THE STERILIZATION OF EMPTY MILK CHURNS BY STEAM UNDER PRESSURE[1].

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In a previous paper[2] it was shown that of the empty milk churns which were examined, 56 per cent. were totally unfit for use, as they contained very large numbers of bacteria and lactose fermenting organisms in high proportion. Table I (1) is taken from this paper and gives the number of bacteria per 1 c.c. of washings with sterile saline solution. These churns were taken at random on a station platform, their origin being unknown.

Table I.

Bacteriological examination of empty milk churns.

(1) On a station platform.

Condition of churn	Bacteria per 1 c.c. washings	Lactose fermenting organisms
Unwashed	Uncountable in 1/100,000 c.c.	+1/100,000 c.c
„	4,000,000	+1/100,000 „
Badly washed (milk and water present)	18,400,000	+1/1000 „
„ „ „	5,300,000	+1/1000 „
Apparently clean but wet	4,100,000	+1/100 „
„ „	780,000	+1/10,000 „
Apparently clean and dry	6,200,000	+1/1000 „
„ „	1,720,000	+1/10,000 „

(2) On a farm attempting to produce clean milk.

Apparently clean and dry	1,500,000	+1/10 „
„ „	1,000,000	+1/100 „
Wet.—Foul smell	38,000	+1/10 „
„ „	1,200,000	+1/10 „

The unsatisfactory condition of these particular churns may have been due to the lack of care on the part of the dealers from whom they happened to have come.

[1] The expenses of this investigation were defrayed by a grant from the Ministry of Health.

[2] Cumming and Mattick, 28. vii. 1920. An Enquiry concerning the State of Cleanliness of Empty Milk Churns. *Journ. of Hygiene*, XIX.

That this fault is however general is well shown by a consideration of the lower set of figures in Table I (2), which gives the results of the bacteriological examination of churns used by a wholesaler who was undoubtedly endeavouring to assist the farmer in the production of clean milk.

These figures demonstrate that although the dealer was aware of the necessity for care and further that steam was available and had been used, it had not been employed to the best advantage.

It would seem, therefore, that there is at present no real conception of the best methods of cleansing milk churns in the industry.

CONDITIONS OF EXPERIMENT.

The following experiments have been carried out in order to discover the minimum time of steaming which is necessary to ensure as complete a sterilization as is possible under commercial conditions.

The steam used in the experiments was obtained from a boiler of a type which is in common use in the industry. The boiler worked at a pressure of from 40–80 lbs. and yielded steam at temperatures which varied, in the course of the experiments, from 89° C.–105° C. at the jet.

It should be noted that these variations of temperature and pressure and, what is probably most important, of the volume of steam, were accepted without question as they are conditions common to the open jets in general use.

It may be that a further study of the conditions governing these variations and their significance in sterilization may result in a considerable saving of time and expense involved in getting steam at an unnecessarily high pressure.

The experiments about to be described are divided into three sections in which the times of steaming are varied.

Series I.

Seventeen-gallon churns artificially contaminated with dirty milk.

Two 17-gallon churns in good condition, but not new, were contaminated by pouring into each two quarts of dirty milk.

Milk such as this was used so that the time of steaming finally arrived at should apply to any conditions likely to be found in practice.

The condition of this milk is shown by the results of the bacteriological examinations which were done at intervals and are tabulated in Table II.

The churns, with their lids on, were left with the milk in them, in an exposed place for 24 hours. At the end of this time the milk was poured out and the churns were washed.

Method of washing and steaming.

The bulk of the contaminating material, remaining in the churns, was removed by washing with a jet of cold water from a hose. Two gallons of cold water were then put in and the internal surface of each churn vigorously

scrubbed with a long handled brush resembling a deck swab ("Turk's Head"). This water was poured out and replaced by a similar quantity of hot water and the brush again used. The churns were then inverted to allow of drainage and finally steamed. One was steamed for thirty seconds and the other for three minutes. After steaming each churn was laid on its side to allow of the escape of steam.

It was found that the churns in this series and throughout the experiments which were steamed for three minutes were almost invariably quite dry after all the steam had escaped, there being sufficient residual heat in the metal to evaporate any water which might have condensed. This is an important point as it is sometimes considered necessary to employ hot air blasts etc. in order to dry churns after steaming.

After steaming, the lids, having received treatment similar to the churns, were replaced and the churns were left with their lids on in an exposed place for 24 hours as before.

Methods of making the bacteriological examinations.

At the end of this time, the internal surfaces of both churns were thoroughly washed by pouring in one litre of sterile saline solution and by rubbing vigorously with a sterile swab to detach bacteria from the sides. A part of the saline was first poured on to the inside of the lid and then allowed to run into the churn.

Samples of the washings from each churn were then taken into sterile bottles and at once examined bacteriologically by plating dilutions from 1/10–1/10,000 c.c. on neutral whey agar plates. These were incubated for five days at 22° C. and then counted.

Litmus lactose peptone water tubes were also inoculated with quantities of the washings varying from 1 c.c.–1/10,000 c.c. and incubated for five days at 37° C. The tubes were then examined for the presence or absence of lactose fermenting organisms as indicated by the production or non-production of acid and gas in the Durham's tubes.

Results of experiments in Series I.

The results, which are shown in Table II, demonstrate the fact that 30 seconds' steaming does not suffice to sterilize a churn which has been contaminated with such milk as was used. The counts obtained were irregular and on six occasions out of fifteen, lactose fermenting organisms were found to be present. When the churns had been steamed for three minutes the counts were usually very small and in some cases no organisms grew. This fact should not be taken to mean that no organisms were present, but simply that they were not found in the quantities examined and that in any case the numbers must have been very small.

The presence of lactose fermenting organisms was not demonstrated in those churns which had been steamed for three minutes.

Table II.

Seventeen-gallon churns artificially contaminated with sour milk.

	30 seconds' steaming		3 minutes' steaming	
Date	Agar count	Lactose fermenting organisms	Agar count	Lactose fermenting organisms
24. vi. 20	100	–	200	–
28. vi. 20	200	–	0	–
30. vi. 20	500	–	330	–
3. vii. 20	180	–	70	–
5. viii. 20	30	–	20	–
18. viii. 20	250	+	20	–
21. viii. 20	240	+	10	–
24. viii. 20	1520	+	0	–
27. viii. 20	0	–	10	–
4. ix. 20	400	+	10	–
8. ix. 20	620	+	370	–
18. ix. 20	30	–	20	–
23. ix. 20	30	–	20	–
25. ix. 20	142	–	12	–
1. x. 20	14700	+	7900	–
	Examination of contaminating material.			
23. vi. 20	Uncountable in 1/1,000,000 c.c.	+1/1,000,000 c.c.	.	.
2. vii. 20	Uncountable in 1/1,000,000 c.c.	+1/1,000,000 c.c.	.	.
26. viii. 20	Uncountable in 1/10,000 c.c.	+1 c.c.	.	.

Series II.

Seventeen-gallon churns artificially contaminated with sour whey.

Since 30 seconds' steaming had been proved to be inadequate to sterilize a heavily contaminated churn and three minutes' steaming appeared to give very satisfactory results, it was thought wise to try and discover the efficiency of a steaming time which was more than thirty seconds but less than three minutes.

A series of experiments was therefore set up in which the churns were steamed for periods of thirty seconds and two minutes respectively, after contamination with whey.

A period of thirty seconds' steaming was again used in this series so as to confirm the results of the former series.

The methods of washing the churns and carrying out the bacteriological examinations were exactly as before.

Results of experiments in Series II.

Forty-six experiments were made in this series, twenty-three after 30 seconds' steaming and twenty-three after two minutes' steaming.

Table III shows the results of the bacteriological examinations.

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Table III.

Seventeen-gallon churns artificially contaminated with sour whey.

	30 seconds' steaming		2 minutes' steaming	
Date	Agar count	Lactose fermenting organisms	Agar count	Lactose fermenting organisms
3. xi. 20	8	–	4	–
9. xi. 20	0	–	1	+
11. xi. 20	160	+	40	–
13. xi. 20	30	–	100	+
16. xi. 20	1600	+	560	+
18. xi. 20	29	–	1	–
20. xi. 20	17	–	10	–
23. xi. 20	84	+	11	–
25. xi. 20	134	+	97	–
27. xi. 20	530	–	1580	+
30. xi. 20	41	–	2	–
2. xii. 20	188	+	10	+
4. xii. 20	138	–	6	–
7. xii. 20	740	+	540	–
9. xii. 20	720	–	9	–
11. xii. 20	12	–	2	–
27. i. 21	22200	–	2640	–
3. ii. 21	1430	–	190	–
5. ii. 21	121	–	14	–
8. ii. 21	760	–	57	–
10. ii. 21	Uncountable	+	140	–
12. ii. 21	101	–	22	–
17. ii. 21	2920	–	370	–
	Examination of contaminating material.			
8. xi. 20	Uncountable	+1/1000 c.c.	.	.
7. xii. 20	Uncountable	+1/1,000,000 c.c.	.	.

The bacterial counts obtained in both cases were found to be low but occasionally large numbers of bacteria were present.

The counts from the churns steamed for two minutes show, however, considerably fewer fluctuations than those from the one steamed for 30 seconds, and the numbers of occasions when lactose fermenting organisms were present, are less in the case of the former than of the latter.

It is seen that although two minutes' steaming gave better results than 30 seconds' steaming, there was still room for improvement.

These two series of experiments demonstrated that a steaming period of 30 seconds was insufficient but left the adequacy of two minutes' steaming still in doubt. A further series of experiments was therefore set up to establish the relative efficiencies of steaming for periods of two and three minutes.

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SERIES III.

Seventeen-gallon churns contaminated with sour whey.

In this series a much greater quantity of whey was used for contaminating the churns, from four to five gallons being used for each.

Four 17-gallon churns were contaminated in this way and left for 24 hours in an exposed position with the lids on.

The methods of washing, steaming and making the bacteriological examinations remained unchanged, except that 1 c.c. of the washings was inoculated into neutral whey agar plates in addition to dilutions of 1/10 c.c. and upwards. Two churns were steamed for two minutes and two for three minutes at each examination.

Results of examinations in Series III.

Forty-four examinations were made under the above conditions, twenty-two after two minutes' steaming and twenty-two after three minutes' steaming. The results are tabulated in Table IV.

Table IV.

Seventeen-gallon churns heavily contaminated with sour whey.

	2 minutes' steaming		3 minutes' steaming	
Date	Agar count	Lactose fermenting organisms	Agar count	Lactose fermenting organisms
26. iv. 21	9	–	96	–
	11	–	50	–
28. iv. 21	350	–	27	–
	Uncountable	+	Uncountable	–
30. iv. 21	2150	–	38	–
	480	–	74	–
3. v. 21	115	–	8	–
	15	–	16	–
5. v. 21	27	–	12	–
	20	–	29	–
7. v. 21	46	–	6	–
	110	–	138	–
10. v. 21	10	–	1	–
	2	–	7	–
12. v. 21	12	–	15	–
	4	–	175	–
19. v. 21	20	–	7	–
	30	–	5	–
21. v. 21	2	–	50	–
	30	–	27	–
24. v. 21	5	–	6	–
	26	–	30	–

Except on one occasion (28. iv. 21) the actual counts were extremely low, there being very little to choose between the two sets of results.

It is, however, notable that on no occasion were lactose fermenting organisms found after three minutes' steaming, but that they were present on one occasion after two minutes' steaming.

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SUMMARY OF RESULTS.

The results of all the experiments are summarized in Table V.

Table V.

Time of steaming	No. of experiments	500 bacteria or less per 1 c.c. of washings	Percentage of counts under 500 per 1 c.c. of washings
30 seconds	38	26	68 %
2 minutes	45	39	86 %
3 minutes	37	35	94·6 %
		Number of occasions when lactose fermenting organisms were present	Percentage of occasions when lactose fermenting organisms were present
30 seconds	38	13	34 %
2 minutes	45	6	13·3 %
3 minutes	37	0	0 %

In constructing Table V all those results giving 500 or less bacteria per 1 c.c. of washings are shown as percentages of the total number of experiments in the series. This figure (500 per 1 c.c.) was adopted for comparison with the figures shown in Table I.

The figures in Table V clearly demonstrate the fact that as the time of steaming increases, the number of bacteria finally found in the churn decreases. When the time of steaming was 30 seconds only 68 per cent. of the churns examined showed counts as low as 500 or less as compared with 86 per cent. after two minutes' and 94·6 per cent. after three minutes' steaming.

The superiority of a period of three minutes' over two minutes' steaming is further clearly shown in Table V by a consideration of the percentages of occasions when lactose fermenting organisms occurred. After 30 seconds' steaming lactose fermenting organisms were found on 34 per cent. of occasions as compared with 13 per cent. after two minutes' steaming and 0 per cent. after three minutes' steaming.

It is of interest to compare the initial contamination of milk put into a properly cleansed churn with that of milk put into an inadequately cleansed churn.

One of the churns in Table I contained 18,400,000 bacteria per 1 c.c. of washings. This figure represents an initial contamination of any milk put into such a churn of 240,000 per 1 c.c. if 17 gallons of milk be introduced.

If, as in the churns of Series III, there are 500 bacteria per 1 c.c. of washings, then 17 gallons of milk would be contaminated to the extent of about 7 bacteria per 1 c.c.

The difference in these figures probably represents many hours difference in the duration of sweetness of the milk.

CONCLUSIONS.

Churns and other milk utensils, if they be dirty, are responsible for a great deal of unnecessary contamination in market milk. Any extra care taken in adequately cleansing churns would be more than repaid by the improvement in the quality of the milk.

The experiments show that if dirty churns be properly washed and then steamed for three minutes they can be used with safety after 24 hours, if the lids are not removed.

This is a point of great importance since the practice of many farmers, of swilling out churns immediately before use, with water which is often open to suspicion, becomes unnecessary.

In depots, where large numbers of churns have to be dealt with, it should be feasible to arrange for the installation of a greater number of steam jets. Since it takes three minutes to steam a churn adequately, each jet would be capable of dealing with 20 churns per hour.

Serious consideration should be given to the desirability of the provision of a duplicate set of churns, since under the present conditions, where lorries wait to return churns to the station, it is impossible to sterilize them properly.

It is undoubtedly the business of the persons receiving the milk to see that the churns are properly sterilized, as the difficulty of cleansing them after milk has been allowed to sour in them is very greatly increased.

Thanks are due to Miss Erskine for permission to use the figures in Table I (2).