BACTERIOLOGICAL STUDIES OF MILKING MACHINES.

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(With 1 Chart.)

CONTENTS.

Introduction.

The utility of the milking machine, with respect to its mechanical efficiency and economic value, is rarely questioned nowadays. On the other hand, its use in the production of high-grade milk still encounters some opposition. Milk distributors, as well as public health authorities, finding frequent evidence of heavy bacterial contamination in machine-drawn milk, sometimes discourage the use of the milker on this account.

A number of workers have shown that improper washing and sterilisation of the milking machine may result in heavy bacterial contamination. The farmer, however, is by no means entirely to blame for this state of affairs. Methods recommended are often so laborious and time-consuming that the time saved during the actual milking process is lost in the cleaning and sterilising. Under the circumstances, the farmer is likely to turn to some less time-consuming but totally inadequate method, with the inevitable result

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that the quality of the milk suffers, and complaints and losses follow. Frequently the machine is condemned and discarded, and suffers consequently in reputation throughout the district.

With the object of studying the relative importance of the various factors concerned in the production of low count milk by machine, and of developing simple, yet adequate methods of caring for the machine, experiments have been conducted by the Division of Bacteriology, Central Experimental Farm, Ottawa, and the findings reported here are based upon data secured during tests carried out in the past three years.

PART I.

A. The influence of factors other than the sanitary condition of the machine.

To study the influence of various factors not directly connected with the machine or its state of cleanliness, the following short series of tests was conducted. Two single units (De Laval) were used, being better suited to the requirements of the investigation than a double unit. In all cases both units were kept in first-class condition, the rubber parts, after thorough washing, being sterilised by flowing steam for 15 minutes and the milker buckets by autoclaving at 5 pounds pressure for 20 minutes. Four cows were used in this series, each cow being milked four times in each of seven tests. In studying each particular factor one unit was so handled as to act as a control, while the other was varied in accordance with the plan of the experiment.

Methods of analysis[1].

Samples were taken with sterile pipettes directly from the milker buckets before the addition of the strippings. Plating was done immediately, using purple lactose agar (Difco)[2] and incubating at room temperature for 5 days.

Discussion.

It would appear from the results outlined in Table I that carelessness in regard to any or all of the factors considered here fails to account for any considerable proportion of the tremendous bacterial contamination frequently encountered in machine-drawn milk. Even such gross carelessness as dropping the teatcups into the bedding for a 10-second period adds relatively few bacteria.

While the effect will vary with the individual cow and her state of cleanliness, discarding the foremilk of well-kept animals is considered of minor

[1] We are indebted to Mr G. S. Fraser, B.S.A., for assistance in the analytical work pertaining to Part I A.

[2] Purple lactose agar (beef peptone lactose agar containing brom-cresol-purple as indicator), used in analysis of samples under Part I, was selected as favouring the growth of the largest number of organisms. Studies conducted concurrently upon the types of organisms present in the milk made this desirable.

Table I. *Showing effect of factors other than sanitary condition of machine.*

		Stable handling										
Effect of factor under test	Exp. no.	Udder not wiped	Wiped water and dried	Wiped water, not dried	Wiped disin-fectant	Fore-milk not dis-carded	Fore-milk dis-carded	Cups put on care-lessly	Cups put on care-fully	Cups dropped on litter	Cups not dropped	Average bacterial count
Not washing cow's udder	1	×	—	—	—	—	×	—	×	—	×	4570
	2 (check)	—	×	—	—	—	×	—	×	—	×	1820
Washing and not drying	3	—	—	×	—	—	×	—	×	—	×	2880
	4 (check)	—	×	—	—	—	×	—	×	—	×	1150
Using disinfectant (½ % lysol) to wash udder	5	—	—	—	×	—	×	—	×	—	×	1020
	6 (check)	—	×	—	—	—	×	—	×	—	×	2240
Discarding foremilk	7	—	×	—	—	×	—	—	×	—	×	1930
	8 (check)	—	×	—	—	—	×	—	×	—	×	1840
Putting teatcups on carelessly (udder washed)	9	—	×	—	—	—	×	×	—	—	×	3430
	10 (check)	—	×	—	—	—	×	—	×	—	×	2620
Putting teatcups on carelessly (udder not washed)	11	×	—	—	—	—	×	×	—	—	×	5960
	12 (check)	×	—	—	—	—	×	—	×	—	×	3700
Dropping teatcups on bedding for 10 seconds	13	—	×	—	—	—	×	—	×	×	—	5600
	14 (check)	—	×	—	—	—	×	—	×	—	×	2260

× denotes conditions observed during tests.

importance in affecting the bacterial content of the milk, as shown by one of us (Lochhead, 1927). In the present experiment the cows normally gave low count milk, and were kept clean, hence the small advantage obtained through discarding the foremilk. Nevertheless, the practice of drawing a stream of milk from each teat into a container covered with fine-mesh wire gauze or black cloth is to be recommended as being invaluable in the early detection of abnormal milk resulting from mastitis, etc.

In the use of a germicide with a strong odour, such as lysol, there is a possibility of the odour being absorbed by the milk. We have never detected this during these tests, although under hand-milking conditions, with much greater exposure of the milk, the probability would be considerably increased. The use of a hypochlorite solution in place of lysol would avoid such a possible tainting of the milk.

B. The influence of methods of cleaning and sterilising the rubber parts.

Having satisfied ourselves that the factors reported under Part I A were not of major importance, attention was given to the relative values of different methods of cleaning and sterilising the rubber parts in reducing bacterial contamination. In these studies, stress was laid upon methods which would be most convenient and time-saving under average farm conditions, bearing in mind that but few users of milking machines are producing milk for a market where a low bacterial content commands a premium. Methods advocated by previous workers were tested out under conditions as uniform as possible, and were frequently modified in the light of our experience. Two standard makes of machine, Empire and De Laval, were used in these tests, in order to determine whether there would be any significant difference between them in regard to the effectiveness of any given treatment. The employment of a new set of rubber parts for each individual test was not feasible. However, observations were made as to whether any treatment was damaging the rubber parts, and replacements were made when necessary.

In earlier work it was observed that conditions beyond our control, such as quantitative variations in the udder flora of certain cows, sometimes tended to obscure the effect of different methods of treatment, making reliable comparisons difficult. To reduce this possibility, for this series of tests heifers in their first lactation period, giving low count milk, were selected, and a check on the udder flora maintained by semi-weekly plating of the foremilk from each cow. In addition to the milk samples, further samples for analysis were secured by "milking" sterile water from an artificial udder similar to that devised by Ruehle, Breed and Smith (1918)[1]. By this means we were able to

[1] We are indebted to Dr A. H. Robertson, formerly of the New York Agricultural Experiment Station, Geneva, N.Y., for having kindly provided us with specifications of the artificial udder used at that station.

obtain a better idea of the amount of bacterial contamination properly chargeable to the machine itself.

Plan of experiment.

An Empire double unit machine with a divided pail and two De Laval single unit machines were operated throughout the experiment. One unit of each make "milked" 5 litres of sterile water from the previously sterilised artificial udder; the remaining units each milked two heifers from a group of four, the different makes alternating from one pair to the other each day. The units which "milked" the artificial udder, together with the other two units, were afterwards used to milk a number of other cows, so that they would all be on a par from the standpoint of cleanliness before washing. Samples were obtained from the evening milking only, being taken directly from the milker bucket before the addition of the strippings. The cows' udders were washed with a 0·5 per cent. solution of lysol immediately before milking; the foremilk was not removed by hand except on Mondays and Thursdays, when it was plated out as a check upon the udder flora.

Plate counts were made as described on p. 36, using purple lactose agar. In addition, 1·0 c.c. and 0·1 c.c. quantities of milk were inoculated into lactose bile broth and incubated for 48 hours at 37° C. The formation of 10 per cent. or more of gas was considered a positive presumptive test for the presence of organisms of the colon-aerogenes group.

I. *Sterilising treatments following thorough washing.* Except where otherwise stated, all units were washed in the following manner: Immediately after milking, cold water was drawn through the machines, using a pailful for each two units. This was followed by an equal quantity of hot water containing tri-sodium-phosphate, a rinse with clear hot water completing the process. The machines were then taken to the dairy, where any dirt on the outside of the rubber parts was washed off, and the sterilising treatments administered. The milker pails and pailheads were thoroughly washed and the check valves cleaned. The pailheads were then hung up, while the milker pails were sterilised with steam at 5 pounds pressure for 20 minutes. Neither for washing nor for sterilisation was the milk tube system (teatcups, claw, and milk tubes) taken apart, except that once a week only (Thursday a.m.) the liners and tubes were detached, given a thorough brushing, rinsed and then reassembled before sterilisation. A brief description of the various sterilising treatments given the assembled milk tube system follows:

(1) Immersion in water at 170° F., the temperature being maintained for 20 minutes, the water allowed to cool, then the parts remaining immersed until required.

(2) Immersion as in (1) but with water at 160° F.

(3) Immersion as in (1) but after 20 minutes parts removed and hung up in the dairy to drain and dry.

(3 br)[1] Immersion as in (3) but preliminary cleaning by a cold water suction rinse, followed by a thorough brushing of the rubber tubes, liners, etc., and their connections, with final rinsing with hot water.

(4) Immersion for 1 minute in water heated to approximately 200° F., then parts removed and hung up to drain and dry.

(5) Treatment with flowing steam for 15 minutes, the parts remaining in the chest until required.

(6 w) No further treatment, parts merely hung up to dry. (February.)

(6 s) As with (6 w) but conducted in July.

(6 br) As with (6 w) but preliminary washing performed as described under (3 br).

(7) Immersion in cold water, the water not being changed throughout the week.

(7 a) Immersion as in (7) but with the water changed each morning.

(8) Immersion in a crock containing a hypochlorite solution made up to 200 parts per million (p.p.m.) available chlorine at start. New solution made up each week.

(9) As with (8) but strength of solution maintained by the addition of concentrated hypochlorite each morning. New solution made up each week.

(10) As with (8) but with sufficient salt added to make a saturated brine. New solution made up each week.

(11) After the usual preliminary rinsing with cold water and hot alkali solution, a cold water solution of hypochlorite (200–300 p.p.m. available chlorine) drawn through in place of the usual final rinse with clear hot water. Parts hung up to dry without further treatment.

(12) As in (11) but with cold hypochlorite rinse given immediately *before* the next milking.

II. *Sterilising treatments following inadequate washing.* All units received a cold water rinse immediately following milking. The rubber parts then received treatment as follows:

(1) Immersion in water at approximately 200° F. for 1 minute, parts then hung up to dry.

(2) Immersion in hypochlorite and saturated brine, strength of solution maintained by addition of concentrated hypochlorite each morning.

(3) Immersion in cold water, fresh each morning.

(4) Parts hung up to dry without further treatment.

Discussion.

Table II gives a summary of results of analyses of sterile water drawn through units treated as described, while corresponding data obtained from milk are presented in Table III.

It will be noted that the tests in this series extended from December to July, and consequently were not conducted under uniform external tempera-

[1] The abbreviations, br, w, s, a, stand for brushed, winter, summer, autumn respectively.

Table II. *Giving analyses of sterile water "milked" by machines receiving various treatments.*

	Treatment	Month	No. of counts	Bacterial counts (both machines)		% distribution of bacterial counts					% positive tests, lactose bile	
				Average	Median	0–100	101–500	501–1000	1001–10,000	Over 10,000	1·0 c.c.	0·1 c.c.
I. *Adequate washing*												
(1)	Water 170°, remaining	Dec.	17	150	42	70·6	21·2	0·0	2·3	5·9	0·0	0·0
(2)	Water 160°, remaining	Jan.	18	952	144	50·0	27·7	11·1	11·1	0·0	0·0	0·0
(3)	Water 170°, 20 minutes only	Jan.	18	335	46	77·8	11·1	0·0	11·1	0·0	0·0	0·0
(3 br)	Water 170°, 20 minutes only (brushed)	Mar.	10	1,854	1,166	0·0	20·0	30·0	50·0	0·0	20·0	20·0
(4)	Water 200°, 1 minute	Jan., Feb.	20	465	25	70·0	25·0	0·0	5·0	0·0	0·0	0·0
(5)	Flowing steam, 15 minutes	Mar.	8	66	52	87·5	12·5	0·0	0·0	0·0	12·5	12·5
(6 w)	Hung up to dry	Feb.	20	204	114	45·0	40·0	10·0	5·0	0·0	0·0	0·0
(6 s)	Hung up to dry	July	7	10,836	3,050	14·3	14·3	0·0	57·1	14·3	14·3	14·3
(6 br)	Hung up to dry (brushed)	Feb., Mar.	10	5,605	4,455	0·0	0·0	0·0	90·0	10·0	20·0	0·0
(7)	Cold water, not changed	Mar., Apr.	12	71,850	65,400	16·7	8·3	8·3	0·0	66·7	16·7	8·3
(7 a)	Cold water, changed daily	June	6	46,733	16,225	0·0	16·7	0·0	33·3	50·0	16·7	16·7
(8)	Hypochlorite	Apr.	20	1,278	135	45·0	20·0	5·0	30·0	0·0	5·0	0·0
(9)	Hypochlorite, strengthened daily	Apr., May	20	361	114	45·0	40·0	0·0	15·0	0·0	5·0	0·0
(10)	Hypochlorite and saturated brine	May	18	600	285	38·9	38·9	5·6	16·6	0·0	0·0	0·0
(11)	Hypochlorite rinse after wash	May	8	1,107	708	0·0	50·0	0·0	50·0	0·0	12·5	0·0
(12)	Hypochlorite rinse before milking	June, July	18	2,595	325	27·8	27·8	22·2	11·1	11·1	0·0	0·0
II. *Inadequate washing*												
(1)	Water 200°, 1 minute	June	8	2,286	1,308	0·0	12·5	37·5	50·0	0·0	0·0	0·0
(2)	Hypochlorite and saturated brine	June	10	4,740	1,930	30·0	0·0	10·0	50·0	10·0	10·0	10·0
(3)	Cold water, changed daily	June	10	661,220	570,250	0·0	0·0	0·0	0·0	100·0	90·0	90·0
(4)	Hung up to dry	Mar.	10	2,088,820	629,600	0·0	0·0	0·0	0·0	100·0	100·0	80·0

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Table III. *Giving analyses of milk drawn by machines receiving various treatments.*

	Treatment	Month	No. of counts	Bacterial counts (both machines) Average	Median	% distribution of bacterial counts 0–1000	1001–2000	2001–5000	5001–10,000	Over 10,000	% positive tests, lactose bile 1·0 c.c.	0·1 c.c.
I.	*Adequate washing*											
(1)	Water 170°, remaining	Dec.	34	1,659	1,100	44·1	36·1	13·9	5·9	0·0	29·4	8·8
(2)	Water 160°, remaining	Jan.	35	1,835	1,365	31·4	28·6	37·1	2·9	0·0	2·8	0·0
(3)	Water 170°, 20 minutes only	Jan.	36	875	550	69·4	25·0	5·6	0·0	0·0	2·8	0·0
(3 br)	Water 170°, 20 minutes only (brushed)	Mar.	20	1,692	1,090	45·0	30·0	20·0	5·0	0·0	55·0	40·0
(4)	Water 200°, 1 minute	Jan., Feb.	40	1,342	800	55·0	27·5	10·0	7·5	0·0	15·4	0·0
(5)	Flowing steam, 15 minutes	Mar.	15	1,581	1,040	46·7	26·6	26·7	0·0	0·0	13·3	6·7
(6 w)	Hung up to dry	Feb.	40	1,268	925	57·5	25·0	15·0	2·5	0·0	7·5	2·5
(6 s)	Hung up to dry	July	16	13,689	4,925	6·3	18·8	31·2	18·7	25·0	43·8	18·8
(6 br)	Hung up to dry (brushed)	Feb., Mar.	20	6,965	6,400	0·0	5·0	20·0	55·0	20·0	55·0	40·0
(7)	Cold water, not changed	Mar., Apr.	24	90,767	38,350	0·0	25·0	8·3	4·2	62·5	29·2	0·0
(7 a)	Cold water, changed daily	June	12	42,500	8,200	0·0	0·0	8·3	50·0	41·7	50·0	50·0
(8)	Hypochlorite	Apr.	37	1,767	1,045	46·0	32·4	16·2	2·7	2·7	13·5	0·0
(9)	Hypochlorite, strengthened daily	Apr., May	40	3,085	2,290	2·5	32·5	55·0	10·0	0·0	25·0	22·5
(10)	Hypochlorite and saturated brine	May	36	1,609	1,405	30·6	44·4	25·0	0·0	0·0	36·1	19·4
(11)	Hypochlorite rinse after wash	May	16	2,768	2,125	6·3	25·0	62·5	6·2	0·0	37·5	0·0
(12)	Hypochlorite rinse before milking	June, July	36	29,889	10,865	0·0	0·0	13·9	33·3	52·8	33·3	16·7
II.	*Inadequate washing*											
(1)	Water 200°, 1 minute	June	15	9,126	7,050	0·0	6·7	33·3	20·0	40·0	6·7	0·0
(2)	Hypochlorite and saturated brine	June	20	5,750	5,025	5·0	5·0	40·0	35·0	15·0	20·0	5·0
(3)	Cold water, changed daily	June	20	706,880	359,000	0·0	0·0	0·0	0·0	100·0	90·0	90·0
(4)	Hung up to dry	Mar.	20	1,321,265	288,800	0·0	0·0	0·0	0·0	100·0	85·0	80·0

ture conditions. As the efficiency of the chemical methods might be expected to be deleteriously affected by higher temperatures, as reported by Burgwald (1925), these treatments were reserved for the warmer months of spring and early summer. Had the order been reversed, it is not improbable that the slight advantage would have been in favour of the chemical methods. However, it is unlikely that, following a good sterilising treatment, the temperatures encountered would be responsible for any significant difference such as appears where the "no treatment" method (I 6 w) is repeated under summer conditions (I 6 s). Data to be presented in Part II (p. 48) tend to substantiate this.

It would appear from the results reported in I 6 w that little bacterial growth takes place in the rubber tubes of a well-washed milker at lower temperatures. However, when the same test was repeated in July (I 6 s), considerably higher counts were obtained, one milk count reaching 104,150 per c.c.

Immersion in cold water gave unsatisfactory results, whether or not the water was changed daily. Although the first few counts obtained were satisfactory, subsequent ones showed a rapid increase in bacterial contamination which pointed to a probable cumulative effect with this method.

The feasibility of using cold running water has been studied by Ruehle, Breed and Smith (1918), Robertson, Finch and Breed (1922) and Fisher and White (1927). The few tests made by us have yielded results agreeing with those published by the above investigators. As running water at sufficiently low temperature is available on few farms, and in view of the danger of water organisms establishing themselves within the milk tubes even at low temperatures, as shown by Robertson, Finch and Breed (1922), this method was not given further study.

The heat treatments tested out were all adequate for the practical sterilisation of the rubber parts. However, in the case of I 1, I 2 and I 5, the treatment had a decidedly detrimental effect upon the elasticity of the De Laval rubber tubing where this was in contact with the metal. This can be avoided by removing the tubing from the metal before giving the sterilising treatment, but the time required to do this and to reassemble the units before milking renders such methods less attractive to the majority of milking machine users. Recognising the need for simple methods of sterilisation, we sought a way of utilising a heat treatment for the rubber parts while still assembled, which would not be so hard on the tubing and yet adequate from a bacteriological standpoint. These desiderata were most successfully met by treatment (I 3). Steam is rarely available on any but the larger dairy farms in Canada, while hot water is more easily obtainable, hence this method (I 3) has much to commend it. Treatment (I 4) was also highly satisfactory, but required more fuel for heating the water an extra 30°.

Well-washed rubber parts may be kept in excellent bacteriological condition by immersion in hypochlorite solutions, our findings corroborating those

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of Wing (1913) and the New York and Connecticut workers referred to above, who have advocated their use, not for "cleansing" the machine, as stated by Mattick and Procter (1928), but for the sterilisation of clean machines. Their rejection of chemical disinfectants for use in milking machine treatment on the basis of the results reported by Hoy and Rennie (1927), who used hypochlorites as rinses for churns, does not appear justifiable.

The differences found between the plain hypochlorite (I 8), hypochlorite reinforced daily (I 9) and hypochlorite and brine (I 10) are hardly large enough to be considered significant. Although there are certain objections to the use of brine with a disinfectant, its greater efficiency in keeping down bacterial growth during the warmer months has been reported by the New York workers (1918, 1922) already referred to, by Bright (1920) and Burgwald (1925). All three methods mentioned above require no extra expenditure for fuel and a minimum of time as compared to the heat treatments, while the rubber parts also show less deterioration. The cost of the home-made hypochlorite solution used in this work is almost negligible, and it is difficult to understand upon what grounds Mattick and Procter (1928) favour "the less expensive sterilisation by steam."

The results obtained with I 11, where a cold hypochlorite rinse was drawn through in place of the final hot water rinse, would indicate that, for the farmer with a limited supply of hot water, here is a simple and rapid method of treatment. However, until it has been tested out more extensively, we prefer not to give this method an unqualified recommendation.

A comparison of the results mentioned above with those obtained where the hypochlorite rinse was deferred until immediately before the next milking (I 12) tends to indicate that the latter method is much less effective in reducing bacterial contamination and is not to be recommended.

In comparing the results obtained with Empire and De Laval machines receiving identical treatment, no significant difference in bacterial counts could be discovered, both machines reacting satisfactorily to both heat and chemical methods.

Special mention may be made of the advantages of the suction method of washing immediately after milking as compared with the more laborious and time-consuming brushing method conducted at the dairy later on. Apart from the convenience and saving of time, the former method leaves the rubber parts in much better condition from a bacteriological standpoint both as regards total count and lactose fermenters. [Compare sterile water counts I 3 with I 3 br, and I 6 w with I 6 br.] Apparently there is a more complete removal of the milk residue with the suction method.

Summary to Part I.

The sanitary condition of the rubber parts of the milking machine is the chief factor affecting the bacterial content of machine-drawn milk. Factors concerned with the stable handling of the machine, such as washing the

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udder, discarding the foremilk, handling the teatcups, etc., assume importance only when the rubber parts have been adequately sterilised.

The efficiency of a sterilising treatment is dependent upon the thoroughness of the preliminary washing, which is best accomplished by the suction method. It is unsafe to rely upon a thorough washing alone; to insure a constant supply of low count milk, some method of sterilisation must be employed.

Treatments by steam, hot water and chemical solutions have been found satisfactory in maintaining the tubes in a sanitary condition. Heat methods were found to have a more deleterious effect upon the rubber parts than the equally effective chemical treatments.

PART II.

THE EFFICIENCY OF HOT WATER AND CHEMICAL TREATMENTS UNDER PRACTICAL CONDITIONS, WITH A COMPARISON OF MACHINE- AND HAND-DRAWN MILK.

Although a number of workers have experimented with methods of caring for the milking machine rubber parts, not a few of them have advocated methods which are hardly likely to be adopted by many farmers. For instance, Burgwald (1925), in comparing the relative efficiency of hot water and chemical methods, immersed the rubber parts in water at 160–165° F. for 20–30 minutes *just before milking*. The impracticability of such a method for the morning milking is obvious. Again, Mattick and Procter (1928) report "an experiment planned with the primary object of discovering whether or not it was possible by practical methods to produce milk of consistently low bacterial content and good keeping quality." As a preliminary to sterilisation with steam these workers rinsed the machine with cold water, using suction, then all rubber parts were detached, thoroughly washed and brushed with hot water. After sterilisation, the unit had to be assembled again before the next milking. Our own experiences have convinced us that such methods, requiring the taking apart of the rubber tubes, teatcups, etc. for washing and sterilising, consume far too much time to appeal to the average farmer. We felt, as a result of our experience as reported on p. 43, that simpler methods are available which are equally successful in reducing bacterial contamination from the rubber parts, and which would be more economically feasible. The experiment reported here was planned to test out hot water versus chemical methods during the warmer months, and to compare their efficiency with that of hand milking for the production of milk of a reasonably low, though not the minimum, bacterial content.

As the hot water immersion method (I 3 in Table III) was the most generally satisfactory of the heat treatments in the previous tests it was selected as representative. In deciding upon the chemical method to use, tests were made of the comparative stability of hypochlorites and chloramines at higher temperatures, the results of which favoured the latter type of compound. Chloramines had been studied in another series of tests run concurrently with

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those reported on pp. 39–40 and had proved highly satisfactory for sterilising rubber parts. It was therefore decided to use a chloramine solution with 10 per cent. brine in this experiment, as representing the most satisfactory chemical method tried by us[1].

In addition to the use of simple methods in the washing and sterilisation of the rubber parts, a number of refinements were eliminated which, though of value in the production of especially low count milk, rarely repay the average producer for the extra trouble involved. Among these may be mentioned: (*a*) the practice of rinsing the rubber parts by drawing clean hot (or cold) water through them immediately before milking, (*b*) the use of a disinfectant in washing the cows' udders, (*c*) the drying of the udder with a clean cloth after washing, (*d*) the discarding of the foremilk, (*e*) the taking apart and brushing of the teatcups, tubes, etc. once a week or oftener, (*f*) the cleaning of the vacuum line weekly. On the other hand, in order to facilitate comparison between machine-drawn and hand-drawn milk, and between rubber parts treated differently, pails, cans, etc. were sterilised by steam under pressure to eliminate an extremely variable source of contamination common to both methods of milking.

Plan of experiment.

Two De Laval units were employed, both receiving the suction washing described on p. 39. The rubber parts of one unit (C) were sterilised by immersion in a crock containing a solution of a commercial chloramine product (sterilac) to which was added sufficient salt to make 10 per cent. brine. This solution was made up to contain approximately 100 parts per 1,000,000 of available chlorine, and received no attention except that once each week it was again adjusted by one of us (Johns) to near the above-mentioned strength. The rubber parts of the other unit (HW) were immersed in water at 170° F. for 20 minutes, then hung up to dry until the next milking.

Except for the weekly adjustment of the chloramine-brine solution, everything in connection with the preparation and handling of the machines was left in the hands of the regular employees, no direct supervision of any kind being maintained by us. During the period of this experiment four different men looked after the washing and sterilisation, two of whom had had no previous experience.

Every Thursday morning the teatcup liners were removed, trimmed to the proper length to maintain their mechanical efficiency, reversed and assembled again. Apart from this adjustment, the milk tube system was at no time taken apart, suction washing alone being relied upon to remove completely the milk residue. The vacuum pipe line received no attention during the test period, and had not been cleaned during the previous 6 months.

[1] Chloramine and brine has been found by Robertson, Finch and Breed (1922) to effect satisfactory sterilisation. Hypochlorite and brine, however, is recommended in preference by them for use by dairymen on the basis of economy. In our tests the cost of the chloramine used was estimated at 11 cents per week.

For this investigation twelve cows were selected, and divided into three groups of four each. The experiment was so arranged that each group was milked an equal number of times under each method, the rotations made being shown in Table IV. Separate milkers were employed for each group, each man milking under all three methods.

Table IV. *Plan of rotation of machines.*

	Cow groups		
Period (1928)	No. 1	No. 2	No. 3
July 30–Aug. 4	(HW)	(C)	(H)
Aug. 6–11	(C)	(H)	(HW)
Aug. 13–18	(H)	(HW)	(C)
Aug. 27–Sept. 1	(HW)	(C)	(H)
Sept. 3–8	(H)	(HW)	(C)
Sept. 10–15	(C)	(H)	(HW)

(HW) = hot water treated machine.
(C) = chemically treated machine.
(H) = hand.

Immediately before milking the cows' udders were washed with a wet cloth, no disinfectant being used in the water. No attempt was made to dry them by wiping. At no time was the foremilk discarded. Rinsing of the machines with clean water just before milking, as advocated by Fisher and White (1927), was not practised. Small-top pails were used for the hand milking and for stripping after the machines. The milk from each group of cows, including the strippings in all cases, was poured into separate 8-gallon cans fitted with strainers.

Methods of sampling and analysis.

Samples were taken from the bulk milk in the cans after each milking from Monday evening to Saturday morning inclusive, and were placed in the regular cooling tank containing ice water. Plating was done at 10.30 a.m., at which time the evening milk was 18 hours, and the morning milk 4 hours old, approximating the age of milk arriving at the average city milk plant. In this experiment, a change was made from the methods of analysis followed in Part I (see p. 36), our object here being to judge the milk in strict accordance with the *Standard Methods of Milk Analysis* of the American Public Health Association (1927), which alone have official standing on this continent for milk-control work. Triplicate plates were poured with nutrient agar, and incubated at 37° C. for 48 hours. In addition, lactose bile fermentation tubes were inoculated with 1·0 and 0·1 c.c. portions of milk respectively, and incubated at 37° for 48 hours. Ten per cent. or more of gas was recorded as positive, no attempt being made to confirm such presumptive tests.

Discussion.

From the data presented in Table V and Chart 1 it would appear that the milk drawn through the rubber parts of the machine treated as previously

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Table V. *Giving analyses of milk drawn by machine and by hand. Summary of weekly averages.*

		Machine-drawn milk									Hand-drawn milk		
		Hot water treated			Chemically treated								
			Lactose bile % positive tubes			Lactose bile % positive tubes		Available chlorine p.p.m.				Lactose bile % positive tubes	
Period	Av. max. temp. (F.)	Official plate count	1·0 c.c.	0·1 c.c.	Official plate count	1·0 c.c.	0·1 c.c.	Crock	Tubes		Official plate count	1·0 c.c.	0·1 c.c.
July 30–Aug. 4	73·6	2244	55·6	0·0	2031	72·7	18·2	82	—		3163	50·0	20·0
Aug. 6–11	77·4	5868	80·0	0·0	5711	75·0	50·0	80	50		3029	50·0	10·0
Aug. 13–18	85·2	3719	60·0	10·0	2436	60·0	40·0	73	56		9313	90·0	40·0
Aug. 27–Sept. 1	78·2	6560	40·0	10·0	6448	80·0	10·0	91	81		4771	50·0	20·0
Sept. 3–8	69·4	2969	30·0	0·0	5738	30·0	10·0	93	84		1549	66·7	11·1
Sept. 10–15	62·6	5322	72·7	27·3	3408	40·0	10·0	81	74		3558	40·0	10·0
Grand average (59 counts each)	—	4484	57·6	6·8	4209	59·3	22·0	—	—		4276	57·6	18·6

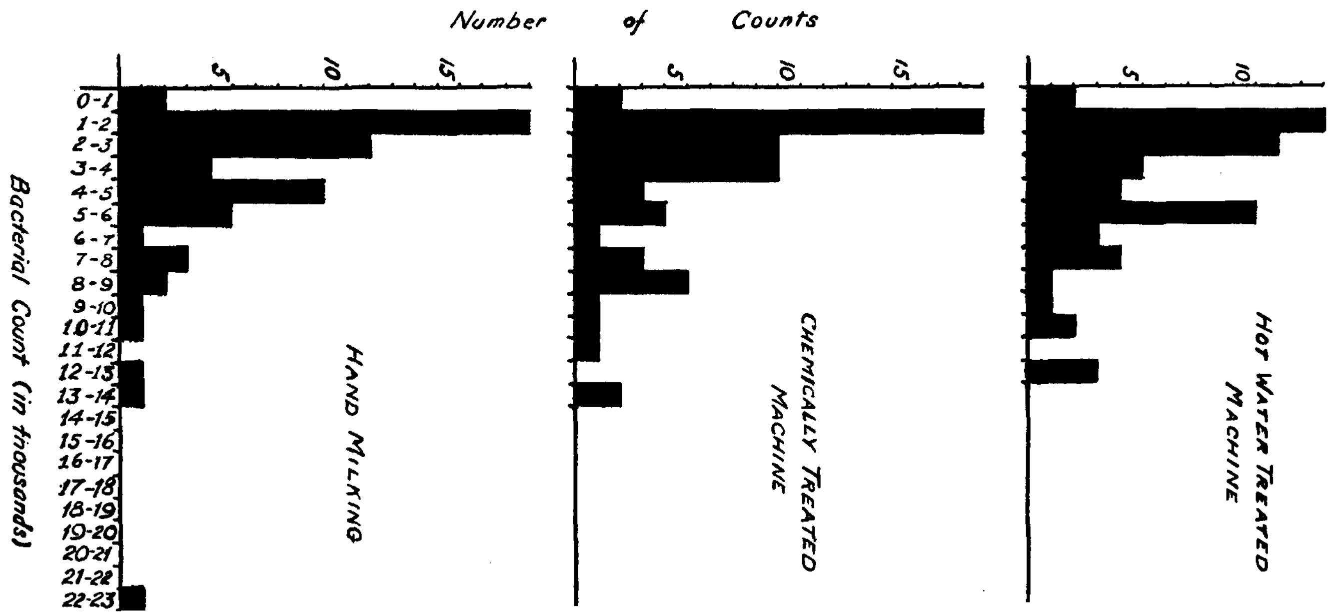

Chart 1. Distribution of bacterial counts (59 in each group).

described compares most favourably with the product of careful hand milking even during the warm weather. The results obtained will also stand comparison with those reported by other investigators where less practicable and economical methods have been followed.

While both heat and chemical methods have proved adequate for sterilising the rubber parts (despite the contention of Hart and Stabler (1920) that the heat treatment is alone successful under practical conditions), yet, from the standpoint of economy, the considerable saving in time and fuel made possible by the chemical method entitles it to preference.

In view of the general impression that chemical solutions are less dependable during warm weather, the results obtained during the week August 13th–18th are of particular interest. Between these dates, the average daily maximum temperature was 85·2° F., yet all ten counts from the chemically treated unit were below 4000 per c.c. During this period the available chlorine content of the chloramine and brine solution decreased to 41 parts per 1,000,000 on August 15th p.m. and was reinforced to 117 p.p.m. the next day. These low counts were obtained by a milker who was strongly prejudiced against milking machines and who had never operated one until the previous week.

While on the point of stability of chemical solutions, we might say that at the end of the experiment reported above, the chemical solution was not strengthened after September 6th. Analyses conducted upon milk drawn by the chemically treated unit on October 3rd and 4th gave counts of 1350 and 2850 per c.c. respectively. By this time the available chlorine in the solution had decreased to 9 and 8 p.p.m. respectively, and a bacterial count made of the solution itself showed but 23 per c.c., mostly spore-formers. It would seem, therefore, that a sterilising solution composed of chloramine and brine affords a wide margin of safety in the event of the farmer neglecting to strengthen it once a week.

Contamination from lactose-fermenting organisms, as revealed by positive tests in lactose bile broth, is slightly less for the hot water treated unit. That the milk tube system in itself, when adequately washed and sterilised, contributes comparatively few lactose-fermenting organisms is suggested by the results obtained in Part I B, where sterile water was drawn through the tubes, etc. (see Table II, p. 41).

During the experiment, careful observations were made of the effect of the different treatments upon the life of the rubber tubing and teatcup liners. Both units were equipped with new rubber parts on July 21st. The rubber tubing in all cases lost its elasticity more rapidly when submitted to the hot water treatment. By September 13th it had been found necessary to replace all four short milk tubes on the hot water treated unit, while on October 1st one of the teatcup liners was replaced. On the other hand, the rubber parts on the chemically treated unit appeared in good condition after three months' use.

Summary to Part II.

Under warm weather conditions, contamination from milking machine rubber parts can be effectively controlled by simple, practicable methods. Milk drawn by machines so treated is equal in sanitary quality to that produced by careful hand milking.

The chloramine-brine treatment proved to be quite as effective as the hot water treatment in controlling bacterial contamination, while superior from the standpoint of economy and simplicity.

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