° F. was heated to 140° F. at the rate of 10 gallons in 13 minutes, the water having continuous flow through the heating coil. Six trials with sterilizer No. 2 averaged 88 minutes to heat 10 gallons of non-circulating water at 53° F. to 140° F.

Fuel consumption for sterilizer No. 2, in heating the 10 gallons of water, was 2½ pints; which at 25 cents per gallon cost 7.75 cents. One-half pint of fuel was required to heat water in sterilizer No. 1, which at 25 cents per gallon, cost 1.45 cents per 10 gallons of water used.

The circulating water feature of sterilizer No. 1 makes possible an unlimited supply of hot water, while the non-circulating feature of water heated in tanks or sterilizing cabinets produces a limited supply and requires more time and fuel.

The yearly cost of operation, based on the average results obtained in sterilization and heating wash water, would be $23 for sterilizer No. 1 and $68 for sterilizer No. 2, provided the sterilizer was used twice daily for sterilizing purposes and for heating water in the quantities used in the study.

Gas Heated Steam Sterilizer

The gas heated steam sterilizer studied had as a source of heat natural gas compressed to liquid form in high pressure cylinders. This liquid gas is now being sold on a commercial scale for all purposes adapted to natural gas. Steam was generated by a gas burner beneath a coil containing slowly circulating water. The steam was conducted through a curved pipe into a galvanized wash tank provided with a galvanized iron cover. A steam jet was also provided at one end of the tank. A cabinet instead of the wash tank, or a combination of both, may be purchased with this type of steam generator.

The same general procedure in determining sterilizing efficiency was used as previously outlined. Since previous experiments had proven the efficiency of steam jet sterilization, and since the manufacturers claimed the wash tank with the unsealed lid could be used as a modified cabinet sterilizer, it seemed advisable to test the sterilizing efficiency of the wash tank chamber. Due to the limited capacity of the tank, it was possible to sterilize only one 25-pound, 10-gallon can. The can was placed in the tank, steamed three minutes, and left in the covered tank five minutes after the steam was shut off.

Sterilizing Efficiency

Six trials showed highly uniform results in sterilizing efficiency with an average of 99.9 per cent as shown in Table III. Although the size of the tank would obviate its use for sterilizing cans, these results prove that the covered tank may be used as a substitute for the steam cabinet in sterilizing strainers, separator parts, etc., while the steam jet may be used for sterilizing cans and pails.

Time and Cost of Sterilization

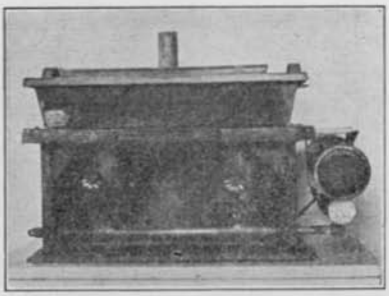

Figure 7.—Kerosene Heated Steam Sterilizer No. 2. Home-made sterilizer recommended in Farmers Bulletin 748. U. S. Department of Agriculture.

The time required for the complete sterilizing process was 10 minutes. Steam was generated in 2 minutes after the burner was lighted and opened two full turns, which, together with the three minutes the can was steamed, made a total of five minutes the fuel was used.

Uniform amounts of fuel were used in six trials, averaging 2.04 ounces of liquid gas, which at 13.5 cents per pound cost 1.75 cents for five minutes' operation.

Time and Cost of Heating Water

Water of 53° F. was heated to 140° F. at the rate of 10 gallons in 10 minutes, and the fuel consumption was at the rate of 3.44 cents per 10 gallons of water heated. Circulating water through the heating coil makes available a supply of hot water limited only by the cost of operation.

Based on these results the yearly cost of sterilizing the

TABLE IV
Kerosene Heated Sterilizers
Sterilizing Efficiency and Cost of Sterilizing

Sterilizer	No. Trials	Water in Sterilizer (Lbs.)	Ave. Sterilizing Efficiency (Per cent)	Ave. Time to Sterilize 60 lbs. Utensils (Minutes)	Ave. Amount of Fuel Used (Pints)	Ave. Cost at 25 cents per gallon (Cents)
1	6	18	99.3	60	0.5	1.55
2	6	9	99.9	43	0.5	1.55

TABLE V
Kerosene Heated Water Heater
Time and Cost of Heating Water

Sterilizer	No. Trials	Water Heated to 205 degrees Fahrenheit (Lbs.)	Ave. Time to Heat (Minutes)	Ave. Amount of Fuel Used (Pints)	Ave. Cost at 25 cents per gallon (Cents)
1	9	25	65	0.5	1.55

smaller dairy utensils in the covered wash tank and heating 10 gallons of wash water twice daily would be $38.

A milk dealer living near Moscow, Idaho, milking 24 cows and retailing an average of 216 quarts and 80 pints of milk daily, has been using this type of fuel and sterilizer for 256 days. The fuel was used to generate steam for sterilizing all utensils and to heat one-half of all wash water used. For the period of 256 days the average cost of fuel was 38 cents per day.

Kerosene Heated Sterilizers

Two kerosene heated sterilizers were studied. No. 1 was a commercially manufactured can sterilizer in which boiling water, applied to the cans under pressure, was the sterilizing medium. The source of heat was a single kerosene burner similar to those in kerosene kitchen stoves. Sterilizer No. 2 consisted of a roasting pan 20 inches by 14 inches and 3 inches deep and covered with an insulated lid having a small steam outlet in the center. This steam generating chamber was heated by a two-burner kerosene stove. When used in this manner it had the same advantage as the open jet steam sterilizer. A cabinet type feature may be easily arranged, however, by constructing a bottomless galvanized iron box with removable lid. The box should be constructed so as to fit snugly over the steam generating chamber. More complete description of this sterilizer is found in Farmers Bulletin 748, United States Department of Agriculture. In this study the steam box was not used, but instead the sterilizer was considered as an open steam jet type.

The same general procedure was used in studying sterilizing efficiency as in studying the other sterilizers. Sterilizer No. 1 was operated according to the manufacturer's directions, which consisted of spraying boiling water inside the can with five operations of the foot lever. With Sterilizer No. 2 the utensils were inverted over the steam jet for five minutes after the steam at the open jet had reached a temperature of 205° F.

Sterilizing Efficiency

The averages of six trials with kerosene heated sterilizers numbers 1 and 2 are shown in Table IV. Comparison of individual trials showed very uniform results with each sterilizer. Sterilizer No. 2 averaged 99.9 per cent, in sterilizing efficiency, while sterilizer No. 1 averaged 99.3 per cent, indicating that it was slightly less efficient; but the difference was slight and within the limits of practical operation.

Time Required for Sterilization

The time required for completing the sterilizing process with four cans was 60 minutes. The actual time for sterilizing the four cans was 4 minutes, the remaining time, or 56 minutes, was required for lighting the burner and heating the 18 pounds of water to 205° F. Only 18 pounds of water were heated as this amount was sufficient to sterilize the number of utensils used. When 35 pounds of water were heated it took 105 minutes to heat the water to 205° F. Sterilizer No. 2 required only 43 minutes for the complete sterilizing operation. The actual time for sterilizing four cans was 21 minutes, and the remaining 22 minutes were required for lighting the burners and generating steam from the 9 pounds of water in the pan. Sterilizer No. 2 produced a sterilizing medium quicker because two burners and one-half as much water were used. Another disadvantage of sterilizer No. 1 is that it is not adapted for sterilizing such equipment as strainers, coolers, separator parts, etc. However, sterilizer No. 1 has the advantage in that actual sterilization is completed quickly after sterilizing conditions have been obtained, while No. 2 is too slow in the actual operation when many utensils are sterilized.

Cost of Sterilization

The fuel required for completing the sterilizing process of four cans was an average of one-half pint of kerosene for each sterilizer. At 25 cents per gallon the fuel would cost 1.55 cents for each operation. Because of their limited capacity these two sterilizers were not studied for time and cost of heating wash water. The yearly cost of operating either of these sterilizers twice daily would be about $23, provided the number of utensils sterilized was the same as used in this study.

Kerosene Heated Water Heater

A commercially manufactured kerosene water heater of 3-gallon hot water capacity was studied. This heater consisted of a galvanized iron tank supported above a kerosene burner similar to those in kitchen stoves. The small capacity of this heater makes it adaptable to only those uses where a relatively small quantity of hot water is needed.

Table V shows that in nine trials the average amount of kerosene used was one-half pint, which at 25 cents per gallon cost 1.55 cents. The time necessary to heat 25 pounds of water at 53° F. to 205° F. averaged 65 minutes.

Discussion of Results

All the sterilizers studied, when operated according to directions, proved to be very efficient in sterilization as measured by the reduction in numbers of bacteria on the utensils. The only basis for selection, as far as sterilizing efficiency is concerned, is the adaptability for sterilizing various types of dairy utensils. The cabinet or steam box type is necessarily limited in capacity without additional complete operations, especially for such utensils as cans and pails, but is particularly well adapted for sterilizing strainers, separator parts, and other small utensils. The open jet type of sterilizer has the advantage in that it is adaptable for any number of partially enclosed utensils, such as cans and pails. However, satisfactory sterilization of such utensils as strainers, separator parts, etc., is difficult with the open steam jet. From the standpoint of sterilization it seems that a sterilizer best adapted to the largest group of producers would be the combination of a cabinet for smaller utensils and an open steam jet for cans and pails. Since all the sterilizers studied were efficient in the destruction of bacteria, other factors must be given primary consideration in selecting one best adapted to individual needs.

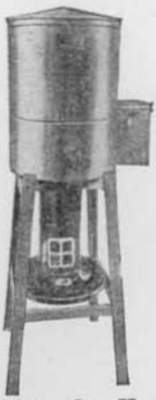

Figure 8—Kerosene Heater Water Heater No. 1. Warco Perfection Set. Warco Manufacturing Co., Bucyrus, Ohio.

Any sterilizer to be general in adaptation must also be suitable for the production of a plentiful supply of hot water for washing purposes. Tempering the hot water to washing temperature by the addition of cool water in the cabinet type sterilizer usually makes available a plentiful supply even in the smaller sizes. However, the cabinet type was not the most efficient water heating type since the water was not circulating. The water heaters consisting of heated coils with water flowing through them seemed to be the most efficient.

Source of heat is one of the important considerations in the selection of a sterilizer. Although electrically heated steam sterilizers have the disadvantages of comparatively high original cost and high cost of operation, and are slow in heating, this type of sterilizer does have a place on some farms. According to Beresford (4), 43.7 per cent of the farms in southern Idaho are electrified. Since electrically heated steam sterilizers are the cleanest, freest from odors, most convenient, and most easily operated (because they may be started with an electric switch and are thermostatically controlled), and are not likely to be a fire hazard, every small producer in southern Idaho, which is a region of ample electric power, should give this type of sterilizer careful consideration.

The gasoline and kerosene heated sterilizers are much cheaper to operate and are more general in adaptation than the electric sterilizers. The gasoline-heated sterilizer heats more quickly and is convenient to operate, but has the disadvantages of producing fumes or odors, and is a greater fire hazard. Kerosene-heated sterilizers produce more objectionable fumes and odors, have a tendency to produce soot, and are harder to keep clean.

Natural gas compressed to liquid form in high pressure cylinders is general in adaptation, heats exceedingly fast, is relatively cheap in operation, produces very little odor, is clean, is simple to operate, and heats water very efficiently.

The short period of time covered by this investigation made it impossible to study the durability of the various sterilizers. In the last analysis the selection of a sterilizer is an individual problem, as with each farmer some factors will be more important than others. For example, farmers who have a very small volume of production might consider initial cost more important, while others with larger herds would place more emphasis on cost of operation. Also, the simplicity and convenience of the electrically heated sterilizer might far outweigh differences in cost of operation. In all cases, convenience would be of paramount importance with all sterilizers. Rapidity of operation may be a secondary consideration, providing the heating unit is turned on and steam or hot water generated during the milking or chore period.

Chemical Sterilization

Chemical sterilization is an efficient alternative method available to producers with very small herds, when the investment in steam sterilizers does not seem possible or justified. Rinsing or immersing the utensils in a sterilizing solution immediately before use is an excellent supplement to steam sterilization and is becoming increasingly popular. Before using chemical sterilization it should be ascertained whether the regulatory authorities recognize or permit its use.

Chlorine compounds are most suitable for chemical sterilization of dairy utensils. The chemicals used are sodium hypochlorite, calcium hypochlorite, or compounds containing chloramines. These are sold under various trade names in liquid or powdered form. They all contain a certain percentage of chlorine, called the available chlorine, which is the active sterilizing agent. Chlorine is continually escaping from these compounds, some losing their chlorine much faster than others, resulting in a loss of sterilizing power.

Efficient sterilization demands that fresh, stable compounds be used. For farm conditions the United States Bureau of Dairy Industry (16) recommends that the sterilizing solution contain approximately 200 parts of available chlorine per 1,000,000 parts of water.

Chemical sterilization is not a substitute for washing. Chlorine in the presence of organic matter such as fat, dirt, etc., found in dirty utensils, loses its sterilizing powers. *Only Clean Utensils* can be effectively sterilized by chemical sterilization. Effective chemical sterilization of dairy utensils is relatively simple, provided directions are followed explicitly.

Directions

A sterilizing solution of 200 parts of available chlorine per 1,000,000 parts of water should be made by adding the chemical to cold or lukewarm water according to the directions of the manufacturer. Utensils may be treated either by immersing them in the sterilizing solution or by rinsing with the solution, being certain in either method that the solution is in contact with all parts of the utensils for at least 30 seconds.

Treatment of utensils should preferably be done immediately before they are to be used, but may be done after they are washed. If sterilized after being washed they should be turned upside down in a clean, dry place, free from dust and odors, and not touched until needed. This last step is important in prolonging the life of the utensils since almost all chlorine compounds are slightly corrosive to metals.

Efficient chemical sterilization depends on: 1. Use of a solution of sufficient strength, 200 parts of available chlorine per 1,000,000 parts of water; 2. Clean utensils, free from dirt, milk residue, grease, etc.; 3. Proper contact of sterilizing solution with utensils for at least 30 seconds.

Precautions

1. Sterilizing solution should never be used a second time on dairy utensils, but may be saved and used for miscellaneous disinfection about the dairy.
2. Never use water above 120° F. with chemical sterilizers.
3. Use only a fresh, full strength sterilizing solution.

(Chlorine solutions may be tested for their strength by chlorine testing equipment which may be purchased from dairy supply houses.)

4. Buy small quantities of sterilizer at a time and be sure material purchased is fresh.

Home-Made Chemical Sterilizing Solution

A home-made sterilizing solution may be made according to the following directions: Obtain a 17-ounce can of the very best grade of commercial chloride of lime, fresh and non-caked and containing at least 24 per cent guaranteed available chlorine. Make a smooth paste by carefully mixing the contents of this can with a little water in a glass or earthenware jar. Then gradually add enough water to make one gallon of chlorine solution. Dissolve 34 ounces of salsoda, or washing soda, in one gallon of warm water. Add the dissolved salsoda, or washing soda, to the chlorine solution and stir thoroughly. Allow this mixture to stand undisturbed for about 10 hours. Pour off, or siphon off, the clear liquid from the top into a tightly stoppered glass bottle and keep it in a cool, dark place. This is the *stock* solution, one pint of which should be added to every eight gallons of water to make a *sterilizing* solution for utensils. Solutions made up in this manner contain approximately 200 parts of available chlorine per 1,000,000 parts of water.

Although chemical sterilization is efficient when directions are followed explicitly and constantly, it is not recommended more generally because of the many instances of unsatisfactory results obtained due to deviations from directions in practical application. Sterilization by steam is more satisfactory under all conditions and has the additional advantage that it usually makes possible a plentiful supply of hot water.

Summary and Conclusions

Sterilization of farm dairy utensils is necessary in the production of highest quality milk. Satisfactory sterilizing facilities on the farm are among the most urgent needs in improving the quality of Idaho dairy products. Few Idaho dairymen, particularly small producers, are properly equipped to meet this problem.

Any recommendations that are to receive general acceptance by the dairymen must be adaptable to the limitations of their conditions. Solution of this problem was attempted through a study of the efficiency and adaptability of a number of sterilizers that have been placed on the market in recent years to meet the needs of the small producer.

Eight commercially manufactured sterilizers and water heaters and one home-made sterilizer were studied. All proved efficient in sterilization when operated according to directions. Cabinet or steam box types were most efficient for all types of utensils, but were limited in capacity. Steam jet sterilizers were not as limited in capacity for such utensils as cans and pails, but were not well adapted to the sterilization of strainers, separator parts, and other smaller utensils. A combination of the cabinet and open steam jet had the widest adaptation.

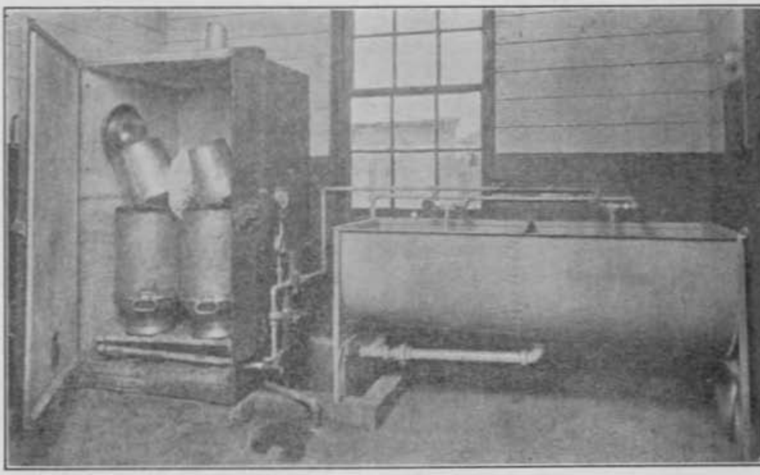

Figure 9.—Steam Heated Sterilizing Cabinet and Galvanized Iron Wash Sink. Home-made or purchased from any dairy supply house.

Electricity, compressed natural gas, gasoline, and kerosene were sources of heat involved in the study. Electricity proved to be most convenient, cleanest, freest from odors, and to have the least fire hazard, but the electric sterilizer was the highest in cost of operation. Compressed natural gas was cheaper and quicker in operation than electricity and ranked next to electricity in the other factors mentioned. Gasoline and kerosene were the cheapest sources of heat, but the sterilizers produced objectionable fumes, were harder to clean, and represented greater fire hazard. Gasoline as a source of heat was superior to kerosene.

Factors, other than sterilizing efficiency, to be considered in the selection of a sterilizer vary in importance with the needs and conditions of the individual producer. The sterilizers and water heaters studied represent a wide range of adaptability and offer the dairyman an opportunity to select one best fitted to his needs.

Chemical sterilization is suggested as an alternative method or supplement to steam sterilization.

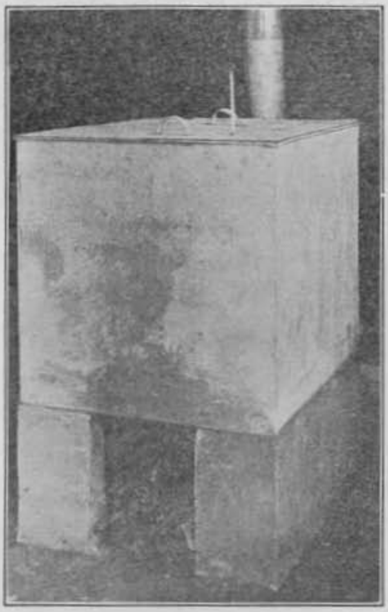

Figure 10. — Galvanized iron box steam sterilizer and water heater. Home-made.

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