UNIVERSITY OF ILLINOIS

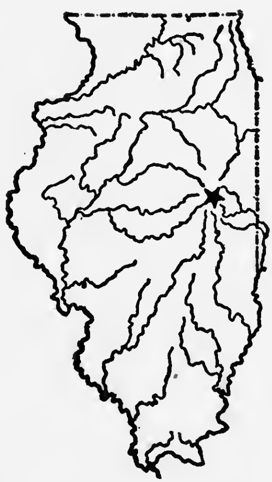
Agricultural Experiment Station

BULLETIN No. 230

ELIMINATION OF GERMS FROM DAIRY UTENSILS

I. BY RINSING II. BY DRYING IN SUN AND AIR

By M. J. PRUCHA and H. A. HARDING



URBANA, ILLINOIS, NOVEMBER, 1920

Contents of Bulletin No. 230

ELIMINATION OF GERMS FROM DAIRY UTENSILS

I. BY RINSING II. BY DRYING IN SUN AND AIR

By M. J. PRUCHA, Chief in Dairy Bacteriology and
H. A. HARDING, Chief in Dairy Bacteriology

INTRODUCTION

Before saying that a milk is good one wishes to know that it is rich, safe, clean, and sweet. Accordingly, quality in milk is said to depend upon the four items: (1) food value, (2) healthfulness, (3) cleanliness, and (4) keeping quality.[1]

Of these four elements, keeping quality, or the ability to remain sweet, is the most difficult to protect successfully during the production and delivery of the milk. If it were not for the action of germ life on the milk it would remain sweet indefinitely. However, every time milk is exposed to dust or is changed from one container to another it receives germ life. This germ life living and growing in the milk breaks the milk sugar into acid and sours the milk. Accordingly the first step in protecting the keeping quality of milk is to reduce as much as practicable the number of germs which get into it.

In Bulletin 204 of this station[2] it was pointed out that the utensils in which milk is handled are an extremely important source of germ life; hence, it is good dairy practice to reduce as far as practicable the number of utensils coming into contact with the milk. As there is a limit to such reduction it is also important to know how the necessary utensils may be handled so as to add the smallest number of germs to the milk.

As a part of the washing process, dairy utensils are practically always rinsed, hot water being commonly used for this purpose. This rinsing, in addition to removing traces of the washing powder, mechanically removes some of the remaining germ life and if the water is hot enough it also destroys some of the germs. A study of the effect of rinsing with water upon the germ life in the cans, is reported in Part I of this bulletin. This study was confined to cans because

[1]Harding, H. A., Breed, R. S., Stocking, W. A., Jr., and Hasting, E. G., What is Meant by "Quality" in Milk. Ill. Agr. Exp. Sta. Circ. 205. 1917.

[2]Prucha, M. J., Weeter, H. M., and Chambers, W. H., Germ Content of Milk: II As Influenced by the Utensils. Ill. Agr. Exp. Sta. Bul. 204. 1918.

among the common dairy utensils cans[1] are the outstanding factor in adding germ life to the milk.

Perhaps the simplest and most universal treatment given utensils is, after washing, to invert them to dry on a rack, preferably in the sun. The effect of this drying in the air, upon the germ life in cans and pails, has been studied and the results are given in Part II of this bulletin.

In stating the amount of germ life in milk it is customary to give the number present in a cubic centimeter (about 20 drops), or more briefly "per cc." The public has become familiar with the fact that certified milk ordinarily contains less than 10,000 bacteria per cc. and that the presence of 1,000,000 bacteria per cc. indicates that the keeping quality of the milk has been seriously impaired. Accordingly it has seemed helpful to state the germ life which would be contributed by any given utensil in terms of the number of germs per cc. it would add if filled with sterile milk. It is believed that this form of expressing the results will not only assist in comparing the results of handling utensils in different ways, but it will also indicate whether the contamination arising from any particular utensil is heavy enough to furnish any considerable part of the final germ content of the milk.

It is a regrettable fact that, particularly in hot weather, much of the milk as it is delivered at the shipping station or the bottling plant is heavily seeded with germ life. In the hope of finding practicable means by which this seeding could be reduced, the present studies were directed primarily to operations which could be carried out on the farm, tho the results are equally applicable in other places.

The larger part of the data reported in this bulletin was obtained during 1915-1917. Messrs. H. M. Weeter and W. H. Chambers, then members of this department, took an active part not only in the routine conduct of experiments but also in developing the plans for this study. The faithful service and intelligent interest in the earlier portions of these studies of both of these men is gratefully acknowledged.

METHODS OF STUDY

These studies were made upon the eight-gallon cans and the fourteen-quart covered milking pails used in caring for the milk from the University dairy herds. The handling of these pails and cans was in close accord with good commercial practice.

How the Utensils Were Washed

The cans were washed at the University creamery in a vat containing about 40 gallons of water at about 110° F. to which was added

[1]See pages 222-230 and 246-247 of Bul. 204, Ill. Agr. Exp. Sta., noted on preceding page.

one percent sodium-carbonate washing powder. Each can was scrubbed with a brush, and after draining for about five seconds was rinsed in another vat containing plain water at about 110° to 120° F. The pails were washed in a similar manner except that the washing took place at the farm.

METHOD OF COUNTING BACTERIA IN THE UTENSILS

After the utensils had received the desired treatment, one liter (approximately one quart) of sterile cool water was poured into each can or pail, and after a thoro shaking the water was poured out and the number of bacteria removed by this water taken as the number present in the utensil. The extended tests of this method of determination which are reported in Bulletin 204 (pages 222-226) indicate that the numbers of bacteria found in this way represent about 75 percent of the total which would be obtained by repeated rinsings. This method of testing was employed, not because it was considered ideal, but because it seemed the best available method.

The plate method was used for counting the bacteria in this water. In all cases three plates were prepared from each of two dilutions. The counts recorded in this bulletin are in each case the average of the counts of the three plates from the dilution in which the number of colonies approached the closer to 200 per plate.

All the plates were incubated for five days at 20° C. and for two days at 37° C. before they were counted.

Nutrient agar of the following composition was used for plating:

Agar shreds	15 grams
Liebig's meat extract	3 grams
Witte's peptone	10 grams
Lactose	10 grams
Distilled water	1 liter

The resulting medium had a reaction varying between 6 cc. and 9 cc. normal acid to the liter, phenolphthalein being used as an indicator.

EXPERIMENTAL DATA

PART I. ELIMINATION OF GERMS FROM CANS BY RINSING WITH HOT WATER

The rinsing of utensils is commonly employed to complete the cleaning process and to remove traces of washing powder. The present study is concerned primarily with the effect of rinsing upon the germ life in the utensils.

According to common commercial practices in moderate sized plants, cans as they come from the washing vat are rinsed in a vat of warm water. This warm water is so efficient in removing germs from the cans that the vat of rinse water quickly becomes loaded with germ life. Samples of typical rinse water were employed on three different days in seeding the cans reported upon in Table 6, and these samples carried 4,220,000, 7,650,000, and 11,500,000 bacteria per cc. respectively. In considering the germ content of cans rinsed under these conditions it should be remembered that about 10 cc. of this rinse water adheres to the inside of even well-drained cans.

The present study is concerned primarily with conditions as they exist on farms, and here the rinse water commonly comes into contact with one or at most only a few utensils. The tests here described were made during June, July, and October, 1915, and April, May, and June, 1916. In these experiments 80 cans were rinsed with water at 70° F., 103 were rinsed with water at 150° F., and 266 were rinsed with water at about 205° F., making a total of 449 cans examined.

The cans which were to be studied were first washed, and after standing in the creamery from one to four hours were rinsed in the following manner: A measured amount of rinse water was poured slowly into each can in such a way that the stream of water came into contact first with the upper edge of the neck of the can and then ran down the inner surface. A portion of the water was also poured over that part of the lid which comes in contact with the milk, and this water was also allowed to run into the can. The cover was replaced and the can was then shaken for 30 seconds in order that the inner surface of the can might come in contact with the rinse water. After this the water was poured from the can.

The effectiveness of hot water was tested at two temperatures—at 150° F. and at about 205° F. At each temperature different amounts of water were tested: at 150° F., 1 quart, 1½ quarts, 2 quarts, and 4 quarts; and at 205° F., 1 quart, 1½ quarts, 2, 3, 4, 6, and 9 quarts.

Rinse water at 70° F. was tested on the same days that similar cans were rinsed with hot water, the only difference in the treatment of the cans being in the temperature of the water used.

It will be noted that the application of this water to the cans constituted in reality a second rinsing inasmuch as the cans had been rinsed in connection with the regular washing process. However, in view of the high germ content of the wash water employed in connection with the regular washing process and the great variability of the germ content of ordinary cans, it is thought that using cans washed in the regular way gave more uniform material upon which to test the effects of the hot-water treatment.

Cooling Effect of Cans on Rinse Water

Everyone knows that when cold hands are placed in hot water the hands are warmed and the water cooled. Likewise everyone understands that when a cool can is rinsed with hot water the can is warmed and the water cooled tho few realize the extent of this temperature change.

The decrease in the temperature of the various amounts of rinse water used in these studies was determined by taking the temperature of the water just before it was poured into the can at 72° F. and again immediately after it was poured out, an interval of about sixty seconds.

The observations made upon the reduction in temperature of the rinse water as used in these studies are summarized in Tables 1 and 2.

Table 1.—Effect of Cans in Reducing Temperature of Rinse Water
When the cans were treated singly

Amount of water	Temperature of water—		Drop in temperature
	Before rinsing	After rinsing	
quarts	*°F.*	*°F.*	*°F.*
1	150	110	40
2	150	122	28
4	150	131	19
1	210	140	70
2	210	154	56
4	210	170	40
6	210	180	30
9	210	187	23

Table 2.—Effect of Cans on Temperature of Rinse Water
When four cans were rinsed in succession by the same lot of rinse water

Amount of water	Before rinsing	Temperature of water—				Total drop in temperature
		After 1st can	After 2d can	After 3d can	After 4th can	
quarts	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*
2	210	158	131	113	100	110
6	210	178	160	150	138	72

As shown in Table 1, the decrease in the temperature of the hot water during the process of scalding was very marked and depended both on the amount of water used and on its initial temperature. For example, one quart of water at 150° fell in temperature to 110°, a drop of 40 degrees; while four quarts decreased to 131°, a drop of 19 degrees. When the cans were scalded with water at 210°, one quart of water decreased in temperature from 210° to 140°, and four quarts dropped to 170°, a loss of 70 and 40 degrees respectively.

The results in Table 2 show that when six quarts of boiling water was applied successively to four cans at 72° F. the temperature of the water fell from 210° to 138°, a drop of 72 degrees, while after a similar application of two quarts of boiling water the temperature of the water fell to 100° F., which is a drop of 110 degrees.

It is thus seen that when hot water is poured into utensils for the purpose of scalding them the heat passes quickly from the water to the walls of the utensils.

In considering the temperatures found in the rinse water as it came from the cans it should be remembered that hot water below 140° F. has but little killing effect when the time of exposure to it is short.[1] Accordingly rinse water at 150° F., in the quantities which are available on any ordinary farm, will be so promptly cooled as to have little killing effect upon the germ life in the utensils. Even boiling water is so promptly cooled by the cans that unless two or more quarts are applied directly to each can the germ-killing effect is much less than is commonly believed.

That the cooling effect of the utensils on the scalding water is probably not fully appreciated by many dairy operators, is shown by the following observation made in a large city milk plant. It was the custom at this plant to treat the pasteurizing vat, 50 feet of sanitary pipe, the tubular cooler, and the tank under the cooler, with hot water for the purpose of "sterilizing" these utensils. Three hundred gallons of boiling water were pumped from the vats thru the pipe, and were allowed to trickle down over the cooler into the tank. It took about twenty minutes to pump this water. When all of the water had reached the tank the temperature of the water had fallen from 210° to 120° F., a drop of 90 degrees. Long before this water had reached the end of its appointed journey its temperature had fallen below the point where it would be destructive to germ life, and any further reduction of germ life resulting from its use depended solely upon its mechanical removal of germs from the utensils.

EFFECT OF RINSE WATER ON GERM LIFE IN CANS

Cans at the farm are scalded or rinsed as a final step in removing the germ life and preparing the cans for receiving milk. Accordingly the amount of germ life remaining in the cans after such treatment

[1]Smith, Theobald. The Thermal Death-point of Tubercle Bacilli in Milk and Other Fluids. Jour. Exp. Med. 4:217-233. 1899.

Russell, H. L. and Hasting, E. G. Thermal Death-point of Tubercle Bacilli under Commercial Conditions. Wis. Agr. Exp. Sta. Ann. Rpt. 17(1900) :147-170. 1900.

is a matter of first importance. In this study such a determination was made in the case of each of the 449 cans tested.

As the available supply of hot water for rinsing utensils at the farm is limited, the question of how much rinse water per can is really needed is likewise important. In these studies the use of varying amounts of water was tested, the range of these tests being especially wide in the case of boiling water.

In the application of rinse water to milk cans, the object usually in mind is the destruction of germ life. While such destruction is a natural result, particularly where boiling water is used, the rapid accumulation of germ life in rinsing vats makes it evident that the mechanical removal of germ life is also an important function of rinse water. As a means of getting information regarding the importance of this mechanical removal of germ life from cans by rinse water, the number of living germs in the rinse water as it came from the cans was also determined.

The results of these studies in connection with the rinsing of 449 cans are given in Table 3, in which the successive columns show the number of the can, the number of living germs found in the rinse water from the can, the number of living germs recovered from the rinsed can according to the method given on page 141, and the number of germs per cubic centimeter which the can would have contributed if it had been filled with milk.

As is ordinarily the case in studies of germ life in cans the results given in Table 3 show wide variations in the findings from apparently similar cans. In order to bring this large amount of data together so that they may be more readily compared the results obtained from each group of cans treated alike have been averaged. However, in considering these averages the varying number of cans which they include and the wide variations in the data which they represent should be kept in mind constantly.

The average number of living germs removed by each different amount of rinse water at each temperature and the corresponding average number of germs found in the rinsed cans are given in Table 4.

Bacteriological Condition of Cans Rinsed with Water at 70° F.

The results as given opposite this temperature in Table 4 show marked irregularities. By referring to the number of cans in each group it is seen that a comparatively small number of cans are represented in each of the averages except those where 1.5 and 6 quarts of water were used.

Taking the averages as a whole, but remembering that those representing cans rinsed with 1.5 and 6 quarts of water are the more representative, it appears that cans rinsed with water at 70° F. and immediately filled with milk will ordinarily add to such milk about

10,000 bacteria per cc. The use of large volumes of rinse water somewhat reduces the number of bacteria remaining in the cans.

TABLE 3.—EFFECT OF VARYING AMOUNTS AND TEMPERATURES OF RINSE WATER ON GERM LIFE IN CANS

No. of can	Number of germs removed by rinse water	Number of germs remaining in can after rinsing	Germs per cc. of milk due to can
	Cans Rinsed with 1 Quart of Water at 70° F.		
1	....	8 000 000	263.2
2	....	46 300 000	1 523.2
3	....	88 000 000	2 894.7
4	....	1 210 000 000	39 802.6
5	....	4 630 000 000	152 315.8
	Cans Rinsed with 1½ Quarts of Water at 70° F.		
6	17 498 000	530 000	17.4
7	17 332 000	547 000	17.9
8	15 393 000	680 000	22.4
9	16 950 000	812 000	26.7
10	22 125 000	1 102 000	36.2
11	64 950 000	1 500 000	49.3
12	64 837 000	1 550 000	50.9
13	53 325 000	2 412 000	79.3
14	54 937 000	2 467 000	81.2
15	41 040 000	3 370 000	110.8
16	242 775 000	11 320 000	372.4
17	42 562 000	12 075 000	397.2
18	88 275 000	19 500 000	641.4
19	178 350 000	30 000 000	986.8
20	330 000 000	33 500 000	1 101.9
21	637 500 000	122 000 000	4 013.3
22	720 000 000	308 600 000	10 151.3
23	9 675 000 000	810 000 000	26 644.7
24	13 950 000 000	1 877 000 000	61 743.4
25	21 750 000 000	3 150 000 000	103 618.4
	Cans Rinsed with 3 Quarts of Water at 70° F.		
26	35 175 000	3 130 000	103.0
27	85 200 000	11 125 000	366.0
28	154 200 000	30 775 000	1 012.3
	Cans Rinsed with 3 Quarts of Water at 70° F.		
29	1 282 000 000	57 700 000	1 898.0
30	130 500 000	58 750 000	1 932.6
31	110 400 000	60 200 000	1 980.3
32	2 550 000 000	213 000 000	7 006.6
33	4 212 000 000	317 000 000	10 427.6
34	4 545 000 000	362 000 000	11 907.9
35	5 625 000 000	370 000 000	12 171.0
36	5 175 000 000	485 000 000	15 953.9
37	8 062 500 000	1 120 000 000	36 842.1

TABLE 3.—*Continued.* EFFECT OF VARYING AMOUNTS AND TEMPERATURES OF RINSE WATER ON GERM LIFE IN CANS

Cans Rinsed with **6** Quarts of Water at **70° F.**

No. of can	Number of germs removed by rinse water	No. of can	Number of germs removed by rinse water	No. of can	Number of germs removed by rinse water
38	606 000	50	48 900 000	62	132 450 000
39	606 000	51	50 700 000	63	183 600 000
40	906 000	52	54 900 000	64	371 700 000
41	1 212 000	53	59 400 000	65	456 498 000
42	6 900 000	54	62 400 000	66	535 398 000
43	7 800 000	55	66 450 000	67	614 196 000
44	18 300 000	56	72 750 000	68	922 200 000
45	30 450 000	57	83 550 000	69	1 794 396 000
46	31 998 000	58	84 600 000	70	2 059 500 000
47	42 900 000	59	84 600 000	71	10 722 000 000
48	43 350 000	60	87 600 000	72	32 580 000 000
49	45 150 000	61	119 100 000		

No. of can	Number of germs removed by rinse water	Number of germs remaining in can after rinsing	Germs per cc. of milk due to can
Four Cans Rinsed in Succession by Same Lot of **9** Quarts of Water at **70° F.**			
73	549 000 000	150 000 000	4 934.2
74	1 395 000 000	170 000 000	5 592.1
75	1 350 000 000	23 500 000	773.0
76	1 530 000 000	6 270 000	206.2
77	15 300 000 000	1 050 000 000	34 539.5
78	16 200 000 000	415 000 000	13 651.3
79	25 200 000 000	910 000 000	29 934.2
80	46 800 000 000	1 000 000 000	32 894.7
Cans Rinsed with **1** Quart of Water at **150° F.**			
81	15 900 000	230 000	7.6
82	110 500 000	520 000	17.1
83	69 000 000	3 830 000	126.0
84	300 000 000	8 510 000	279.9
85	605 200 000	11 500 000	378.3
86	3 000 000 000	44 500 000	1 463.8
87	24 600 000 000	1 840 000 000	60 526.3
Cans Rinsed with **1½** Quarts of Water at **150° F.**			
88	16 162 000	243 000	8.0
89	15 055 000	302 000	9.9
90	17 460 000	310 000	10.2
91	19 522 000	335 000	11.0
92	16 650 000	401 000	13.2
93	21 543 000	417 000	13.7
94	9 120 000	470 000	15.5
95	17 812 000	475 000	15.6
96	18 195 000	490 000	16.0
97	19 980 000	502 000	16.5
98	10 850 000	810 000	26.6
99	15 532 000	1 295 000	42.6
100	207 000 000	6 500 000	213.8
101	450 000 000	28 010 000	921.4
102	1 050 000 000	37 507 000	1 235.1
103	9 975 000 000	265 000 000	8 717.1

TABLE 3.—*Continued.* EFFECT OF VARYING AMOUNTS AND TEMPERATURES OF RINSE WATER ON GERM LIFE IN CANS

No. of can	Number of germs removed by rinse water	Number of germs remaining in can after rinsing	Germs per cc. of milk due to can
	Cans Rinsed with 2 Quarts of Water at 150° F.		
104	800 000	40 000	1.3
105	1 200 000	80 000	2.6
106	3 600 000	100 000	3.3
107	2 600 000	100 000	3.3
108	2 200 000	120 000	3.9
109	2 000 000	140 000	4.6
110	2 000 000	150 000	4.9
111	2 600 000	210 000	6.9
112	....	210 000	6.9
113	1 000 000	220 000	7.2
114	3 800 000	230 000	7.6
115	3 000 000	240 000	7.9
116	1 200 000	240 000	7.9
117	4 500 000	270 000	8.9
118	2 400 000	460 000	15.1
119	1 400 000	460 000	15.1
120	4 600 000	560 000	18.4
121	5 800 000	1 040 000	34.2
122	5 000 000	1 510 000	49.7
123	12 600 000	3 390 000	111.5
124	5 400 000	4 200 000	138.2
125	10 800 000	4 700 000	154.6
126	19 800 000	7 510 000	247.0
127	77 600 000	24 400 000	802.6
128	56 200 000	38 590 000	1 269.4
129	347 600 000	50 700 000	1 667.8
130	1 976 000 000	67 500 000	2 220.4
131	200 000 000	77 000 000	2 532.9
132	163 400 000	95 620 000	3 145.4
133	2 166 000 000	113 000 000	3 717.1
134	151 800 000	116 520 000	3 832.9
135	964 800 000	252 500 000	8 305.9
136	683 400 000	294 000 000	9 671.1
137	2 000 000 000	313 000 000	10 296.5
138	2 800 000 000	403 000 000	13 256.6
139	1 734 400 000	420 000 000	13 815.8
140	1 332 000 000	560 000 000	18 421.5
141	2 800 000 000	613 000 000	20 164.5
142	1 580 000 000	1 040 000 000	34 210.5
143	4 460 000 000	1 183 000 000	38 914.5
144	22 000 000 000	3 130 000 000	102 960.5
	Cans Rinsed with 4 Quarts of Water at 150° F.		
145	2 520 000	30 000	1.0
146	1 200 000	70 000	2.3
147	5 600 000	70 000	2.3
148	2 400 000	90 000	2.9
149	800 000	110 000	3.6
150	10 800 000	120 000	3.9
151	3 200 000	120 000	3.9
152	5 200 000	170 000	5.6
153	6 800 000	490 000	16.1

TABLE 3.—*Continued.* EFFECT OF VARYING AMOUNTS AND TEMPERATURES OF RINSE WATER ON GERM LIFE IN CANS

No. of can	Number of germs removed by rinse water	Number of germs remaining in can after rinsing	Germs per cc. of milk due to can
Cans Rinsed with 4 Quarts of Water at **150° F.** (*Cont'd.*)			
154	4 400 000	520 000	17.1
155	14 800 000	540 000	17.8
156	6 800 000	1 100 000	36.1
157	2 120 000	1 260 000	41.4
158	36 800 000	3 440 000	113.2
159	16 000 000	4 250 000	139.8
160	27 200 000	4 950 000	162.8
161	56 400 000	8 320 000	273.7
162	57 200 000	13 000 000	427.6
163	67 200 000	13 400 000	440.8
164	107 600 000	15 000 000	493.4
165	126 800 000	22 920 000	753.9
166	61 200 000	23 300 000	766.4
167	304 400 000	36 250 000	1 192.4
168	235 600 000	58 000 000	1 907.9
169	296 000 000	80 300 000	2 641.4
170	322 800 000	103 000 000	3 388.2
171	163 600 000	114 860 000	3 778.3
172	482 800 000	123 400 000	4 059.2
173	1 172 000 000	164 500 000	5 411.2
174	4 547 600 000	243 200 000	8 000.0
175	40 800 000 000	366 000 000	12 039.5
176	3 664 000 000	440 000 000	14 473.7
177	1 724 000 000	526 000 000	17 302.6
178	6 400 000 000	673 000 000	22 138.2
179	4 544 000 000	700 000 000	23 026.3
180	4 584 000 000	790 000 000	25 986.8
181	8 880 000 000	922 000 000	30 328.9
182	10 564 000 000	970 000 000	31 907.9
183	10 000 000 000	1 385 000 000	45 559.2
Cans Rinsed with **1** Quart of Water at **200°–208° F.**			
184	2 400 000	150 000	4.9
185	1 000 000	190 000	6.2
186	3 700 000	190 000	6.2
187	1 300 000	200 000	6.6
188	1 700 000	460 000	15.1
189	7 300 000	550 000	18.1
190	3 900 000	1 100 000	36.2
191	5 300 000	1 700 000	55.9
192	6 900 000	2 000 000	65.8
193	14 500 000	2 010 000	66.1
194	6 100 000	2 260 000	74.3
195	5 000 000	2 310 000	75.9
196	9 300 000	2 600 000	85.5
197	11 400 000	2 710 000	89.1
198	3 900 000	3 010 000	99.0
199	4 400 000	3 200 000	105.3
200	72 400 000	5 900 000	194.1
201	25 400 000	6 600 000	217.1
202	60 000 000	9 400 000	309.2
203	71 600 000	11 000 000	361.8
204	370 000 000	20 000 000	657.9
205	140 000 000	20 000 000	657.9

TABLE 3.—*Continued.* EFFECT OF VARYING AMOUNTS AND TEMPERATURES OF RINSE WATER ON GERM LIFE IN CANS

No. of can	Number of germs removed by rinse water	Number of germs remaining in can after rinsing	Germs per cc. of milk due to can
Cans Rinsed with 1 Quart of Water at 200°–208° F. (*Cont'd.*)			
206	37 000 000	21 000 000	690.8
207	24 800 000	22 000 000	723.7
208	20 300 000	24 000 000	789.5
209	34 400 000	32 000 000	1 052.6
210	44 900 000	44 000 000	1 447.3
211	95 600 000	47 660 000	1 567.8
212	234 300 000	56 000 000	1 842.2
213	345 300 000	67 300 000	2 213.8
214	210 000 000	76 000 000	2 500.0
215	620 000 000	83 000 000	2 730.3
216	50 300 000	100 000 000	3 289.5
217	530 000 000	110 000 000	3 618.4
218	1 100 000 000	120 000 000	3 947.4
219	5 000 000 000	730 000 000	24 013.2
220	9 000 000 000	1 060 000 000	34 868.4
Cans Rinsed with 1½ Quarts of Water at 200°–206° F.			
221	3 093 000	....	....
222	3 600 000	30 000	0.9
223	7 380 000	65 000	2.1
224	5 844 000	70 000	2.3
225	1 087 500	78 000	2.6
226	1 705 500	100 000	3.3
227	1 462 500	111 000	3.7
228	1 200 000	136 000	4.5
229	1 855 500	144 000	4.7
230	6 474 000	145 000	4.8
231	20 535 000	165 000	5.4
232	12 070 500	180 000	5.9
233	579 000	231 000	7.6
234	1 263 000	284 000	9.3
235	11 177 500	377 000	12.4
236	7 957 000	445 000	14.6
237	8 845 000	520 000	17.1
238	11 310 000	541 000	17.8
239	3 075 000	560 000	18.4
240	3 543 000	653 000	21.5
241	1 222 500	762 000	25.1
242	6 738 000	932 000	30.7
243	12 513 000	1 127 000	37.1
244	44 775 000	1 465 000	48.2
245	19 462 500	1 815 000	59.7
246	12 607 500	2 276 000	74.9
247	83 025 000	3 347 000	110.1
248	77 362 500	4 357 000	143.3
249	32 512 500	4 975 000	163.7
250	34 725 000	6 640 000	218.4
251	94 575 000	18 300 000	601.9
252	359 850 000	22 632 000	744.5
253	456 000 000	49 000 000	1 611.8
254	360 000 000	64 150 000	2 110.2
255	1 800 000 000	129 000 000	4 243.4
256	1 905 000 000	348 000 000	11 447.4

TABLE 3.—*Continued.* EFFECT OF VARYING AMOUNTS AND TEMPERATURES OF RINSE WATER ON GERM LIFE IN CANS

No. of can	Number of germs removed by rinse water	Number of germs remaining in can after rinsing	Germs per cc. of milk due to can
Cans Rinsed with 2 Quarts of Water at 200°–208° F.			
257	200 000	....	....
258	4 200 000	....	....
259	200 000	10 000	.3
260	400 000	10 000	.3
261	600 000	10 000	.3
262	400 000	10 000	.3
263	400 000	20 000	.7
264	400 000	30 000	1.0
265	600 000	50 000	1.6
266	200 000	50 000	1.6
267	1 000 000	60 000	2.0
268	400 000	60 000	2.0
269	200 000	60 000	2.0
270	200 000	80 000	2.6
271	400 000	80 000	2.6
272	200 000	100 000	3.3
273	200 000	150 000	5.0
274	600 000	160 000	5.3
275	200 000	160 000	5.3
276	200 000	220 000	7.2
277	600 000	230 000	7.6
278	600 000	280 000	9.2
279	200 000	300 000	9.9
280	600 000	300 000	9.9
281	1 200 000	320 000	10.5
282	2 000 000	390 000	12.8
283	3 400 000	460 000	15.1
284	800 000	530 000	17.4
285	1 200 000	530 000	17.4
286	800 000	610 000	20.1
287	960 000	690 000	22.9
288	1 000 000	700 000	23.0
289	1 800 000	710 000	23.4
290	600 000	760 000	25.0
291	400 000	1 160 000	38.2
292	6 400 000	1 170 000	38.5
293	1 000 000	1 290 000	42.4
294	4 000 000	1 320 000	43.4
295	200 000	1 500 000	49.3
296	5 400 000	1 570 000	51.6
297	8 800 000	1 600 000	52.6
298	2 800 000	1 710 000	56.2
299	2 000 000	2 300 000	75.7
300	34 200 000	2 320 000	76.3
301	22 800 000	2 710 000	89.1
302	3 800 000	2 850 000	93.7
303	25 200 000	2 900 000	95.4
304	11 600 000	3 420 000	112.5
305	60 000 000	3 620 000	119.1
306	144 000 000	5 300 000	174.3
307	23 200 000	10 780 000	354.6
308	80 000 000	11 200 000	368.4
309	77 000 000	15 920 000	523.7

TABLE 3.—*Continued.* EFFECT OF VARYING AMOUNTS AND TEMPERATURES OF RINSE WATER ON GERM LIFE IN CANS

No. of can	Number of germs removed by rinse water	Number of germs remaining in can after rinsing	Germs per cc. of milk due to can
	Cans Rinsed with **3** Quarts of Water at **204°–208° F.**		
310	210 000	46 000	1.5
311	381 000	74 000	2.4
312	960 000	101 000	3.3
313	306 000	215 000	7.1
314	7 260 000	275 000	9.0
315	2 955 000	553 000	18.2
316	2 676 000	627 000	20.6
317	2 106 000	660 000	21.7
318	6 231 000	766 000	25.2
319	7 371 000	771 000	25.4
320	9 900 000	785 000	25.8
321	15 636 000	994 000	32.7
322	5 496 000	1 232 000	40.5
323	17 106 000	2 849 000	93.7
324	69 750 000	3 183 000	104.7
325	2 040 000	4 337 000	142.7
326	444 750 000	5 225 000	171.9
327	243 000 000	10 100 000	332.2
328	118 800 000	12 250 000	403.0
329	777 000 000	48 700 000	1 602.0
330	1 387 500 000	63 525 000	2 089.6
331	1 014 000 000	72 500 000	2 384.9
332	997 500 000	73 000 000	2 401.3
333	5 880 000 000	258 750 000	8 511.5
	Cans Rinsed with **4** Quarts of Water at **200°–208° F.**		
334	....	10 000	.3
335	....	30 000	1.0
336	1 200 000	30 000	1.0
337	1 200 000	30 000	1.0
338	1 200 000	30 000	1.0
339	400 000	40 000	1.3
340	800 000	40 000	1.3
341	....	50 000	1.6
342	....	60 000	2.0
343	2 800 000	70 000	2.3
344	....	80 000	2.6
345	1 200 000	80 000	2.6
346	4 400 000	100 000	3.3
347	....	120 000	3.9
348	1 200 000	130 000	4.4
349	7 600 000	340 000	11.1
350	....	750 000	24.7
351	1 600 000	1 050 000	34.5
352	2 000 000	1 060 000	34.9
353	60 800 000	1 430 000	47.0
354	6 000 000	1 600 000	52.6

TABLE 3.—*Continued.* EFFECT OF VARYING AMOUNTS AND TEMPERATURES OF RINSE WATER ON GERM LIFE IN CANS

Cans Rinsed with 6 Quarts of Water at 190°–208° F.

No. of can	Number of germs removed by rinse water	No. of can	Number of germs removed by rinse water	No. of can	Number of germs removed by rinse water
355	....	378	36 000	401	294 000
356	....	379	42 000	402	300 000
357	6 000	380	48 000	403	300 000
358	6 000	381	60 000	404	360 000
359	12 000	382	60 000	405	444 000
360	12 000	383	60 000	406	534 000
361	12 000	384	66 000	407	600 000
362	12 000	385	72 000	408	600 000
363	12 000	386	84 000	409	600 000
364	12 000	387	90 000	410	648 000
365	12 000	388	102 000	411	678 000
366	18 000	389	120 000	412	678 000
367	18 000	390	120 000	413	1 332 000
368	18 000	391	120 000	414	1 500 000
369	18 000	392	120 000	415	1 524 000
370	24 000	393	150 000	416	1 716 000
371	24 000	394	150 000	417	2 154 000
372	24 000	395	174 000	418	2 424 000
373	24 000	396	180 000	419	3 120 000
374	30 000	397	246 000	420	9 612 000
375	36 000	398	258 000	421	19 600 000
376	36 000	399	264 000		
377	36 000	400	264 000		

No. of can	Number of germs removed by rinse water	Number of germs remaining in cans after rinsing	Germs per cc. of milk due to can
Four Cans Rinsed in Succession by Same Lot of 6 Quarts of Water at 190° F.			
422	....	10 000	.3
423	....	25 000	.8
424	....	45 000	1.5
425	....	85 000	2.8
426	....	30 000	1.0
427	....	50 000	1.6
428	....	5 000	.2
429	....	105 000	3.5
Four Cans Rinsed in Succession by Same Lot of 6 Quarts of Water at 205° F.			
430	....	20 000	.7
431	....	170 000	5.6
432	....	200 000	6.6
433	....	765 000	25.2
434	....	55 000	1.8
435	....	18 825 000	619.2
436	....	200 000	6.6
437	....	1 680 000	55.3

TABLE 3.—*Concluded*. EFFECT OF VARYING AMOUNTS AND TEMPERATURES OF RINSE WATER ON GERM LIFE IN CANS

No. of Can	Number of germs removed by rinse water	Number of germs remaining in cans after rinsing	Germs per cc. of milk due to can
Four Cans Rinsed in Succession by Same Lot of 9 Quarts of Water at 206°–208° F.			
438	1 233 000	144 000	4.7
439	1 593 000	22 000	.7
440	29 385 000	2 892 000	95.1
441	460 800 000	35 000 000	1 151.3
442	351 000	50 000	1.6
443	1 710 000	2 750 000	90.5
444	3 015 000	24 750 000	814.1
445	1 665 000 000	107 000 000	3 519.7
446	315 000	280 000	9.2
447	1 530 000 000	31 500 000	1 036.2
448	1 305 000 000	4 655 000	153.1
449	2 790 000 000	132 500 000	4 358.6

TABLE 4.—AVERAGE NUMBER OF BACTERIA IN CANS AFTER BEING RINSED

Number of cans	Amount of rinse water used	Temperature of rinse water	Average number of germs removed by rinse water	Average germ content of cans after rinsing	Germ content per cc. of milk due to can
	qts.	*°F.*	*per can*	*per can*	
5	1	70	....	1 196 460 000	39 357
20	1.5	70	2 399 142 450	319 448 250	10 508
12	3	70	2 663 914 583	257 390 000	8 467
35	6	70	1 470 773 314	....	....
7	1	150	4 100 086 000	1 909 090 000	8 971
16	1.5	150	742 492 560	21 441 750	705
41	2	150	1 111 987 802	215 073 414	7 075
39	4	150	2 546 354 870	200 225 129	6 586
37	1	200–208	491 200 000	72 716 216	2 392
36	1.5	200–206	150 400 736	18 433 694	606
53	2	200–208	10 184 151	1 561 698	51
24	3	204–208	458 872 250	23 396 583	770
21	4	200–208	4 400 000	339 524	11
67	6	190–208	780 686	....	....

Bacteriological Condition of Cans Rinsed with Water at 150° F.

Too close comparisons of the results with different amounts of rinse water cannot be made because the testing of the effect of 1.5 quarts was done in June, 1915, and the remaining tests were made in April, 1916. Again only seven cans were tested after being rinsed with one quart of water at 150° F. and these seven cans were all examined on the same day.

Bearing these facts in mind it will be seen from Table 4 that rinsing cans with water at 150° F. leaves them in somewhat better condition than when rinse water at 70° F. is used.

Bacteriological Condition of Cans Rinsed with Water at 190°-208° F.

Rinsing dairy utensils on the farm is commonly referred to as scalding them. Accordingly there is an unusual interest connected with the results from the use of boiling water. On this account the number of cans in each of these high-temperature groups is large and the range in amounts of rinse water tested is wider than in the case of the other temperatures.

The results from the two groups of cans rinsed with one quart and three quarts of water, seem unduly high as compared with those from the other groups. An inspection of the detailed results as given in Table 3 shows that 66 percent of the bacteria found in the 37 cans rinsed with one quart of water came from two of the cans. Had the remaining 35 cans been filled with milk they would have increased the germ content of the milk but 835 bacteria per cc. Among the 24 cans rinsed with three quarts of water, three cans contributed 70 percent of the germs. The remaining 21 cans would have increased the germ content of milk by only 231 bacteria per cc.

Considering these results as a whole it is seen that these cans were in much better condition than those rinsed with cooler water. When a can is rinsed with more than one quart of boiling water, it will rarely add 1,000 bacteria per cc. when filled with milk. When the amount of rinse water becomes large, the effect of the can on the milk would usually be below 100 per cc.

In considering the relation of these results to farm practice it should be remembered that the water available for rinsing at the farm is frequently not fully up to the boiling point and the amount available rarely permits the use per can of the larger amounts tested in these studies.

Mechanical Removal and Destruction of Bacteria by Rinse Water

References have already been made (page 142) to the high germ content of rinse water in commercial plants. This suggests that rinse water mechanically removes from the cans a large amount of germ life. Again the fact that rinsing with a liter of sterile water gives a usable measure of the germ life in the cans is further evidence of the ease with which water loosens and removes germs.

By using sterile rinse water at a temperature too low to destroy the germs, and determining the germ content of the rinse water as it comes from the can, the mechanical removal may be accurately measured. When the temperature of the rinse water is increased, its efficiency in removing germ life is probably also increased. However, a count of the living germs in the rinse water as it comes from the can under such conditions gives, not the total number of germs removed, but rather the total number removed less the number which at the same time have been destroyed by the heat of the rinse water.

When the cans were rinsed with water at 70° F., no killing effect occurred; and from Table 4 it is seen that as an average of seventy-two cans this rinse water mechanically removed more than 2 billion living germs per can.

When rinse water was applied at 150° F., the average number of living germs found in the rinse water from the 103 cans was slightly under 2 billion per can. When but one quart of rinse water was applied, it was promptly cooled below the temperature at which germs are destroyed, as shown in Table 1. The average number of living germs found in the rinse water from 7 cans, each rinsed with one quart at 150° F., was practically double the average of the rinse water at 70° F., but 85 percent of these germs came from a single can. The average germ content of the rinse water from the other six cans was 683,433,333. The temperatures given in Table 1 indicate that when larger amounts of rinse water were used the rinse water remained for only a few seconds at a temperature sufficiently high to destroy germ life. Allowing for the variation noted in the cans rinsed with one quart of water at 150° F., the measurements of germ life as given in Table 4 indicate the removal of an increasing number of bacteria by the use of increasing amounts of rinse water.

The small number of living germs in the rinse water at 190°-208° F. makes it quite clear that here the effect of mechanical removal is overshadowed by the destructive effect of the high temperature. Even where but one quart was applied the average germ content of the rinse water from 37 cans was only one-half billion per can as contrasted with about 2 billion per can where cooler water was applied. With the use of increasing quantities, the water remains at destructive temperatures for a longer time, and fewer germs survive in the rinse water. The result from the use of three quarts of rinse water is an apparent exception, but an inspection of the detailed results in Table 3 shows that these high averages were due to the results from a few cans.

From the data here presented it would appear that the use of one quart of rinse water per can, at a temperature of 150° F., gives good results in the mechanical removal of germ life but has only a small destructive effect upon the germs present. With the use of larger amounts of water at 150° F., or the same amount at higher temperatures, the removal or destruction of germ life is constantly increased.

PART II. ELIMINATION OF GERMS FROM CANS BY DRYING IN SUN AND AIR

Between May 22 and June 9, 1917, two hundred and thirteen cans and fifty-eight pails, after having been washed and rinsed as described on page 141, were inverted on a rack and exposed to sun and air. This rack was located on the south side of a farm building so that the utensils might have the fullest exposure to the sun. It should be noted, however, that their inner surfaces were not exposed to the direct rays of the sun, and hence the data in this study have no relation to the disinfecting action of direct sunlight. Each day the pails and cans were placed on the rack at 8 a. m. At 4 p. m., after having been exposed for eight hours, all the pails and half of the cans were examined. The remaining half of the cans were examined at 4 a. m. the following morning. The examination consisted first, of noting whether the utensils were dry, clean, and free from odors, and second, of determining the number of bacteria in each according to the method already described on page 141.

The fourteen check cans used in connection with these experiments were examined for bacteria immediately after being washed and rinsed.

The results of the bacteriological examinations are given in Table 5. The number of bacteria found in each utensil at the time it was removed from the drying rack is recorded, and the numbers so obtained are also stated in terms of the number of bacteria which would have been added per cc. of milk had each utensil been filled with sterile milk.

GENERAL CONDITION OF THE CANS AND PAILS AFTER BEING KEPT ON THE RACK

As far as could be judged by ordinary inspection, the cans and pails which had been inverted on the rack for eight and twenty hours respectively were in good condition for receiving milk. They were uniformly clean and free from any odor.

All of the cans held for eight hours appeared dry at the time of final examination except those of May 22. On this day rain had fallen fairly continuously and the humidity had evidently prevented drying. Similarly moisture was evident in the cans held for twenty hours, on May 22 and 28, rain having fallen on the latter night as well. It rained on the nights of May 23, 29, 31, June 4, and 5, and was cloudy on May 31 and June 1. No moisture was found in these cans at the close of the twenty-hour period but the effect of the weather conditions upon their germ content is discussed on page 164.

TABLE 5.—NUMBER OF BACTERIA IN CANS AND PAILS AFTER BEING EXPOSED TO SUN AND AIR

Cans and Pails Exposed 8 Hours						Cans Exposed 20 Hours		
No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can	No. of pail	No. of bacteria in pails	Germ content per cc. of milk due to pail	No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can
May 22								
1	610 000	20.0	1	460 000	32.8	10	35 000 000	1 151.3
2	1 230 000	40.4	2	2 760 000	197.1	11	41 000 000	1 348.6
3	17 000 000	559.2	3	13 640 000	974.2	12	169 000 000	5 559.2
4	18 000 000	592.1	4	21 270 000	1 519.2	13	189 000 000	6 217.1
5	26 000 000	855.2	5	21 380 000	1 527.1	14	220 000 000	7 236.8
6	38 000 000	1 250.0				15	285 000 000	9 375.0
7	50 000 000	1 644.7				16	312 000 000	10 263.1
8	57 000 000	1 875.0				17	539 000 000	17 730.2
9	103 000 000	3 388.1						
May 23								
18	10 000	0.3	6	38 000	2.7	27	90 000	2.9
19	20 000	0.6	7	39 000	2.8	28	90 000	2.9
20	20 000	0.6	8	94 000	6.7	29	110 000	3.6
21	30 000	0 9	9	1 900 000	135.7	30	260 000	8.5
22	40 000	1.3	0	3 310 000	236.4	31	400 000	13.1
23	170 000	5.5				32	1 220 000	40.1
24	420 000	13.8				33	1 360 000	44.7
25	1 830 000	60.1				34	2 360 000	77.6
26	22 800 000	750.0						
May 24								
35	20 000	0.6	11	20 000	1.4	44	20 000	0.6
36	20 000	0.6	12	80 000	5.7	45	50 000	1.6
37	20 000	0.6	13	118 000	8.4	46	50 000	1.6
38	30 000	0.9	14	13 100 000	935.7	47	60 000	1 9
39	40 000	1.3	15	15 100 000	1 078.5	48	420 000	13.8
40	50 000	1.6				49	500 000	16.4
41	190 000	6.2				50	580 000	19.0
42	4 460 000	146.7				51	930 000	30.5
43	10 600 000	348.6						

TABLE 5.—*Continued.* NUMBER OF BACTERIA IN CANS AND PAILS AFTER BEING EXPOSED TO SUN AND AIR

Cans and Pails Exposed **8** Hours						Cans Exposed **20** Hours		
No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can	No. of pail	No. of bacteria in pails	Germ content per cc. of milk due to pail	No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can
May 25								
52	10 000	0.3	16	20 000	1.4	61	30 000	0.9
53	20 000	0.6	17	120 000	8.5	62	60 000	1.9
54	40 000	1.3	18	330 000	23.5	63	120 000	3.9
55	60 000	1.9	19	7 600 000	542.8	64	250 000	8.2
56	110 000	3.6				65	260 000	8.5
57	250 000	8.2				66	740 000	24.3
58	940 000	30.9				67	1 300 000	42.7
59	1 220 000	40.1				68	1 500 000	49.3
60	11 840 000	389.4						
May 28								
69	21 000	0.7				78	6 000	0.1
70	85 000	2.7				79	25 000	0.8
71	123 000	4.0				80	118 000	3.8
72	151 000	4.9				81	403 000	13.2
73	913 000	30.0				82	526 000	17.3
74	1 170 000	38.4				83	12 500 000	411.1
75	2 700 000	88.8				84	17 000 000	559.2
76	3 500 000	115.1				85	84 200 000	2 769.7
77	15 900 000	523.0						
May 29								
86	68 000	2.2	20	1 227 000	87.6	95	55 000	1.8
87	255 000	8.3	21	1 240 000	88.5	96	481 000	15.8
88	470 000	15.4	22	7 100 000	507.1	97	1 200 000	39.4
89	935 000	30.7	23	80 800 000	5 771.4	98	2 000 000	65.7
90	4 600 000	151.3				99	3 100 000	101.9
91	4 800 000	157.8				100	29 100 000	957.2
92	8 900 000	292.7				101	30 100 000	990.1
93	9 900 000	325.5				102	32 500 000	1 069.0
94	11 000 000	361.8						

TABLE 5.—*Continued.* NUMBER OF BACTERIA IN CANS AND PAILS AFTER BEING EXPOSED TO SUN AND AIR

Cans and Pails Exposed 8 Hours						Cans Exposed 20 Hours		
No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can	No. of pail	No. of bacteria in pails	Germ content per cc. of milk due to pail	No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can
				May 31				
103	120 000	3.9	24	880 000	62.8	112	680 000	22.3
104	670 000	22.0	25	4 820 000	344.2	113	1 940 000	63.8
105	870 000	28.6	26	11 100 000	792.8	114	4 000 000	131.5
106	1 500 000	49.3	27	18 900 000	1 349.9	115	19 500 000	641.4
107	1 800 000	59.2	28	27 000 000	1 928.5	116	138 500 000	4 555.9
108	2 600 000	85.5				117	278 800 000	9 171.0
109	10 200 000	335.5						
110	11 800 000	388.1						
111	21 500 000	707.2						
				June 1				
118	2 000 000	65.7	29	6 900 000	492.8	126	5 800 000	19.0
119	5 900 000	194.0	30	13 100 000	935.7	127	12 500 000	411.1
120	6 700 000	220.3	31	15 900 000	1 135.7	128	16 800 000	552.6
121	7 600 000	250.0	32	49 500 000	3 535.7	129	25 600 000	842.1
122	15 300 000	503.2	33	61 100 000	4 364.2	130	31 000 000	1 019.7
123	19 400 000	638.1				131	73 700 000	2 424.3
124	24 900 000	819.0				132	93 700 000	3 082.2
125	41 300 000	1 358.5				133	113 900 000	3 746.7
				June 4				
134	1 840 000	60.5	34	520 000	37.1	142	1 390 000	45.7
135	2 040 000	67.1	35	5 300 000	378.5	143	2 090 000	68.7
136	2 090 000	68.7	36	6 700 000	478.5	144	2 810 000	92.4
137	2 910 000	95.7	37	10 600 000	757.1	145	3 760 000	123.6
138	3 630 000	119.4	38	14 700 000	1 049.9	146	5 100 000	167.7
139	4 850 000	159.5				147	21 100 000	694.0
140	31 700 000	1 042.7				148	60 800 000	2 000.0
141	74 500 000	2 450.6				149	67 000 000	2 203.9

TABLE 5.—*Continued.* NUMBER OF BACTERIA IN CANS AND PAILS AFTER BEING EXPOSED TO SUN AND AIR

Cans and Pails Exposed **8** Hours						Cans Exposed **20** Hours		
No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can	No. of pail	No. of bacteria in pails	Germ content per cc. of milk due to pail	No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can
				June 5				
150	480 000	15.7	39	1 420 000	101.4	159	390 000	12.8
151	2 530 000	83.2	40	3 200 000	228.5	160	13 300 000	437.5
152	2 730 000	89.8	41	4 000 000	285.7	161	28 800 000	947.3
153	4 500 000	148.0	42	6 100 000	435.7	162	60 900 000	2 003.2
154	4 700 000	154.6	43	9 300 000	664.2	163	71 000 000	2 335.5
155	4 800 000	157.8				164	77 500 000	2 549.3
156	27 400 000	901.3				165	122 500 000	4 029.6
157	37 500 000	1 233.5				166	258 000 000	8 486.8
158	71 900 000	2 365.1						
				June 6				
167	120 000	3.9	44	4 700 000	335.7	176	1 690 000	55.5
168	1 600 000	52.6	45	5 800 000	414.2	177	5 000 000	164.4
169	5 900 000	194.0	46	11 700 000	835.7	178	20 400 000	671.0
170	7 900 000	259.8	47	17 200 000	1 228.5	179	22 500 000	740.1
171	10 300 000	338.8	48	22 000 000	1 571.4	180	22 500 000	740.1
172	19 500 000	641.4				181	28 600 000	940.7
173	24 400 000	802.6				182	30 100 000	990.1
174	37 900 000	1 246.7				183	35 700 000	1 174.3
175	50 600 000	1 664.4						
				June 7				
184	200 000	6.5	49	800 000	57.1	192	610 000	20.0
185	850 000	27.9	50	1 130 000	80.7	193	2 460 000	80.9
186	910 000	29.9	51	3 500 000	249.9	194	3 730 000	122.6
187	3 090 000	101.6	52	3 600 000	257.1	195	5 100 000	167.7
188	3 300 000	108.5	53	6 500 000	464.2	196	6 900 000	226.9
189	13 900 000	457.2				197	10 900 000	358.5
190	17 300 000	569.0				198	18 800 000	618.4
191	33 600 000	1 105.2				199	34 900 000	1 148.0
Check	346 300 000	11 391.4						

TABLE 5.—*Concluded.* NUMBER OF BACTERIA IN CANS AND PAILS AFTER BEING EXPOSED TO SUN AND AIR

Cans and Pails Exposed 8 Hours						Cans Exposed 20 Hours		
No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can	No. of pail	No. of bacteria in pails	Germ content per cc. of milk due to pail	No. of can	No. of bacteria in cans	Germ content per cc. of milk due to can
				June 8				
200	80 000	2.6	54	914 000	65.2	207	2 000 000	65.7
201	2 100 000	69.0	55	3 700 000	264.2	208	3 000 000	98.6
202	7 800 000	256.5	56	5 000 000	357.1	209	5 200 000	171.0
203	8 500 000	279.6	57	5 300 000	378.5	210	6 500 000	213.8
204	34 400 000	1 131.5	58	5 900 000	421.4	211	9 000 000	296.0
205	38 100 000	1 253.2				212	21 500 000	707.2
206	42 500 000	1 398.0				213	27 400 000	901.3
Check	58 500 000	1 924.3						
				June 8				
Check cans								
1	7 100 000	233.5						
2	47 500 000	1 562.5						
3	250 000 000	8 223.6						
4	237 000 000	7 796.0						
				June 9				
5	14 600 000	480.2						
6	17 200 000	565.7						
7	47 700 000	1 569.0						
8	117 000 000	3 848.6						
9	117 000 000	3 848.6						
10	142 600 000	4 690.7						
11	162 300 000	5 338.8						
12	301 600 000	9 921.0						

NUMBER OF BACTERIA IN UNTREATED CANS

The results from the examinations of the check cans were quite in accord with the results given in Bulletin 204 of this station (pages 222-239) in that the number of bacteria present in apparently similar cans varied to an astonishing degree. It is not uncommon to find a can which has twenty times more bacteria than other cans which have had apparently identical treatment. Accordingly the number of bacteria found in the untreated cans is only a rough measure of the bacteria that may have been present in the treated cans before they were exposed to the sun and air.

Of the fourteen check cans, eight had more than one hundred million bacteria each, and the smallest number was 7,100,000 bacteria. The average for the fourteen cans was 133,314,111 bacteria. If these cans had been filled with milk at the time they were examined they would have added to it an average of 4,385 bacteria per cc. of milk.

In connection with other studies on utensils, several hundred individual utensils, mostly cans, have been examined. All the utensils were washed in a similar manner and by the same operator as those used in these studies, so that they may be taken to represent in a measure the condition of the utensils in the present study before they were placed on the rack. The number of bacteria found in the cans first referred to, which were examined soon after they were washed, was invariably much larger than the number found in the check cans in this study: for example, a set of fifty cans would have added 87,059 bacteria per cc. of milk; and another set of thirty-two cans would have added 47,863 bacteria per cc. of milk (Bulletin 204, pages 222-224).

All of these examinations point to the conclusion that the cans selected as checks in this study contained much smaller numbers of bacteria than the average freshly washed can. Accordingly this treatment of the utensils,—namely, to invert them on the rack so that they are exposed to the air and the sun,—undoubtedly brings about a more decided reduction in the germ life in the utensils than is indicated by comparison with the numbers found in these check cans.

BACTERIA IN CANS AND PAILS AFTER EIGHT HOURS OF EXPOSURE TO SUN AND AIR

The number of bacteria in the cans and pails after they had been exposed to sun and air from 8 a.m. to 4 p.m. varied widely. The smallest number found in a can was 10,000 and the largest was 103,000,000. Seventeen percent of the cans and 10 percent of the pails had less than 100,000 bacteria; 19 percent of the cans and 14 per cent of the pails had more than 100,000 and less than one million bacteria; and 64 percent of the cans and 76 percent of the pails had more than one million bacteria. The average for all the cans was about 24,000,000 and for the pails about 10,000,000 bacteria.

The importance of these cans and pails in milk contamination may be shown by calculating how many bacteria they would have added to the milk poured into them. Such calculation shows that 26 percent of the cans and 14 percent of the pails would have added less than 10 bacteria per cc. of milk; 25 percent of the cans and 15 percent of the pails would have added more than 10 and less than 100 bacteria; 36 percent of the cans and 50 percent of the pails would have added more than 100 but less than 1,000 bacteria; and 13 percent of the cans and 21 percent of the pails would have added more than 1,000 bacteria per cc. The average contamination by these cans would have been 385 bacteria per cc. of milk and by the pails 848 bacteria. These calculations are based on the assumption that each utensil is filled with milk but once. In actual operations each pail is commonly used in milking several cows, and thus is filled a number of times, so that the number of bacteria added to the milk by the pails in practice would be smaller than the above calculated number.

A comparison of these results with those from the check cans shows that there were eleven times as many germs in the check cans as in those cans which were kept on the rack for eight hours. Assuming that the cans which were exposed to the sun and air had approximately the same germ life before they were placed on the rack as the check cans, it is evident that a decided reduction in the germ life in the cans was brought about by this treatment.

BACTERIA IN CANS AFTER TWENTY HOURS' EXPOSURE TO SUN AND AIR

The data given in Table 5 show that in the cans of May 22, 28, 29, 31, and June 1, 4, 5, and 6 more bacteria were found after twenty hours than in the corresponding cans after being held for eight hours. It is of significance in this connection that rain fell[1] on each of these nights except June 1 and on this night the relative humidity was 80 at 7 p. m., with the practical certainty that this increased as the temperature fell during the night, it being 90 at 7 a.m. the following morning. Under such meteorological conditions a deposition of moisture on the surface of the cans would readily occur and thus produce conditions favorable to germ growth. During the nights of May 23, 24, 25, and June 7 and 8, when there was no rain and the relative humidity was much lower, the germ content of the cans held for twenty hours, as compared with those held eight hours, remained fairly constant or continued to decrease.

Of the 101 cans kept on the rack from 8 a. m. to 4 a. m. the following morning, 19 percent would have added less than 10 bacteria per cc. of milk, 26 percent more than 10 and less than 100, 28 percent more than 100 and less than 1,000, and 27 percent more than 1,000.

[1]Data furnished from the record sheets of the Local Volunteer Weather Observation Station thru the kindness of Prof. J. G. Mosier.

The average contaminations per cc. of milk, if all the cans had been filled, would have been 1,303 bacteria.

BACTERIA IN DRY CANS AND IN MOIST CANS

While the observations summarized in Table 5 were made upon cans held under conditions identical with those to which cans are exposed in practice, it was somewhat difficult to interpret the results because the humidity of the air varied so widely. Likewise the amount of germ life present in the cans before treatment could not be satisfactorily determined.

For the purpose of supplementing this data, a test was made during January and February, 1919, with eight-gallon cans which had been so thoroly steamed as to render them free of germ life. After they were cool and dry there was added to each can 10 cc. of wash water or rinse water which was taken from vats in which milk utensils had just been cleaned and the germ content of which had been carefully determined. After adding this liquid to the cans they were covered and shaken vigorously to distribute the material over the inner surface. This volume of liquid was chosen because observation had shown that about this quantity of liquid usually remains in well-drained cans.

Six eight-gallon cans were treated in this way on each of eight days. On each day, immediately after the liquid had been thoroly distributed in the cans, the covers were removed from three cans, which were left lying on their side, but left on the other three cans. The cans were then held for twenty-four hours in a room with a temperature of approximately 70° F. and a relatively low humidity, ordinarily between 40 and 60.

The bacterial life found in these two groups of cans at the end of twenty-four hours, determined according to the methods described on page 141, is recorded in Table 6. To facilitate comparisons of the results, the cans are grouped in the order of the increasing amount of original inoculation added to the cans.

Perhaps the most evident point in the data in Table 6 is the lack of any apparent relationship between the extent of the original inoculation placed in the cans and the amount of germ life found at the end of twenty-four hours. This is equally evident in the cans from which the covers had been removed and in those on which the covers had been left. This suggests that the final germ content of cans held for a period of twenty-four hours during warm weather depends more upon the conditions under which the cans are held than upon their germ content at the close of the washing process.

In all but three of the cans from which the covers were removed the germ life fell quite sharply during the twenty-four hours. On the other hand, in all the covered cans the germ life increased, the extent of the increase varying from 20 to 3,000 fold.

Of the twenty-four cans from which the covers were removed sixteen, if filled with milk, would have added to each cc. a germ content of between 10 and 100; four would have added between 100 and 1,000; three between 1,000 and 10,000; and one can 21,381 per cc.

Of the twenty-four cans which stood with their covers on there were none which would have added a germ content below 10,000 per

TABLE 6.—CHANGES IN BACTERIAL LIFE IN COVERED AND IN UNCOVERED CANS DURING TWENTY-FOUR HOURS

10 cc. of rinse water added to each can at beginning of period

No. of can	Cans Not Covered		No. of can	Cans Covered	
	Germs remaining in can	Germs per cc. of milk due to can		Germs remaining in can	Germs per cc. of milk due to can
Each Can Inoculated with 12,300,000 Bacteria					
1	400 000	13.1	4	24 375 000 000	801 809.2
2	500 000	16.4	5	31 200 000 000	1 026 315.8
3	85 000 000	2 796.0	6	35 350 000 000	1 162 829.0
Each Can Inoculated with 42,200,000 Bacteria					
7	9 000	0.2	10	1 610 000 000	52 960.5
8	25 000	0.8	11	1 700 000 000	55 921.0
9	1 800 000	59.2	12	3 500 000 000	115 131.5
Each Can Inoculated with 43,900,000 Bacteria					
13	1 400 000	46.0	16	2 600 000 000	85 526.3
14	35 300 000	1 161.1	17	2 680 000 000	88 157.9
15	81 750 000	2 689.1	18	2 700 000 000	88 815.7
Each Can Inoculated with 46,900,000 Bacteria					
19	1 150 000	37.8	22	7 000 000 000	230 263.1
20	4 875 000	160.3	23	9 300 000 000	305 921.0
21	5 050 000	166.1	24	11 800 000 000	388 157.9
Each Can Inoculated with 55,600,000 Bacteria					
25	400 000	13.1	28	3 740 000 000	123 026.3
26	550 000	18.0	29	4 920 000 000	161 842.1
27	900 000	29.6	30	5 220 000 000	171 710.5
Each Can Inoculated with 76,500,000 Bacteria					
31	500 000	16.4	34	1 500 000 000	49 342.1
32	1 000 000	32.8	35	2 300 000 000	75 657.9
33	2 000 000	65.7	36	2 700 000 000	88 815.7
Each Can Inoculated with 82,000,000 Bacteria					
37	280 000	9.2	40	3 350 000 000	110 197.3
38	405 000	13.3	41	4 750 000 000	156 250.0
39	1 700 000	55.9	42	7 150 000 000	235 197.3
Each Can Inoculated with 115,500,000 Bacteria					
43	5 600 000	184.2	46	2 200 000 000	72 368.4
44	44 000 000	1 447.3	47	2 350 000 000	77 302.6
45	650 000 000	21 381.5	48	4 400 000 000	144 736.8

cc. of milk; seventeen cans would have added a germ content of between 10,000 and 100,000; five cans a germ content of between 100,000 and 1,000,000; and two cans a germ content of over 1,000,000 per cc.

These results may be summarized by saying that the worst of the open cans showed less than one-half the germ content of the best of the cans which were covered. Had all the cans been filled with sterile milk, that in the covered cans would have had an average germ content of 247,772 per cc.; while similar milk in the open cans would have had an average germ content of 1,284 per cc., and two-thirds of these germs would have come from a single one of the twenty-four open cans.

Since the six cans used each day were practically identical except in the matter of moisture the marked differences in final germ content may be attributed to differences in moisture. In the closed cans the moisture could not escape, the air promptly became saturated, and the conditions for the growth of bacteria became good over the entire inner surface of the can. The amount of germ life present in these moist cans at the end of twenty-four hours seemed to depend mainly upon the vigor of the germs present and upon the amount and character of food available to them.

In the open cans evaporation began at once. Ordinarily the cans became apparently dry within a few hours. However, in a few cans, probably because of the uneven distribution of the moisture, the drying was materially retarded and at least a few drops of water remained in the cans at the end of twenty-four hours. For example, when Cans 13, 14, and 15 were tested at the end of twenty-four hours, Can 13 seemed quite dry, while moisture was evident in Cans 14 and 15. The examination of these cans indicated a germ content in Can 13 of 46 per cc., while Cans 14 and 15 had a germ content of 1,161 and 2,689 per cc. respectively. Again, the day on which Cans 43, 44, and 45 were tested was damp and rainy, and at the end of twenty-four hours moisture was evident in all of the cans but was most pronounced in No. 45. The germ content found in these cans was 184, 1,447, and 21,381 per cc. respectively.

These observations of the presence of moisture in certain cans account for all the comparatively high numbers found in the cans from which the covers had been removed, except in the case of Can 3. The notes do not show that any moisture was present at the end of twenty-four hours in this can, but the whole trend of the data makes it highly probable that the can, for some reason, dried very slowly.

Importance of Dryness in Controlling Germ Life in Utensils

The main fact which stands out distinctly as the result of the studies reported in Part II is the overshadowing importance of dryness as a means of reducing and keeping down germ life in utensils.

Pails and cans given such a washing as is practicable even on the farm, where steam is not available, will add to the milk later put into them less than 100 bacteria per cubic centimeter, provided they are promptly and thoroly dried and kept dry until used.

When the sun is hot and the air dry, the exposure of the utensils, with the covers off, to the heat of the sun is a satisfactory treatment. However, when the weather is rainy, exposure to the damp air does not lead to quick and thoro drying and under such conditions the germ life in the utensils may hold its own or even increase in number.

GENERAL DISCUSSION

From information kindly furnished by milk companies in various cities it is evident that the morning's milk as it reaches their bottling plants or shipping stations in warm weather rarely contains less than 50,000 bacteria per cc. and occasionally exceeds 1,000,000 per cc. It should be remembered that the interval between milking and delivery in these cases is so short that little growth has occurred. Accordingly the above large numbers of bacteria indicate the amount of seeding to which the milk is normally exposed under present conditions.

The studies described in Bulletin 204 make it evident that the seeding of the milk under normal conditions comes principally from the utensils in which the milk is handled. It further points out that among the utensils coming into contact with the milk up to the time of its delivery to the milk plant, the cans are ordinarily the principal source of the bacteria added to the milk.

The present publication points out that the amount of germ life in milk cans in warm weather twenty-four hours after they have been fairly well washed is controlled principally by the moisture which remains in the washed cans.

Observations made upon the milk cans as sent out by a considerable number of the leading milk companies show that a considerable proportion of these cans are moist as returned to the producers. Accordingly in these cans the conditions are favorable for the development of an amount of germ life which will fully account for the seeding which the milk ordinarily receives before it reaches the milk plant.

The present publication further points out that when these high germ content cans reach the farm a rinsing with liberal amounts of water at or near the boiling point will so reduce the number of germs in them that if used immediately they will ordinarily add only about 100 bacteria per cc. to the milk. It also points out that if such of these cans as are not needed immediately are promptly and thoroly dried and kept dry, the germs in them will not grow but will continue to decrease, and the cans when used will have little effect upon the germ content of the milk.