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ELIMINATION OF GERMS FROM DAIRY UTENSILS

III. STEAMING CANS OVER A JET

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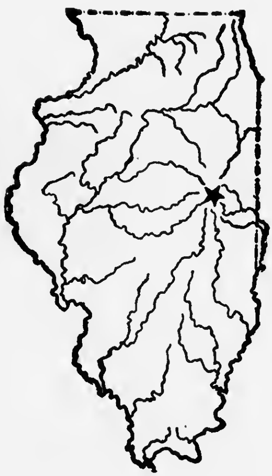

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ELIMINATION OF GERMS FROM DAIRY UTENSILS

III. STEAMING CANS OVER A JET

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The large number of bacteria commonly found in market milk has long been a matter of concern.[1] The bulk of the raw milk, when it reaches the milk dealer, contains probably more than 100,000 bacteria per cubic centimeter. In the warmer seasons of the year the number is larger, some millions of bacteria per cubic centimeter not uncommonly being found. How to account for the presence of these bacteria in the milk and how to keep them out of the milk has been a subject of much study.

Previous investigations have shown that probably more than 80 percent of the bacteria in fresh market milk come from the utensils in which the milk is handled.[2, 3, 4, 5, 6, 7] Among the utensils, the cans in which the milk is shipped to the milk plant are of outstanding importance. The milk cans are the source of this surprisingly large amount of germ life, not necessarily because they have been improperly washed at the milk plant, but because they have not been properly steamed and dried after the washing process. By the time the farmer receives such cans, some 10 to 40 hours later, the bacteria in them have increased into millions and they are unfit to receive milk. While it is possible for the producer to put such cans into reasonably good condition on the farm, it is manifestly undesirable that cans so heavily laden with germ life should be returned to him.

In the dairy industry the steaming of cans in order to destroy the germ life in them has become almost universal. Since the steam is commonly applied to the cans by what is called "jet steaming," this method of steam application is the subject of this study.

METHODS OF STUDY

The work described in this bulletin included the bacteriological examination of 1,348 milk cans, of which 1,157 were steamed and 191 were left unsteamed as check cans. These cans were of 5-, 8-, and 10-gallon capacity, and were used for shipping fresh milk from thirty-four different farms to two milk plants.

The amount of steam which is blown into a can thru a jet opening of a given size depends upon two factors: (1) the length of time of steaming, and (2) the pressure at which the steam escapes from the jet opening. These two factors were varied in this study. The cans were steamed for 3, 5, 10, 15, 20, 25, 30, 35, 40, 50, 60, 120, and 180 seconds, and the pressures used were 3, 5, 10, 15, 20, 25, 30, 35, 45, and 50 pounds. In all, thirty-six different combinations of time and pressure were tested. At each combination, a number of cans were steamed and then were examined for bacteria. A jet opening ¼ inch in diameter was the only size used.

Washing the Cans.—The cans were washed in two different milk plants in which the method of washing varied somewhat. In plant A, about 50 gallons of water was used to wash about 20 cans and the water then discarded. After being washed, the cans were rinsed and then steamed. In plant B, only about 25 gallons of water was used for 50 to 70 cans, and the cans were not rinsed before they were steamed. The wash water in both plants contained about one percent of sodium-carbonate washing powder.

Steaming the Cans.—The cans from both plants were steamed at plant A. The steam used was conveyed about one-fourth of a mile from the central heating plant to the dairy thru a large pipe. The steam pressure in the main at the dairy varied from 70 to 90 pounds.

The equipment for jet steaming was the kind commonly found in dairies. A strong galvanized iron plate 20 inches long and 12 inches wide was fastened horizontally to the side of the washing vat, and thru the center of this plate the open end of the steam pipe protruded about four inches above the surface. The can to be steamed was inverted on this plate and the steam blown into it. The covers of the cans were steamed separately by placing them in a metal box and inverting the box over the steam jet. The pressure at which the steam was blown into the cans was measured by a sensitive steam gage placed about 18 inches from the jet opening, between the jet opening and the valve which admitted the steam.

Counting the Bacteria in the Cans.—Each can to be examined was rinsed with one liter (approximately one quart) of sterile water, and after a thoro shaking, so as to bring the water into contact with the interior of the can, a sample of the water was taken. The germ count of this water was determined by the plate method. The total number of bacteria found in this rinse water was taken as the number of bacteria to have been in the can.

The medium used for the plating was an agar of the following composition: agar shreds, 15 grams; Witte's peptone, 10 grams; Liebig's meat extract, 3 grams; lactose, 10 grams; distilled water to make 1 liter. The reaction of this medium was adjusted to one percent normal acid to phenphthalein. The plates were incubated seven days; five days at 20° C. and two days at 37° C.

Amount of Steam Blown into a Can per Second at Different Pressures.—The first step in this study was to determine the amount of steam that is blown into the can at the different pressures. When steam is flowing into the atmosphere, the amount that will escape per second may be calculated by the formula $\frac{EP}{70}$, provided the pressure at which the steam escapes from the jet opening is 15 pounds or more.[8] In this formula, E stands for the area of the jet opening; P stands for the absolute pressure, that is the steam pressure plus the atmospheric pressure; and 70 is a constant.

When the steam pressure is less than 15 pounds, this formula does not hold. Hence it was necessary to make direct determinations by the following method: About 10 pounds of finely crushed ice was placed in a pail and the steam was blown into it for a given length of time and at a given pressure. The pail was weighed before and again after the steaming and the difference in the weight gave the amount of steam in pounds. The volume of steam was calculated on the basis of one pound equalling 26 cubic feet.

TABLE 1.—VOLUME AND WEIGHT OF STEAM THAT ESCAPES PER SECOND THRU A JET OPENING ¼ INCH IN DIAMETER

Steam pressure	Amount of steam	Weight of steam	Steam pressure	Amount of steam	Weight of steam
lbs.	*cu. ft.*	*lbs.*	*lbs.*	*cu. ft.*	*lbs.*
3	.1664	0.0064	30	.8190	0.0315
5	.2704	0.0104	35	.9100	0.0350
10	.4134	0.0159	40	1.0010	0.0385
15	.5177	0.0199	45	1.0920	0.0420
20	.6292	0.0242	50	1.1752	0.0452
25	.7280	0.0280			

As would naturally be expected, the results show that the amount of steam blown into a can per second thru a given opening increases directly with the pressure. With the ¼-inch opening, at 3 pounds pressure the amount is .1664 cubic feet and at 50 pounds pressure it is 1.1752 cubic feet, the latter being more than seven times larger than the former. It is evident that in considering the efficiency of steaming as a means of destroying germ life in milk cans, the pressure at which the steam is blown into the can as well as the length of time should be taken into consideration.

EXPERIMENTAL RESULTS

Bacterial Count of the Cans Before Steaming.—Information regarding the bacteriological condition of the steamed cans just before they were steamed was obtained by the use of check cans. On each day after the cans were washed and were ready to be steamed, a few cans were selected at random and, without being steamed, were examined for bacteria. In all, 191 such check cans, constituting 14.2 percent of all the cans, were thus examined.

The germ counts of these check cans varied astonishingly, but in most cases the count was large. Of these 191 cans, 2 appeared practically free from germ life; 2 others showed less than 1,000,000 bacteria; in 110 cans the count varied between one million and one billion, and 77 cans had a count of more than one billion bacteria each. The largest count from a single can was 38,670,000,000. The average bacterial count per can was over 2,357,000,000.

The effect of these cans upon the germ count of milk poured into them would have been very marked. If all the cans had been filled with milk, the average increase in the germ count of the milk as a direct result of the bacteria in the cans would have been 83,400 bacteria per cubic centimeter.

The above data make it evident that the cans which were to be steamed were abundantly supplied with germ life.

Bacterial Count of the Steamed Cans.—A summary of the results of the examination of the 1,157 steamed cans is given in Table 2. The data are so arranged as to show the effect of an increasing volume of steam. As the volume of steam applied increased, there was

TABLE 2.—RELATION BETWEEN AMOUNT OF STEAM USED AND NUMBER OF BACTERIA LEFT IN STEAMED CANS

Time steamed	Pressure of steam	Amount of steam		Number of cans	Calculated contamination of milk due to bacteria in cans	
					Average can	Worst can
seconds	*lbs.*	*lbs.*	*cu. ft.*		*germs per cc.*	*germs per cc.*
3	10	0.048	1.248	21	1,574	22,048
5	5	0.052	1.352	12	44,838	266,667
5	10	0.079	2.054	24	386	2,408
3	25	0.084	2.184	26	1,166	12,884
10	5	0.104	2.704	9	12,080	45,333
20	3	0.128	3.328	58	11,923	184,210
5	25	0.140	3.640	69	46,784	1,666,667
15	5	0.156	4.056	10	5,962	32,667
10	10	0.159	4.134	65	22,588	473,684
5	35	0.175	4.550	5	246	789
30	3	0.192	4.992	55	3,781	52,368
20	5	0.208	5.408	23	603	3,667
5	45	0.210	5.460	38	248	3,777
5	50	0.226	5.876	36	100	1,770
40	3	0.256	6.656	23	20	227
25	5	0.260	6.760	26	452	8,000
10	25	0.280	7.280	29	20	447
30	5	0.312	8.112	36	269	4,667
10	30	0.315	8.190	38	129	5,789
20	10	0.318	8.268	22	779	933
50	3	0.320	8.320	30	159	2,362
10	35	0.350	9.100	25	21	270
15	20	0.363	9.438	25	121	1,867
35	5	0.364	9.464	70	1	34
60	3	0.384	9.984	35	37	449
25	10	0.398	10.348	26	24	237
20	15	0.399	10.374	24	11	138
15	25	0.420	10.920	39	8	215
30	10	0.477	12.402	73	2	45
20	20	0.484	12.584	58	6	135
25	15	0.498	12.948	51	7	152
30	20	0.726	18.876	50	2	14
30	25	0.840	21.840	6	1	1
60	25	1.680	43.680	6	1	1
120	25	3.360	87.360	6	1	1
180	25	5.040	131.040	6	1	1
0	0	0	0	191	83,186	1,289,000

a corresponding decrease in the number of bacteria in the cans. Within wide limits, it apparently is not very important whether this volume results from a short steaming at high pressure or a longer steaming at lower pressure.

The volume inclosed by a 8-gallon can is practically one cubic foot. When the steam blown into the can was equal to 2 cubic feet, the destruction of germ life became apparent. When 5 cubic feet of steam was used, the average number of bacteria in the cans after steaming was such that if the cans had been filled with milk the bacterial count of the milk would have been increased less than 1,000 per cc. When the volume of steam was increased to about 9 cubic feet, the effect of the can on the milk was reduced to less than 100 bacteria per cc. When it was 11 cubic feet, the average contamination of the milk by the can was reduced to less than 10 per cc.

WHAT IS THE BACTERIAL COUNT OF A SATISFACTORY CAN?

It is evident from the data presented that it is impracticable to obtain sterile cans by the application of flowing steam. The cans were not sterile even when steam at a pressure of 25 pounds was blown into them continuously for three minutes. Since steam costs money, it is desirable to have in mind some standard as to the maximum number of bacteria that a can may add to the milk and still be considered satisfactory. There is an almost complete lack of information or even discussion regarding this point, and any standards which may be suggested will undoubtedly be found inappropriate under some conditions.

In order to learn the opinions of those best qualified to judge, a questionnaire was sent to 250 individuals—representative health officials, milk dealers, and dairy scientists. The questionnaire explained the need of a definition of a satisfactory can, and asked for an expression of judgment as to the maximum number of bacteria which such a can might add to the milk which filled it. One hundred definite replies were returned, and these are summarized below:

Number of replies	*Permissible germs per cubic centimeter*
5	0
1	1
1	5
21	10
1	25
1	30
6	50
1	75
58	100
1	500
2	1,000
1	2,000 to 3,000
1	10,000

The replies represented considerable difference of opinion but the most common view was that a can may add to the milk put into it up to about 100 bacteria per cubic centimeter and still be considered in satisfactory condition.

In this connection it should be kept clearly in mind that putting a can into satisfactory condition for immediate use by steaming is an entirely different matter from treating it so that it will be in a satisfactory condition ten or twenty hours later. The data presented in an earlier publication of this Station[6] show that if steamed cans are allowed to remain at summer temperature and moist, the growth of germ life in them will soon render them unfit for receiving milk.

TIME AND STEAM PRESSURE REQUIRED TO PRODUCE A SATISFACTORY CAN

It is evident from the data in Table 2 that the application of at least 9 cubic feet of steam is necessary in order to produce a can which upon being promptly filled with milk will not increase the germ count of the milk more than 100 bacteria per cubic centimeter. In translating the results of controlled laboratory experiments into commercial operations, it is advisable to provide for a margin of safety. This margin should be at least 10 percent, and if conditions permit, it should be about 25 percent. Hence, under commercial conditions the amount of steam per can should be increased from 9 to about 12 cubic feet.

The length of time it takes to blow this amount of steam thru a given jet opening depends upon the pressure with which the steam is blown thru the opening—the higher the pressure, the shorter the time. At 3 pounds pressure it would take 72 seconds to force 12 cubic feet of steam thru a jet opening 1/4 inch in diameter, while at 50 pounds pressure it would take only 10 seconds.

The various combinations of time and pressure which yielded approximately 9 to 12 cubic feet of steam, as tested in this study, are given in Table 3. In considering the practical application of these data, it should be remembered that where the milk is brought to the bottling plant by the producer, he waits at the receiving plat-

TABLE 3.—TIME AND PRESSURE NECESSARY TO FORCE 9 TO 12 CUBIC FEET OF STEAM THRU A JET OPENING 1/4 INCH IN DIAMETER

Time	Pressure	Steam
seconds	*lbs.*	*cu. ft.*
10	35	9.100
15	20	9.438
15	25	10.920
20	15	10.374
20	20	12.584
25	10	10.348
25	15	12.948
30	10	12.402
35	5	9.464
60	3	9.984

form until his cans are ready to be returned to him. It is desirable that the washing and steaming be handled as quickly as possible in order to cause no delay in the receipt of the next load of milk. Where the milk cans are shipped by train, there usually is an equal necessity for haste in making the cans ready for the outgoing trains. To accomplish the work in the time available, it is necessary that the minimum amount of time be given to each step in the process.

On the other hand, when the pressure at which the steam is forced thru a ¼-inch jet opening amounts to more than 25 pounds, there is an escape of an undesirable amount of steam into the room. This causes inconvenience to the workmen. In the plants where cans are dried by machines, the high humidity of the air, which is partly due to this escaping steam, interferes with proper drying of the cans. Moreover, there is every reason to believe that the steam which thus escapes does not exert its full effect upon the germ life in the cans.

Considered from every angle, it may be said from the results of these experiments that the steaming of cans is most satisfactory when the flow of steam is so controlled that it requires from 15 to 30 seconds to blow into each can 12 cubic feet of steam.

As judged by repeated observations, the cans in commercial dairy plants are not as a rule steamed uniformly nor are they steamed sufficiently. This is due, in part at least, to the fact that the steaming is subordinated to other plant operations. The length of time the can is steamed is set by the length of time it takes the operator to wash a can or to empty a can; such steaming is not reliable. The length of steaming should be determined by the steam pressure and the size of the jet opening, and may be readily calculated by using the formula given on the preceding page.

If the steaming of cans in the commercial dairy plants were properly standardized, a marked improvement in the bacteriological condition of the milk supply would result.

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