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THE CLEANING OF MILKING MACHINES AND MILK QUALITY

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ALTHOUGH the dairy industry has made considerable progress in the efficient production of milk and has built large factories for the processing of milk into the multitude of dairy products required for world markets, there has been a considerable lag in the use of improved cleaning techniques and the replacement of antiquated milking machinery at the farm level. It is seldom realized by production-conscious people that all their efforts can be destroyed by merely passing milk through contaminated milking equipment, and hence product value may be reduced in terms of returns to both farmer and factory.

It would appear, perhaps, that the present quality of milk is such that there is no need for improvement. Such is not the case. The acceptance of any innovation is limited by the incentive for its adoption. In the dairy industry, the problem centres around the measure of milk quality and the effect occasional production of poor quality milk has on financial returns. The yardstick for measuring milk quality is also the guide-line for the farmer to determine the effectiveness of his cleaning procedures and milk cooling. If the grading system is lenient, then cleaning is less efficient, and if the payment differential between milks of various qualities is low, then there is little profit loss through inadequate cleaning or cooling. Coupled with this is the need for the assistance of those responsible for farm dairy instruction, for generally if a farmer is not encountering quality problems, detailed inspection and advice on the improvement of cleaning techniques are not given.

It is difficult to influence a farmer when, according to the grading system, his methods are adequate — a frustrating impasse for the improvement of dairy hygiene practices.

The aim of quality milk production is to have milk with a low number of pasteurization-resistant bacteria (thermodurics) and proteolytic, lipolytic or acid-producing bacteria. Thermoduric bacteria are derived in the main from milkstone on machine surfaces. The other types of bacteria come from a multitude of sources, but primarily they reflect unhygienic equipment due either to poor cleaning, poor sanitizing, or both, coupled with poor cooling.

THE CLEANING SYSTEM

It is obvious from the above that, for effectiveness, a cleaning system must aim at both the complete removal of milk deposits and the sanitizing of machine surfaces, prior to milking. This aims at preventing milkstone formation, the source of most thermoduric bacteria, and reducing the numbers of other organisms to an insignificant level.

The recommended system consists of rinsing the plant with an iodophor — an iodine-containing acid detergent — to remove acid-soluble fractions of milk deposits and kill bacteria; after milking, the machine is rinsed with cold water containing non-ionic surfactant, and this is followed by hot (160° F) alkaline detergent. Although this system is complicated by the number of steps, the design and materials used in the construction of milking machines makes this necessary if cleaning is to be efficient and corrosion controlled. There are other cleaning systems available which are based on the same principle of alternate use of acid and alkali to prevent milkstone formation. Whilst the cleaning system is officially recommended, it is only used, consistently, by approximately 40% of farmers. The remainder use various alkaline detergents and a large proportion only caustic soda and boiling water. As a re-

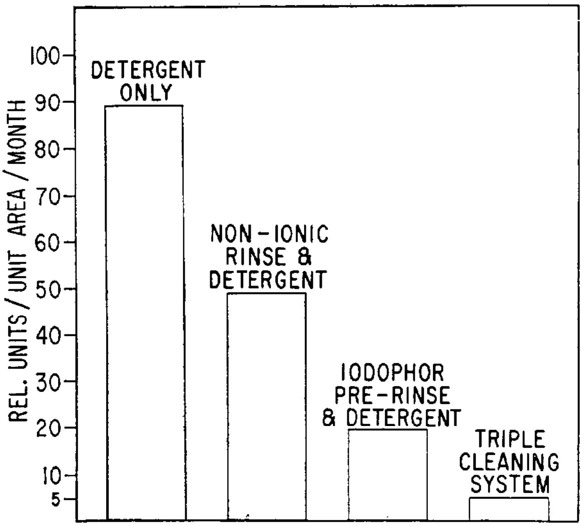

FIG. 1: *Effect of four cleaning systems on milkstone deposits.*

sult, most milking machines are contaminated with milkstone or other deposits. Figure 1 shows the effect of four cleaning systems on milkstone deposits.

The construction of milking machines is also a limiting factor in the production of quality milk, and in many cases, even if a cleaning system were used, complete deposit removal would not be possible. Most machines are not designed to be cleaned to modern-day requirements without manual assistance. The time of milking is now such that, the less time a farmer spends on cleaning without affecting the grading of milk, the better off he is.

The most important single factor limiting cleaning is the presence of different metals coupled together on milk contact surfaces. Of these, copper-based alloys coupled to tin or stainless steel create most problems. There are many instances where copper piping is used as a recirculation cleaning line. The result of dissimilar metal contact is the formation of an electrolytic cell which precipitates milk protein and this results in the formation of a resistant milkstone. Where copper is present, it is released into the milk and can cause flavour defects at levels of 0.07 ppm. It has damaging effects on butterfat and has been implicated in various organoleptic defects in manufactured products. Copper gaining entry to detergents reacts with milk proteins to form a soft slimy deposit which strongly adheres to stainless steel. Copper also adsorbs on to stainless steel during cleaning and is removed by milk at the subsequent milking. The materials of machine construction thus contribute to both the chemical and bacteriological quality of milk.

MILK COOLING

Milk is an excellent medium for bacterial growth and, unless properly cooled, bacterial numbers will increase significantly during the holding period in the farm vat. As most of the milk produced in New Zealand is water-cooled in the region of 60 to 65° F and is collected only once daily, there are real difficulties in maintaining milk quality. The refrigeration of milk is, however, not the complete answer as it may mask poor quality by changing the microflora of raw milk so that Gram-negative psychrotrophic bacteria, which are not detected by current test methods, may proliferate at refrigeration temperatures. Refrigeration also has the effect of masking unhygienic conditions of production, unless more stringent test methods are adopted.

Coupled with the cooling of milk is the dilution effect that the milk has on the bacteria in the machines. On the assumption of a 100 sq. ft machine through which 500 l of milk pass at any one milking, and a final bacteria count of 100,000/ml of milk, we arrive at the astronomical figure of 500,000,000 bacteria per sq. ft; 50,000 per sq. ft is regarded as a reasonable standard for milking machines.

THE GRADING SYSTEM

The majority of milks are graded solely on the methylene blue reductase test (MBRT). In isolated cases, plate counts, microscopic counts and the resazurin test are used. Much of the milk used for cheese manufacture is subjected to a fermentation test. The MBRT is carried out at temperatures well above the optimal for the growth of spoilage bacteria. The predominant organisms responsible for rapid reduction are the lactic acid bacteria and the coliforms. Other bacteria are only important when active strains are present. The test is not specific for the organisms which are dominant in most New Zealand milk examined — micrococci. It does not determine the presence of psychrotrophic bacteria unless they are in extremely high numbers, and, further, it does not show the presence of thermoduric bacteria such as the coryneforms and micrococci which are dominant in New Zealand milks. The latter groups, psychrotrophics and thermodurics, are the most important from the milk quality point of view, so it is strange that we do not test for them. As was stated earlier, the detection of unhygienic milk-producing conditions relies on test methods which determine the presence of these bacteria, and the aim of a cleaning system is to prevent their occurrence.

In Table 1 the results of 552 refrigerated milk samples graded on the MBRT and the viable count (72 hr at 30° C) are shown. Of the 171 samples with viable counts in excess

TABLE 1: THE RELATIONSHIP OF THE METHYLENE BLUE REDUCTASE TEST AT 37° C TO THE VIABLE COUNT RANGE (72 hr, 30° C).

Viable Count Range × 10^{-3}	*Methylene Blue Reductase Time (hr)* 0-1	1-3	3-6	6	*Total Samples*
0- 100	1	1	12	210	224
100- 500	2	2	14	139	157
501-1,000	3	4	11	49	67
> 1,000	8	16	27	53	104
Total samples	14	23	64	451	552

of 500,000/ml, only 31 (18.6%) were of inferior quality according to the MBRT.

In a detailed study of 348 non-refrigerated milks, 52% had thermoduric counts less than 2,000/ml and 7% were greater than 10,000/ml. The coliform counts were high with 22% being greater than 100/ml and 22% were greater than 500/ml. A further study on 653 refrigerated milks showed them to be of higher quality on the basis of these criteria, 78% having thermoduric counts less than 2,000/ml and 78% coliform counts less than 100/ml. It is of interest that, of the total viable counts on the refrigerated samples, 80% were less than 50,000/ml. Other workers have shown that the combined coliform-thermoduric testing system is the best indicator of milk quality. This poses several practical problems for the rapid assessment of milk quality by large factories. Several sophisticated methods are being developed overseas but it is not envisaged that they will be practicable in New Zealand factories in the near future. Another possibility is the concept that it is unnecessary to test all milk samples each day and hence a more detailed study on fewer samples may be performed. This is used at present in testing for antibiotics, and has been adopted for milk quality in some areas of Europe.

In attempting to provide an answer to the problem of rapid grading methods, a study was undertaken of various classes of milks. The study is as yet incomplete and the results shown in Table 2 are only to be regarded as a preliminary survey. The methylene blue reductase test (MBRT) is normally conducted at 37° C, a temperature above that which is optimal for the growth of most bacterial types. The results for MBRT conducted at 30° C and 37° C are shown in Table 2.

As can be seen, this test is more sensitive than that carried out at 37° C. It still leaves a lot of latitude with respect to detection of inferior milk. A more sensitive test

TABLE 2: COMPARISON OF THE GRADING OF MILK SAMPLES OF VARIOUS COUNT RANGES BY THE METHYLENE BLUE REDUCTASE TEST AT 37° C AND 30° C.

Viable Count Range $\times 10^{-3}$	*MBRT 30° C* 2	1	F	*MBRT 37° C* 2	1	F	*Total Samples*
< 200	0	0	20	0	0	20	20
201- 500	0	0	20	0	0	20	20
501-1,000	0	0	18	0	1	17	18
> 1,000	12	27	22	5	16	40	61
Total Samples	12	27	80	5	17	97	119

is the nitrate reduction test carried out at 30° C which, in trials to date, has only failed to detect 25% of the high count samples, a decided improvement on present rapid test methods. This test has the advantage that both the dominant psychrotrophic and thermoduric bacteria exhibit nitrate reductase activity. The results of this work are to be reported elsewhere.

The theme of this paper is that unhygienic equipment is the source of most bacteria occurring in milk of low quality. Unhygienic equipment occurs as a result of either the failure to clean machines properly or using machines which, because of faulty design, cannot be cleaned. This situation is aggravated by the fact that the present method for quality assessment is of such a low sensitivity that it does not clearly distinguish between milks of various qualities. The question may well be asked, "How important, then, is quality?" The milking shed is a food factory and as such should be maintained in a hygienic condition. The use of some low quality milk may have little effect on final product quality if there is sufficient good milk to effect adequate dilution. For most products this is adequate protection under most conditions. However, in the production of high-grade casein and low temperature powdered milk, the initial quality of the raw milk has a profound effect on product quality. To overcome this problem, many factories collect milk twice daily, at great expense, to achieve better quality. This would be unnecessary with adequate cleaning and cooling. A less obvious loss is the degradation of milk constituents which are lost during processing. The dramatic increase in farm production has increased collection difficulties and there has been a gradual increase in alternate day collection and refrigeration to offset the cost and difficulty of collection. This, in turn, has increased the need for high initial quality standards at the farm. Finally, overseas customers have set higher standards for the bacteriological quality of dairy products and some buyers now require information on the raw milk quality. The industry can no longer accept antiquated methods for milk quality evaluation or milking machine cleaning if such standards are to be consistently attained.