THE INFLUENCE OF DIFFERENT METHODS OF CLEANSING DAIRY UTENSILS ON THE BACTERIAL CONTENT OF CHURNS AND ON THE KEEPING PROPERTIES OF MILK.

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In the handling of milk no single factor is of more importance than the cleanliness of the vessels used, and steam sterilisation is an essential part of correct cleansing technique of dairy utensils. Although several hundred dairy farmers have installed apparatus for steam sterilisation, the majority are still content with less efficient methods and rely upon "scalding" as the final operation in washing a utensil, although the water used for scalding is seldom at a sufficiently high temperature to kill many bacteria, and it is usually poured from one vessel to another in the hopes of efficiently finishing the cleansing processes although it is only comfortably warm to the fingers.

The following paper is an account of a series of experiments conducted in autumn months to determine the bacterial content of 10 and 17 gallon railway milk churns, some of which had been only washed, some washed and then "scalded," whereas others had been washed and finally sterilised by steam. Tests were also made in each case to find out what effect the different methods of cleansing had upon the keeping quality of milk. The source of steam for this work was an ordinary farm copper boiler, a point of special interest to those farmers who are not at present prepared to purchase the usual pressure steam boiler and sterilising tank.

PART I

THE INFLUENCE OF DIFFERENT METHODS OF CLEANSING DAIRY UTENSILS ON THE BACTERIAL CONTENT OF CHURNS.

Conditions of experiment and methods.

Four 10 gallon and four 17 gallon churns were employed and they were divided into four lots of two—each pair including one 10 and one 17 gallon churn. All the churns were washed under similar conditions, one lot was scalded in addition, two lots were steam sterilised for different periods of time, and the remaining churns had nothing done to them after being washed, since they were to act as controls to the scalded and sterilised churns. The experiment was repeated ten times, but the scalded churns were not included until the fourth experiment.

Since the churns were not in use between experiments it was decided to

add sour milk to them to ensure adequate initial contamination; after two days' contact this milk was poured away, each churn was rinsed well in cold water from a hose, well scrubbed in hot water containing washing soda, and then thoroughly rinsed in clean cold water. After draining for two hours in an inverted position two of the washed churns had sterile lids placed on them. Another pair of churns were "scalded" and, after draining for two hours, were fitted with steam sterilised lids. The "scalding" was carried out as follows: Vigorously boiling water was carried as quickly as possible from the copper to the churns which were nearly twenty yards away, and the temperature was taken on arrival. Three gallons of "scalding" water were poured into the 17 gallon churn and two into the 10 gallon churn. In all cases the water was poured down the sides and the churns were held in an oblique position and were rocked and turned so that the water came in contact with all the inner surface; after half a minute's treatment the water was poured out, the temperature was taken, and the churns were carried away to drain. Table I shows all the temperatures recorded, and experiments 4–9 bring out the interesting fact that nearly a third of the heat given up by the water during the whole scalding process was lost during its carriage from the copper to the churns. The entire scalding process was carried out much more expeditiously and efficiently than has been observed in any farm dairy by either of the writers, and it may be safely assumed that on very few dairy farms is the scalding done so effectively.

Table I. *Showing temperatures of hot water before and after scalding the churns.*

Expt. No.	Sizes of churns	Temp. of hot water before scalding ° Fahr.	Temp. of water after scalding ° Fahr.
*4	10 gallon	200	175
	17 ,,	195	170
5	10 ,,	196	164
	17 ,,	195	163
6	10 ,,	197	158
	17 ,,	199	160
7	10 ,,	196	160
	17 ,,	200	168
8	10 ,,	201	170
	17 ,,	201	166
9	10 ,,	200	164
	17 ,,	200	168
†10	10 ,,	183	157
	17 ,,	186	160

* The "scalded" churns were not introduced until the fourth experiment.
† The water used for scalding had just gone "off the boil" before its removal from the boiler.

The above table shows that the temperature of the scalding water fell from 11° F. to 17° F. in the different experiments during the short transportation period, and in ordinary farm practice a greater fall would probably be experienced. The result obtained in the tenth experiment is extremely illuminating; in this case the water had just gone "off the boil," but since this

would still be used for scalding in most farm dairies, it was decided to carry on the experiment; the result was that when the water reached the churns it was 26° F. and 29° F. below boiling point.

Procedure adopted for steaming.

The remaining four churns were sterilised over an adapted copper boiler, the use of which has already been described (Hoy, 1923), until they were unbearably hot to the fingers in all parts. In addition to this basal time period two of the churns were steamed for one minute longer (Series A), and the last pair were steamed for an extra five minutes (Series B). The object of this was to determine if one minute's steaming after the unbearably hot stage had been reached gave as good results as steaming for five minutes. Table II gives the times required in each experiment for the churns to become unbearably hot to touch. The steaming process having been completed each churn was removed and held in a horizontal position until the lid had been fitted on; in this way much steam was enclosed, thus tending to reduce the good results of sterilisation by leaving the interior moist, and so aiding the multiplication of bacteria or their spores within. All the churns, whether washed, scalded or sterilised were left in a room at ordinary temperature for twenty-four hours, so that any bacteria or spores would have ample time for multiplication. The same churns were used in each lot for the entire series of experiments.

To reduce the number of factors involved all churn lids were washed and steam sterilised, hence it is the bacterial cleanliness of the churns alone that is involved in this work.

Table II. *Times recorded for the steamed churns to become unbearably hot.*

	Series A				Series B			
	10 gallon		17 gallon		10 gallon		17 gallon	
Expt. No.	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.
1	1	40	3	20	2	0	2	35
2	1	50	3	5	1	50	3	40
3	1	45	3	0	1	50	3	30
4	1	50	3	10	1	50	4	0
5	2	5	3	30	1	55	3	30
6	1	45	4	0	2	0	3	0
7	2	5	4	0	2	0	3	0
8	1	10	2	40	1	50	2	35
9	2	20	4	10	2	0	3	50
10	1	5	2	52	1	35	2	50

Series A. In each case the 10 and 17 gallon churns received an additional one minute steaming period which must be added to the above times when comparing results of Bacteriological examinations and "Keeping Quality" tests.

Series B. The 10 and 17 gallon churns in this series received a further five minutes steaming period after the unbearably hot stage had been reached.

Methods of obtaining bacterial count.

The churns having been left on one side for a day, the internal surfaces were rinsed with sterile water to collect the bacteria and moulds; to do this more thoroughly, specially made sterilised swabs with long handles were used

to aid the detachment of the organisms from the churn walls. A litre of sterile water was used for each 17 gallon churn, and $\frac{10}{17}$ of a litre (588 c.c.) was used for the 10 gallon churns so as to get more easily comparable results. Samples of the rinsings from each churn were collected in closed sterile vessels, and were examined at once by plating 1 c.c. on standard agar in the case of the steamed churns, and dilutions of 1 c.c. from the scalded and washed churns. Litmus lactose peptone water tubes were inoculated with quantities of the washings varying from 1 c.c. to $\frac{1}{1000}$ c.c. to determine the presence or absence of coliform organisms. The plates and coli tests for the steamed churns were

Table III. *Results of the bacteriological examinations of the washed and scalded churns.*

	Churns washed only				Churns washed and scalded			
	10 gallon		17 gallon		10 gallon		17 gallon	
Expt. No.	Bacteria per c.c. of rinsings	*B. coli*	Bacteria per c.c. of rinsings	*B. coli*	Bacteria per c.c. of rinsings	*B. coli*	Bacteria per c.c. of rinsings	*B. coli*
1	10,600,000	+1/1000	36,900,000	+1/1000	No test		No test	
2	590,000	–	64,000	–	,,		,,	
3	56,000	+1/100	5,800,000	+1/100	,,		,,	
4	4,240,000	+1/1000	710,000	+1/1000	46,000	–	9,500	+1 c.c.
5	590,000	+1/10	2,280,000	+1/1000	10,100	–	9,800	–
6	2,800,000	+1 c.c.	790,000	+1/1000	3,000	–	2,000	–
7	4,220,000	+1/1000	6,420,000	+1/1000	21,700	+1 c.c.	5,800	–
8	540,000	+1/1000	3,460,000	+1/1000	2,500	–	1,050	–
9	2,080,000	+1/1000	14,600	+1/10	56,000	–	6,920,000	+1/1000
10	48,000	+1/100	152,000	+1/1000	5,400	+1 c.c.	4,300	–

– = *B. coli* not found in 1 c.c. + = *B. coli* found in 1 c.c. or less.

In this paper the formation of acid in the litmus lactose peptone water, and of gas in the Durham's tube, has been taken as signifying the presence of *B. coli*, so that the results may be considered in relation to the requirements of the Ministry of Health regarding the sale of Certified and Grade A milk; a better description would have been "Presence of lactose fermenting organisms with gas formation."

Table IV. *Results of the duplicated bacteriological examinations of the rinsings from the steam sterilised churns.*

	Series A								Series B							
	10 gallon				17 gallon				10 gallon				17 gallon			
Expt. No.	Bacteria per c.c.		*B. coli*		Bacteria per c.c.		*B. coli*		Bacteria per c.c.		*B. coli*		Bacteria per c.c.		*B. coli*	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1	1	0	–	–	8	5	–	–	5	0	–	–	5	0	–	–
2	4	3	–	–	3	1	–	–	7	2	–	–	4	0	–	–
3	4	4	–	–	0	0	–	–	16	13	–	–	3	1	–	–
4	11	0	–	–	4	2	–	–	506	286	–	–	0	0	–	–
5	4	1	–	–	9	8	–	Slight acidity	5	1	–	–	1	0	–	–
6	2	0	–	–	2	0	–	–	7	5	–	–	6	2	–	–
7	33	30	–	–	12	7	–	–	7	5	–	–	47	34	–	–
8	2	1	–	–	13	12	–	–	4	1	–	–	18	14	–	–
9	5	0	–	–	4	3	–	–	7	3	–	–	10	6	–	–
10	9	4	–	–	5	2	–	–	8	5	–	–	4	3	–	–

The factor causing the variation in Series B, Experiment 4, 10 gallon churn was not traced; three types of Staphylococci were present, and as these bacteria would certainly not survive the treatment to which the churn was subjected it is presumed that contamination took place after steam sterilisation.

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all done in duplicate. The plate cultures were incubated at 22° C. for five days, and the lactose tubes were incubated for a similar period at 37° C. The results per cubic centimetre of the rinsings from the washed and scalded and from the steamed churns are shown in Tables III and IV respectively.

PART II.

THE EFFECT ON THE KEEPING QUALITIES OF MILK OF CLEANSING CHURNS IN DIFFERENT WAYS.

In order to distinguish between the keeping qualities of clean milk and portions of the same milk after contact with (1) a washed churn, (2) a washed and scalded churn, and (3) a washed and steam sterilised churn, it was necessary to obtain milk with as good a keeping quality as possible.

The milk used for this purpose was obtained by that attention to detail at the farm which has been shown in previous papers to be necessary (Mackintosh, 1922; Hoy, 1924).

No extraordinary precautions were taken, but the udders and teats of the cows were washed before each milking, and all the dairy utensils which came in contact with the milk were sterilised before use by means of the simple steam steriliser (Hoy and Williams, 1921). The milker wore a clean overall and used a covered milking pail, from which the milk was poured into half gallon cans without straining or cooling. These cans were taken by road a distance of three miles to the laboratory and immersed in running water until the milk was used. On each occasion bacteriological tests were made and the results are shown in Table V.

Table V. *Results of the bacteriological examination of milk used for keeping quality tests.*

Expt. No.	Bacteria per c.c.	*B. coli* per c.c.
1	3250	–
2	2500	–
3	450	–
4	2100	–
5	1200	–
6	360	–
7	280	–
8	8500	–
9	2000	–
10	2850	–

Table V shows that the milk used for the keeping quality tests was of good hygienic quality.

Method of determining keeping qualities.

One litre of sterile water was used for rinsing each 17 gallon churn after it had been treated by one or other of the methods described in the opening paragraph, and in order that the results should be comparable 588 c.c. of sterile water were used for rinsing each 10 gallon churn. The rinsings, containing as far as possible all the bacteria surviving the cleaning process, were

used for the bacteriological examinations already described in Part I and also for adding to clean milk, so rendering it possible to observe the effect churn contamination had upon the subsequent keeping qualities.

The test for keeping qualities as effected by the addition of the rinsing water was made as follows:

In each case 5 c.c. of the rinsing water from the churn under test were added to 379 c.c., that is to say two-thirds of a pint, of the clean milk contained in a sterile bottle. The addition of 5 c.c. of the rinsing water to 379 c.c. of milk represented as nearly as possible the contamination that would have occurred to the milk if the test churns had been in actual use and filled with 10 and 17 gallons respectively.

The clean milk used in the tests was thoroughly mixed before distribution into sterile bottles so as to ensure as far as possible an equal quality in each case.

Two bottles of clean milk containing no rinsings were used for controls in each experiment and these were placed together with the inoculated bottles in an incubator and kept at a temperature of 60° F. After 24 hours small quantities were poured from each bottle into a glass and tasted, and this procedure was repeated every 12 hours until the milk was sour. In Table VI the lengths of time in days during which the samples remained quite sweet are compared.

Table VI. *Results of "Keeping Quality" tests in days; milk stored at* 60° F.

Expt. No.	Test milk Controls (1)	(2)	Washed churns 10 gall.	17 gall.	Washed and Scalded churns 10 gall.	17 gall.	Series A Washed and Steamed churns 10 gall.	17 gall.	Series B Washed and Steamed churns 10 gall.	17 gall.
1	2½	2½	1½	1½	No test		2½	2½	2½	2½
2	3½	2½	1½	1½	,,	,,	3½	3½	3½	3½
3	3	3	1½	1½	,,	,,	3	3	3	3
4	3	3	1½	1½	2	2	3	3	3	3
5	3	3	1½	1½	2	2	3	3	3	3
6	3	3	1½	1½	2	2	3	3	3	3
7	3½	3½	1	1	1½	1½	3½	3½	3½	3½
8	3	3	1	1	1½	1½	3	3	3	3
9	3	3	1	1	1½	1½	3	3	3	3
10	3	3	1½	1½	2½	2½	3	3	3	3

This table clearly shows that if churns are properly sterilised by steam the keeping quality of milk which is put into them is not reduced in any way. On the other hand, mere washing of churns—in this case the most thorough possible—is certainly not effective, and milk put into churns treated in this way is shown to have its period of sweetness reduced by 50 per cent. Even thorough scalding, which has in the past been recommended by some writers, is definitely shown not to be nearly so efficient as sterilisation by steam.

The loss of keeping quality which varies from 12 to 36 hours in these experiments would in all probability be increased in practice.

Discussion.

Prucha and Harding (1924) state that a churn is regarded by many as being reasonably clean if not more than about 100 bacteria are added to each cubic centimetre of milk. This means that according to the writers' technique one could be satisfied with a bacterial count of 7,730 per c.c. of rinsings. This figure seems inordinately high when compared with the authors' results from steamed churns, and half the figures from the scalded churns fall below the 7730 bacteria per c.c. of rinsings. In order to study this suggested American standard of bacterial cleanliness more thoroughly Table VII has been drawn up, which deals with the figures obtained from the scalded churns; the first column gives the bacterial count of the rinsings, the second column gives the number of bacteria that would have been added to each cubic centimetre of milk if the churns had been filled to their capacity, while the third column gives the loss of keeping quality obtained in comparison with churns that had been steamed on the same days. Columns 4, 5 and 6 repeat columns 1, 2 and 3 for 17 gallon churns instead of 10 gallon churns.

Table VII.

10 gallon churns			17 gallon churns		
Count per c.c. of rinsings	No. of bacteria added per c.c. of milk	Loss of keeping quality through scalding instead of steaming in days	Count per c.c. of rinsings	No. of bacteria added to each c.c. of milk	Loss of keeping quality through scalding instead of steaming in days
46,000	595	1	9,500	123	1
10,100	131	1	9,800	127	1
3,000	39	1	2,000	26	1
21,700	281	2	5,800	75	2
2,500	32	1½	1,050	14	1½
56,000	724	1½	6,920,000	89,562	1½
5,400	70	½	4,300	56	½

It appears that the number of bacteria added to each c.c. of milk is not the only important point in connection with this problem, because Table VII indicates how the period of sweetness may be much reduced in spite of the addition of an insignificant number of bacteria to the milk. Moreover, it is brought out how important the keeping quality test is in the examination of milk and dairy utensils, particularly since a long period of sweetness is essential for the farmer, the milk dealer and the consumer.

The figures obtained from the examination of steam sterilised churns force us to suggest tentatively a very much higher standard of bacterial cleanliness for churns than that brought forward by Prucha and Harding: namely, that if sterilisation has been efficient under farm conditions there should not be added to the milk more than five organisms per c.c. up to twelve hours after sterilisation has taken place.

In the above work it has been shown that steam sterilisation is the chief factor in maintaining the keeping qualities of clean milk to a really satisfactory standard. Efficient scalding usually reduces the bacterial and coliform contents

of utensils to a low level, but cannot be relied upon, while the keeping qualities of milk placed in scalded vessels are frequently reduced.

Examination of the results obtained from the scalded churns, although they are small in number, shows that the actual bacterial count and coli content of milk vessels cannot be considered as an index of the effect which the flora will have on the actual period of sweetness of milk placed in them.

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