

HARDNESS OF WATER IN RELATION TO THE CLEANING OF FARM DAIRY EQUIPMENT

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SUMMARY

Ten different cleaning mixtures were used with waters ranging from 41 p.p.m. to 1020 p.p.m. total solids.

When used with soft waters, six mixtures cleaned the equipment sufficiently well to permit effective sterilization. Sodium metasilicate/wetting agent and sodium carbonate/wetting agent were indicated as the most economical.

Stone-like deposits built up in equipment when cleaning mixtures were made up with hard waters, and periodical cleaning with hydrochloric acid was needed to remove these deposits; otherwise, cleaning was not done effectively and subsequent sterilization was inadequate.

With waters of more than 200 p.p.m. total hardness, chemical cleaning became very difficult and heat sterilization was indicated.

I. INTRODUCTION

In most dairying districts of Queensland the cleaning of farm dairy equipment is complicated by the necessity of using hard waters which react with chemical cleaning compounds to produce stone-like formations on the surface of the equipment. The high humidity which is often present under tropical and sub-tropical conditions keeps the stone-like deposits moist, and the moisture and favourable temperatures provide good conditions for bacterial growth.

The investigations reported here were designed to test the cleaning efficiency of a large number of compounds when used with natural waters of various degrees of hardness. They were conducted on 44 commercial dairy farms in various districts.

II. MATERIALS AND METHODS

The chemicals used either alone or in mixtures for cleaning equipment are shown in Table 1. Each chemical or mixture was made up as a stock solution in water and dispensed in bottles. The stock solution was diluted with water from the farm water supply in each case for cleaning the milking machine, milk vat, cooler, cans, separator parts and milk buckets.

The waters used ranged in total hardness from 41 p.p.m. to 1020 p.p.m.

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TABLE 1
MATERIALS USED FOR CLEANING EQUIPMENT

Material	Percentage by Weight of Each Chemical in Each Mixture									
	A	B	C	D	E	F	G	H	I	J
Sodium hydroxide	91	..	..	..	..	..	..	..	..	..
Sodium carbonate .. .. .	..	80	74	..	55	..	..	..	..	..
Sodium metasilicate .. .. .	..	..	..	90	20	50	..	..	..	..
Sodium hexa-meta-phosphate .. .. .	..	..	..	..	10	10	..	..	..	..
Tri-sodium phosphate .. .. .	..	..	20	..	..	25	..	..	..	..
Tetra-sodium pyrophosphate .. .. .	..	..	..	..	..	10	..	..	..	..
Alkyl-aryl-sulphate .. .. .	..	20	6	10	15	5	100	10	14	..
Citric acid crystals .. .. .	..	..	..	..	..	..	..	50	..	..
Phosphoric acid .. .. .	..	..	..	..	..	..	..	..	36	..
Hydrochloric acid .. .. .	..	..	..	..	..	..	..	..	..	100
Water .. .. .	..	..	..	..	..	..	..	40	50	..
Sodium sulphide	9	..	..	..	..	..	..	..	..	..
“Strength” in use as percentage in chemical mixture in water	0.2	0.15	0.16	0.15	0.14	0.16	0.2	0.16	0.15	2.8*

* For intermittent use only, e.g. when stone build-up has occurred with hard water.

The test mixture was used to clean the equipment immediately after each milking over a period of not less than 12 months. The sterilization treatment was applied about 20 min before the commencement of milking, a solution containing 100 p.p.m. available chlorine (as sodium hypochlorite) being used. The methods used for cleaning and chlorination were those described by Major (1956*a*) in recirculation cleaning and Major (1960) in rinse cleaning. Where intermittent hydrochloric acid treatment was included to remove stone, it was applied by the method of Major (1956*b*).

A sample was drawn from the first can of milk at intervals ranging from 7 to 30 days over a period of 12 months or more. Bacterial counts were made on the samples as an assessment of the efficacy of the sterilizing process, which in turn is an indication of the effectiveness of the cleaning process.

III. RESULTS

The results of the bacteriological examinations are summarized in Table 2.

The wetting agent alkyl-aryl-sulphate used without an alkali was unsuitable for cleaning dairy equipment, plate counts being high in over half the samples even when soft waters were used. The wetting agent did not induce stone formation but permitted the accumulation of soft deposits of milk solids.

The remaining treatments that were used with soft water all proved suitable. The treatments tested with slightly hard waters yielded satisfactory plate counts in only 50 per cent. of the samples, and with moderately hard and hard waters, satisfactory results were obtained only where accumulated stone was removed at intervals with hydrochloric acid (Treatment J and D). Treatment H + B, in which a citric acid/wetting agent mixture was used one day each week and sodium carbonate/wetting agent on the remaining six days, did not give satisfactory results, nor did Treatment I + B, in which phosphoric acid was used instead of citric acid.

Stone formation was observed in all cases where hard waters were used. Treatments containing carbonate built up stone deposits more rapidly than did those containing phosphates or silicate.

IV. DISCUSSION

Where adequate supplies of soft water are available, a range of six equally satisfactory cleaners is available, and the choice would depend largely on cost. Sodium metasilicate/wetting agent and sodium carbonate/wetting agent are the most economical, and subsequent experience has shown that the amount of wetting agent can be reduced to 10 per cent. by weight for use with soft waters.

The percentage of water supplies with a total hardness of less than 50 p.p.m. is, however, fairly low. Table 3, summarizing the results of 1365 samples of water made over a period of 10 years, shows that only 14 per cent. of the samples were of soft waters (less than 50 p.p.m.) and that 62 per cent. contained over

TABLE 2
INFLUENCE OF HARDNESS OF WATER ON EFFICIENCY OF CHEMICALS USED
Percentage of Occasions on Which Counts Fell within Various Categories*

Mixture of Chemicals	Total Hardness of the Water Used for Cleaning											
	Soft (50 p.p.m.)			Slightly Hard (51-100 p.p.m.)			Moderately Hard (101-200 p.p.m.)			Hard (over 200 p.p.m.)		
	I	II	III	I	II	III	I	II	III	I	II	III
A	96	4	0	52	38	10	11	57	32	0	32	68
B	96	4	0	60	40	0	30	60	10	0	57	43
C	98	2	0	61	37	2	20	80	0	0	62	38
D	98	2	0	62	38	0	45	55	0	16	58	26
E	97	3	0	63	37	0	40	50	10	10	67	33
F	98	2	0	61	39	0	32	56	12	13	67	20
G	41	59	0	50	48	2	13	53	34	0	61	39
H+B .. .. .	..	..	..	..	..	..	24	46	30	0	70	30
I+B .. .. .	..	..	..	..	..	..	25	50	25	0	100	0
J as required and D .. .. .	..	..	..	98	2	0	86	14	0	61	39	0

* I—Satisfactory, i.e. plate count of sample from first can of milk produced was less than 30,000 colonies per ml.

II—Poor, i.e. plate count of sample from first can of milk produced was more than 30,000, but less than 500,000 colonies per ml.

III—Unsatisfactory, i.e. plate count of sample from first can of milk produced was greater than 500,000 colonies per ml.

200 p.p.m. The results reported in this paper indicate that none of the available cleaners is suitable for use with hard water unless periodical removal of stone-like deposits is undertaken. For waters of moderate hardness the use of sodium metasilicate/wetting agent, together with occasional destoning with hydrochloric acid, is indicated. With waters above 200 p.p.m. total hardness, heat sterilization is indicated.

TABLE 3
TOTAL HARDNESS OF WATERS SAMPLED OVER 10 YEARS

Range of Total Hardness (p.p.m.)	Samples in Each Range	
	No.	Percentage
Less than 50	186	14
51- 100	137	10
101- 200	200	15
201- 400	278	20
401- 800	271	20
801- 1600	166	12
1601- 3200	90	7
3201- 6400	34	2
6401-12800	3	less than 1
All samples	1365	100

The possibility of softening hard waters has been investigated, but softening has on many occasions not provided an economic solution to the problem. Moreover, a considerable variation occurs in the composition of a water from a particular source. Table 4 shows the range for three different farms over a period of three years. Such variations would require frequent analysis of a water to indicate the dosage of softening agents.

TABLE 4
VARIATIONS IN HARDNESS OF BORE WATER OVER A 3-YEAR PERIOD

Farm	Total Hardness			
	Untreated Bore Water		Treated Bore Water	
	Maximum (p.p.m.)	Minimum (p.p.m.)	Maximum (p.p.m.)	Minimum (p.p.m.)
A	1,010	520	375	25
B	1,020	135	780	10
C	1,180	380	930	10

By analysing the raw waters from the three farms at monthly intervals over a period of six months and matching the softening treatment to the latest analysis, stone formation was prevented on Farms B and C, but there was a progressive build-up of stone on Farm A, requiring treatment with hydrochloric acid (Major 1956*b*) during the fifth month.

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