HANDLING AND PROCESSING OF MILK IN THE DAIRY

MILK CONTROL ON RECEPTION

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Formerly, official concern over milk quality was largely confined to freedom from adulteration. While this is still a problem, even in the more advanced countries, the realization that disease could be spread by milk has led to the emphasis being placed upon the safety of milk supplies. Routine testing for the presence of pathogens is impracticable, but it was felt that the greater the care taken in production and handling of milk, the less the danger to the consumer. Consequently, methods developed by the medical bacteriologist for testing water supplies—plate count and coli—were adapted for assessing the bacteriological quality of milk. Davis (1950) has reviewed developments in the bacteriological testing of milk up to 1950.

The widespread adoption of pasteurization or other heat treatments of milk has largely removed the concern over safety, particularly of supplies intended for pasteurization. With such supplies the results of bacteriological tests are regarded chiefly as an indication of the care taken in production and handling of milk. Where milk is consumed raw, bacteriological tests also give an indication—although a far from precise one—of the probable keeping quality of the milk.

In many respects the receiving platform is the key point in relation to the quality of milk or of the products made therefrom, and the man inspecting the milk is the key figure. He should, however, be assisted by the control laboratory on the one hand and by the farm inspection or advisory service on the other. A laboratory should be provided in all but the smallest processing establishments; it affords the best and cheapest means of assessing the care taken in the production and processing of milk. It can frequently aid the inspection or advisory service by indicating the probable cause of unduly high bacterial populations, as well as giving evidence of mastitis, adulteration, etc. Finally, it can carry out compositional tests (fat, total solids, etc.) to detect sub-standard supplies, or as a basis for payment.

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Platform Tests

These are necessarily rapid tests which can serve as a basis for acceptance or rejection of milk. A review of this subject was published in 1952 by Clegg. In most dairying countries, chief reliance is placed upon the keen nose of a trained man at the intake. By smelling the can lid as it is removed, he is able to detect undesirable odours indicative of feed, weed or stable flavours, as well as of excessive numbers of bacteria. In some countries this is supplemented by tasting the milk. This, however, may involve some hazard unless cattle are known to be free from tuberculosis and other bovine diseases affecting man. While it would be preferable to use an objective test for this purpose, there is unfortunately no test available which does not involve some delay. Where the producer has to get his own cans back, the delay involved may have serious consequences.

Milk cooled in farm bulk tanks is so cold that detection of off-flavours or odours is difficult. Heating a sample in an electric bottle-warmer or soup-cup is helpful here.

Acidity test

This is a crude test for quality, most useful with poor-quality milk supplies. It is carried out by titrating a definite volume of milk with standard alkali solution. [1] The result is often misleadingly expressed as " per cent lactic acid ". In actual fact, fresh milk, especially from Channel Island breeds, may show a titratable acidity as high as 0.23 %, none of which is lactic acid (Sommer, 1952). This titration value simply measures buffer capacity; it represents the amount of alkali required to bring the pH from the initial value of approximately 6.6 to about 8.3, the endpoint of the phenolphthalein indicator. Thus, if a low limit, say 0.16 %, is set, this may be exceeded by perfectly fresh milk with a high solids content (Sommer, 1952). On the other hand, with a limit of, say, 0.18 %, milk low in solids, or mastitis milk, could undergo appreciable acid development and still meet the standard. In most progressive countries, this test is rarely applied to market milk, but may be used to check doubtful cans of milk for manufacturing purposes.

In titration, some directions (e.g., the American Public Health Association, 1960) call for diluting milk with from one to ten volumes of water. As has been pointed out (Sommer, 1952), such dilution permits a shift in the phosphate equilibrium, with a resulting titration value lower than for an undiluted portion.

Alcohol test

This is the fastest of the objective tests. Usually, equal volumes of milk and 68 % ethyl alcohol are mixed; if the milk curdles, it is considered

[1] A rougher test, in which definite values of milk and alkali solution are mixed, is commonly used to tell whether the acidity exceeds a certain level.

unsatisfactory and is rejected. Like the acidity test, it is of little value where a quality improvement programme has been in effect. It is used mainly with milk for manufacturing purposes.

This test is open to objections on both sides. On one hand, milk giving a positive reaction has usually so deteriorated that within a few hours it will clot on boiling; on the other hand, occasional samples which appear normal in every respect react positively even when fresh (Clegg, 1952). Not only acidity but also increased albumen and salt concentration may be responsible for a positive test (Sommer, 1952).

Ten-Minute Resazurin Test

In Great Britain, a committee was appointed during the Second World War to study the various tests proposed as a basis for rejecting milk unfit for pasteurization. They recommended the ten-minute resazurin test for this purpose (Barkworth et al., 1942).

The dye-milk mixture is incubated at 37°C for 10 minutes. The readings are interpreted as follows:

Resazurin disk reading	*Action recommended*
4-6	Accept for pasteurization
1-3½ inclusive	Advisable to reject as unsuitable for pasteurization
0 and ½	Reject

These standards, while more stringent than those for the acidity and alcohol tests, are still very lenient in comparison with bacterial count standards for market milk currently in force in the more progressive areas. Milks with counts in the millions per ml may still be classed as acceptable (Thomas & Andrews, 1943). While the ten-minute resazurin test is commonly used by pasteurizing establishments in Britain, in North America it is considered that (*a*) milk failing the test has deteriorated so much that it should readily be detected by the odour test, and (*b*) where shipping cans are owned by the farmer, the delay involved in performing the test makes it impracticable for any but the smallest establishment.

Lactic Acid Test

A test for developed acidity would be preferable to the titratable acidity test. Lactic acid is the chief product of bacterial activity, and various workers have developed tests for it; the latest is that of Taylor & Clegg (1958). A value of 0.03 % lactic acid has been suggested as a useful limit for acceptability. It is claimed that a single test can be run in 5 minutes; if so, this method may be widely adopted where this much delay is not crucial.

Sediment Test

Visible dirt has no place in milk. Consequently, sediment tests to demonstrate such dirt are a routine practice in many countries. While a poor sediment test is indisputable evidence of carelessness, a clean test may merely represent efficient straining on the farm. It should also be emphasized that there is little or no correlation between the amount of sediment and the bacteriological quality of the milk. Milk heavily contaminated with sediment may contain only a modest number of bacteria, while one devoid of sediment may teem with them.

Originally the test was conducted by forcing a measured amount (usually 1-pint—about half a litre) of mixed milk through a 1¼-inch (3.2-cm) lintine disk. More recently the " off-the-bottom " type of test has been preferred (American Public Health Association, 1960). In this, the measured volume of milk is sucked through the lintine disk while the tester is moved in a definite pattern across the bottom of the shipping can. Testers using compressed air are also in general use in North America. Where milk is handled in farm bulk cooling-tanks, recourse is had to a sample taken after thorough agitation of the milk. Either a 1-gallon sample (about 4 litres) is filtered through the regular size of disk (1¼-inch or 3.2-cm) or a 1-pint (half-litre) sample is filtered through a proportionately smaller aperture (Liska & Calbert, 1954). Standards representing definite quantities of sediment have been in use for years (American Public Health Association, 1960); milks containing over 3 mg sediment per pint (per half-litre) with the " off-the-bottom " type tester are usually rejected. After grading the sediment disk into three or four grades by comparison with the standards, it is customary to return it to the producer. Where sediment is excessive, it is obvious to the producer that he should check on his production practices. Such evidence is more easily understood than are the results of bacteriological tests.

Watering

Where the milk looks suspiciously " thin ", a specific gravity reading using a lactometer may be made (American Public Health Association, 1960). If the reading is appreciably subnormal, the milk may be rejected. However, it is advisable to confirm the suspicion by a freezing-point determination (American Public Health Association, 1960). The newer equipment (Shipe, 1959) is very much faster and more accurate.

Routine Control Tests

As quality improvement progresses, interest goes far beyond rapid rejection tests. The ideal is a milk supply of good flavour and composition which is free from pathogenic organisms, is derived from disease-free udders, and has been so carefully produced and handled that it is virtually free from sediment, and the bacterial content is exclusively composed of the udder flora. Such milk shows little or no deterioration in quality even when held at a temperature high enough to allow extensive bacterial growth.

Various methods are employed in assessing the bacteriological quality of raw milk. The choice of method will be influenced by such factors as the general quality of the supply, cost, interest in quality improvement, etc. Where little quality improvement work has been carried out, tests such as the " one-hour " resazurin or the methylene-blue reduction test (American Public Health Association, 1960) are useful. As quality improves, the " one-hour " resazurin test can be replaced with the " triple-reading " test, the direct microscopic count (DMC) or the standard plate count (SPC) (American Public Health Association, 1960). Finally, where bacterial numbers are extremely low, the SPC appears to be the most suitable test.

With all the emphasis on prompt, efficient cooling of milk there is a danger that cooling may mask careless production practices. To put more emphasis on cleanliness, "preliminary incubation" at 12.8°C for 18 hours has been advocated (Johns & Berzins, 1959). Holding at 15.6°C for 21 hours has also been used (Chalmers, 1956). Cleanly produced milks are not adversely affected by this treatment; those containing external contaminants generally show marked bacterial growth, sometimes an increase of over one hundredfold. (Thermoduric bacteria are an exception; they fail to grow in raw milk at 12.8°C.) The inadequacy of examining the freshly-taken sample has long been recognized in Britain, where samples are held at atmospheric shade temperature for 12 or 18 hours before being tested (England and Wales, Ministry of Health, 1937). (Holding at a fixed temperature would appear to be much more satisfactory, even where, as in Britain, the atmospheric temperature range is fairly narrow.)

The need for preliminary incubation is most evident where a dye reduction test is employed. In Britain it was early recognized (Wilson, 1935) that dye reduction tests during the winter months frequently fail to detect milks containing large numbers of bacteria; these are so dormant as a result of the low atmospheric temperature during preliminary storage that growth and consequent reduction of the dye during incubation at body temperature are slowed down. This is even more true of milk rapidly cooled to 4°C or lower in farm bulk tanks and collected every other day. With such well-cooled milks, the formerly established relationships between bacterial numbers and reduction times have been seriously distorted. Preliminary incubation at 12.8°C helps overcome this distortion; following this treatment, grading by the triple-reading resazurin test is in closer agreement with that by the SPC (Johns & Berzins, 1959).

Results of routine tests should be sent to producers to stimulate their interest in the bacteriological quality of their milk. A competitive element may be introduced by listing all producers in order of quality and marking for each producer his own standing. Prizes or bonuses offered for the best year's record have also been effective in stimulating interest in quality improvement (S. J. Olsen, personal communication, 1956).

Where milk is to be pasteurized, the chief purpose of routine control tests is to assess the care taken in the production and handling of milk. Keeping quality is of little significance, since the types of organism usually responsible for spoilage of pasteurized milk are almost all destroyed by the heat treatment. Where raw milk is bottled and distributed, keeping quality is of great importance. Whether or not a special test for keeping quality, such as the "clot-on-boiling" test (Barkworth et al., 1942), should be used is a matter of opinion. Milk which will meet most current standards, especially if subjected to preliminary incubation, should have ample keeping quality under all but exceptionally unfavourable conditions. The subject of quality tests for milk has recently been reviewed (Galesloot, 1956; Johns, 1959; Overby, 1955).

Viable counts

The well-known plate-count or Petri-dish method was the first one developed and is still the most widely favoured test for low-count milks. It is, however, expensive and time-consuming and requires well-trained personnel.

Over the years, with increased knowledge, the standard plate-count procedure has been improved by the use of lower incubation temperatures and more productive media. Much of this improvement can be credited to the committees responsible for the various editions of *Standard Methods for the Examination of Dairy Products* (published by the American Public Health Association). Although dairy bacteriologists (Babel et al., 1955) uniformly prefer 30°-32°C to the 35°C alternative currently recommended in *Standard Methods*, public health laboratories more often favour the higher temperature. This frequently yields much lower counts, especially on pasteurized samples. In Britain, while incubation at 30°C is favoured for advisory work (Griffiths et al., 1957), 37°C is still employed for official analyses by health departments. At this temperature all psychrophilic organisms, and many thermoduric organisms, fail to develop colonies in 48 hours.

The SPC is intended to reflect as closely as possible the total number of bacteria present in a sample. However, not all bacteria will form visible colonies on the standard agar medium under the specified incubation conditions. Furthermore, a colony may arise from a single bacterial cell or from a chain or clump of cells containing a hundred or more. Nevertheless, the plate count is still the most precise means of estimating the bacterial population of milk, especially where bacterial numbers are low.

Several other procedures have been advocated as substitutes for the more expensive plate-count method, especially for use as "screening" tests. In the Burri slant method (American Public Health Association, 1960) a measured loopful of milk is spread over the surface of an agar slant, and the colonies are counted after incubation. It is particularly handy for studies where laboratory facilities are not available. In the "little plate" method (Frost, 1916), bacteria grow on a microscope slide in a thin film of agar medium inoculated with the milk. The film is dried and stained and the colonies are counted under the microscope. The original method has been modified by various workers, but has not come into general use. In America, however, interest appears to be increasing. The "roll-tube" (*Lab. Practice*, 1957) and "agar-strip" methods (Stirling et al., 1950) have also been developed as cheaper modifications of the plate-count method.

In most areas, official count limits have been established for pasteurized milk. To meet these limits the raw milk must not contain too many thermoduric (heat-resistant) bacteria.[1] Consequently, incoming supplies should routinely be tested for these organisms by a "laboratory pasteurization" test (American Public Health Association, 1960). Thermoduric bacteria are rarely found in the udder; neglected milking equipment, especially the rubber-ware, is usually responsible for their presence in milk. Therefore the laboratory pasteurization test is considered by some to give a more satisfactory indication of faulty production practices than does the SPC. Several simplified methods for determining thermoduric counts have been described (American Public Health Association, 1960; Egdell et al., 1950); they are cheaper and less refined than the plating method but are quite adequate to detect heavily contaminated milks.

Direct microscopic count (DMC)

This method (American Public Health Association, 1960), with which the name of Breed has long been associated, has been extensively used in North America for the examination of raw milk. In qualified hands it can furnish much useful information concerning the past history of the milk, and in addition can reflect abnormal udder conditions such as mastitis. It may be used as a rapid means of checking the quality of any can or tank of milk, the results being available within minutes.

The direct microscopic test is most reliable when applied by trained workers to milks with counts in excess of 500 000 per ml (Wilson, 1935). As the bacterial numbers decrease, the experimental error increases, and more fields must be examined in order to obtain a reliable estimate. This makes the method even more expensive than the plate count for low-count milks. Consequently, in North America the popularity of this method

[1] In Britain the problems posed by heat-resistant bacteria have been by-passed by substituting a keeping-quality test for the plate count on pasteurized milk; in North America high counts of these organisms are taken as indicating insanitary milking equipment.

for market milk has declined. This has been hastened through the phenomenal expansion in the use of farm bulk cooling-tanks, [1] wherein bacterial growth in the milk is virtually eliminated, and lower bacterial count standards (50 000 per ml) are being employed (Corash, 1956).

Recently it has also been realized that wide variations in counts on " split " samples, and poor agreement between direct microscopic and plate counts are largely attributable to inadequate illumination, poorly trained workers and—most often—counting far too few fields (Levowitz, 1957). Even with well-trained technicians, there is also a fatigue factor which has not previously been recognized (W. C. Lawton, personal communication, 1959). Finally, technicians prefer to make plate counts.

When the plate count or the methylene-blue reduction test is used, no indication of abnormal udder conditions (mastitis, etc.) is obtained. Hence it is desirable to examine the milk for cells occasionally by the direct microscopic test. The "strip-counting" procedure (Levowitz, 1957) using the low-power objective, enables the entire area of the milk film to be surveyed in a few seconds. An improved " single-dip " staining solution (Levowitz & Weber, 1956) to replace the Newman-Lampert stain is giving good results.

Dye Reduction Tests

Bacteria growing in milk bring about a decrease in the oxidation-reduction potential. This can be detected through the use of a suitable indicator, such as methylene-blue or resazurin (American Public Health Association, 1960). These form the basis for simple methods of measuring the bacteriological quality of milk. Such tests require little equipment or technical skill, and allow rapid evaluation of the quality of large numbers of samples. Poor-quality milks are reduced most quickly, enabling a check to be made at the farm without delay.

Bacteria vary in their reducing activities and optimum growth temperatures. Consequently, the agreement between reduction time and viable count is greatest with high-count milks. Other factors also tend to distort the correlation originally established. Rapid cooling and holding of milk at a low temperature leaves the bacteria dormant, increasing the reduction time. Under such conditions, too, psychrophilic bacteria may make up a large percentage of the population; these fail to grow at the usual incubation temperatures—35°-37°C. Increasing numbers of heat-resistant bacteria, coming largely from neglected milking machines, are not adequately detected by dye reduction tests (Smythe, 1959) as these organisms are weakly reducing. On the other hand the use of more suitable media and incubation temperatures has increased the level of plate counts,

[1] In January 1961 over 160 000 of these tanks were in use in the USA. It is probable that within a few more years all market milk in the USA will be handled in bulk tanks.

while increased dye concentration in the methylene-blue reduction test has prolonged reduction time. Finally, the indicator resazurin is partially reduced by abnormal milk (for example, that associated with mastitis, late lactation, etc.).

Methylene-Blue Reduction Test

The methylene-blue reduction test, described by Barthel and Orla Jensen in 1912, is probably the most extensively used bacteriological test for raw milk. Its advantages are simplicity, reproducibility, cheapness, and rapid detection of poor-quality milks. Little technical training is required, and several hundred samples may be tested simultaneously.

In Britain a modification (Wilson, 1935) of the methylene-blue reduction test replaced the plate count for the examination of raw milk in 1937 (England and Wales, Ministry of Health). This modification calls for frequent [1] inversion of tubes during incubation to redistribute the bacteria which are swept to the surface by gravity. Results are more accurate and reproducible than with undisturbed incubation. The test is not run on the fresh sample. Instead, the sample is held at atmospheric shade temperature for 12 or 18 hours before testing. While this has definite advantages, in cold weather the grading is too lenient. Storage all year round at a fixed temperature in the range of 10°-15°C would seem much preferable.

In areas where mechanical refrigeration is not generally used, and where less stringent standards are in force, as with milk for manufacturing purposes, the methylene-blue reduction test, applied to the freshly-taken sample, is still widely used and is generally giving satisfaction.

Resazurin Reduction Test

One objection to the methylene-blue reduction test has been the lengthy incubation period. For a plate-count standard of 200 000 per ml, a reduction time of over 5 ½ hours has been accepted as equivalent (*Publ. Hlth Bull. (Wash.)*, 1953). Where milk supplies arrive at noon or later, testing involves either overtime work in the laboratory or refrigeration of samples overnight. Consequently, there has been interest in the use of other dyes which would give results more quickly. Of these, resazurin has been most widely accepted. A number of modifications have been described, only three of which appear to have come into general use. The original " one-hour " test graded the milk by the degree of colour change after one hour at room temperature; incubation at 37°C was subsequently adopted (Ramsdell et al., 1935). A " temperature-compensated " test is employed in Britain (by the Department of Health for Scotland); in this the reduction

[1] Inversion every hour gives the same results as inversion every 30 minutes, as recommended by Wilson (Johns, 1939).

time for acceptable milk varies according to the mean atmospheric shade temperature during the preliminary holding period.

While the " one-hour " test has some value where bacteria-count levels are high, it is generally considered to be of limited value for most market milk supplies. A more acceptable modification is the triple-reading test (American Public Health Association, 1960). This test employs as end-point a colour (5P7/4 in the Munsell system) midway between the initial blue and full pink, which is reached in approximately half the time required for complete reduction of methylene-blue. In addition to correlating well with the bacteria count, it also reflects excessive numbers of leukocytes. It has been accepted as a standard method (American Public Health Association, 1960) since 1948, and is widely used in controlling fluid milk supplies in Canada. In Denmark a slightly stiffer grading has been suggested (Hempler, 1950), using a slightly earlier end-point, which is considered superior in distinguishing exceptionally good milk from that of only satisfactory quality. As a means of distinguishing between reduction by leukocytes and that by bacteria, Hempler has recommended a second end-point at the full pink stage, in addition to the earlier one. Another Danish bacteriologist (Overby, 1955) studied the various dye reduction tests. He was most impressed with the effectiveness of the triple-reading test.

The third modification, the " ten-minute " test, has already been described under "platform tests" (see page 224). It is only effective in detecting milk too deteriorated to be accepted for pasteurization.

It is unfortunate that many writers refer to the resazurin test without indicating which one they mean. Many comments on the inadequacies of the test obviously refer to the " one-hour " test, and not to the triple-reading test.

Like the methylene-blue test, the resazurin test has been affected by those factors tending to distort the former relationship between reduction time and bacterial count. There is much better agreement between resazurin reduction time and plate count following preliminary incubation at 12.8°C for 18 hours (Johns & Berzins, 1959). It is also true that low-count milk containing numerous leukocytes brings about early reduction of resazurin (Ramsdell et al., 1935). This is regarded as an advantage of the test since such milk cannot be considered desirable. Resazurin is more sensitive to light than methylene blue but does not stain glass-ware as does the latter. As 8 % of the male population are colour-blind, workers using the test should be tested for colour vision. Colour changes should be observed under a fluorescent daylight lamp. Munsell colour standards (American Public Health Association, 1960) in test-tubes are more convenient than the Lovibond apparatus described by Davis & Thomas (1940).

Of recent years another indicator—2,3,5-triphenyltetrazolium chloride—has been advocated (Mustakallio et al., 1955). Its value appears to be greatest in indicating high-count milks and detecting substances inhibiting lactic streptococci (Neal & Calbert, 1956). The dye is highly sensitive to light.

Keeping-Quality Tests

As the proportion of milk delivered raw continues to drop in most countries, interest in keeping-quality tests for raw milk declines. Where milk is to be pasteurized or sterilized, the value of determining keeping quality before heating is open to question. Testing after bottling would be more useful, especially since spoilage of cooled milk is most frequently attributable to growth of psychrophilic bacteria which have contaminated the milk after pasteurization.

Various procedures, mostly modifications of the dye reduction tests, have been advocated as keeping-quality tests. Since the organisms which grow best at the temperatures at which milk is commonly held are not necessarily those that grow best at body temperature, incubation at lower temperatures, for example, 18°C, has been suggested. In Britain, a great deal of attention has been devoted to keeping-quality tests for raw milk; in particular, the " clot-on-boiling " test, in which portions of the samples are immersed in boiling water twice daily, has been advocated (Rowlands et al., 1950) for this purpose. This method was adopted for routine testing in England and Wales in 1961.

Coliform Tests

Authorities in North America have rarely been interested in the coliform (colon-aerogenes) content of raw milk, feeling that high counts more frequently indicate growth than initial contamination. They cannot be taken as an indication of faecal contamination; neglected milking machine rubber-ware is the most frequent source of high counts (Smillie, 1953). In Britain, on the other hand, many authorities feel that the coliform count furnishes a better indication of the care taken in production than does the total bacterial content (Griffiths et al., 1957; Smillie, 1953; Thomas, 1955). Since the volume of milk being cooled in farm bulk tanks in America is rapidly increasing, however, more interest in the coliform content of raw milk may be expected there.

The coliform content may be determined by either of two general methods (American Public Health Association, 1960), both of which have their adherents. In the tube dilution method, measured amounts of milk (or its dilutions) are inoculated into a selective fluid medium containing ingredients tending to inhibit growth of non-coliforms. In the plating method, 1-ml or smaller amounts are plated directly in a selective agar medium. Incubation was formerly at 37°C but various workers have shown that many lactose-fermenting organisms escape detection at this temperature; roughly twice as many positive tests were obtained by incubating at 30°C (Wilssens & de Vleeschauwer, 1956). It is not considered necessary to confirm positive tests, or to determine the type of organism present, as in water analysis, since the presence of faecal types does not indicate a potential health hazard as it does in water.

Tests for Mastitis

Milk is usually defined as the normal secretion from a healthy udder. This has been largely overlooked in many milk regulations, where emphasis has been mainly or entirely on the bacterial content. Of the routine control tests, the " one-hour " and triple-reading resazurin tests are the only ones which automatically penalize abnormal milk, i.e., that containing excessive numbers of leukocytes or other body cells. With low-bacteria-count milk, non-bacterial reduction can readily be distinguished by the rapid change in colour during the first hour or two, followed by little further change until bacterial growth causes further reduction. Hempler's procedure for distinguishing non-bacterial reduction has already been mentioned.

One weakness of the preliminary incubation at 12.8°C is the sharp decline which occurs in the reducing activity of the leukocytes. This makes it necessary to employ a separate test for their detection. A leukocyte count may be made in conjunction with the direct microscopic count. This is one of the most satisfactory procedures; a trained worker can frequently make useful deductions concerning the type of infection, especially if the sample is incubated for some hours or overnight at body temperature before the smear is made.

During recent years there has been increasing interest in the use of rapid chemical tests for the detection of abnormal milk. These may be used on individual quarter samples or on bulked herd-milk samples, and are simple enough for use on the farm or on the receiving platform. Of these, the modified Whiteside test is the most widely known (Murphy & Hanson, 1941). One drop of 4% NaOH is stirred into 5 drops of milk for 20 seconds. Abnormality is indicated by the extent of flaking and thickening that develops. The test is highly regarded by many who have had experience with it. An off-shoot of the Whiteside test, known as the California Mastitis Test (Schalm & Noorlander, 1957) has been developed to replace the strip-cup test on the farm. It utilizes a pH indicator, in addition to a surface active agent, to indicate abnormal conditions. Another modification using a surface active agent (Teepol) has also been described (McKenzie & Cameron-MacKintosh, 1958). The routine use of tests of this nature would help to direct attention to those herds most in need of veterinary service.

Tests for Antibiotics

The presence of detectable quantities of antibiotics in milk has recently given both health officials and industry some concern. Although occasionally added deliberately, most often antibiotics are residual from mastitis therapy. They may inhibit bacterial growth to the extent that milk is graded as better than it is, and may also interfere with acid production in the manufacture of fermented dairy products. Various procedures have been recommended for their detection in milk; the agar diffusion method (American Public Health Association, 1960) and the TTC (2, 3, 5-triphenyltetrazolium chloride) reduction test (Neal & Calbert, 1956) are two that are frequently used.

It seems unlikely that a test rapid enough to serve as a rejection test will be developed. The incorporation of a marker dye in the antibiotic preparation (Hargrove et al., 1959) appears to be the most promising approach.

Compositional Tests

Butterfat

Since the publication of the Babcock test in 1890, and of the Gerber test in 1892, it has been customary to determine the butterfat content of milk supplies received from farmers. In most countries the fat content is a factor in determining the price paid. In North America, Australia and New Zealand, the Babcock test is still generally used, although in the States of California, New Jersey, New York and Pennsylvania the Gerber test is officially approved. In Europe the Gerber test has long been favoured. Both tests yield results sufficiently close to those by the extraction method to be considered satisfactory, although minor modifications to obtain closer agreement are being advocated.

There has always been interest in a test which avoided the need for using strong acid. During the past decade, several " detergent "-type tests have been described in which a surface active agent plus an alcohol has been used to free the fat from the non-fatty materials. Comparative trials (Herreid, 1957; Hoover et al., 1958) indicate a degree of accuracy comparable to that of the Babcock test.

Solids-not-fat

Gravimetric procedures are time-consuming and expensive. Consequently, reliance is placed upon density measurements employing special hygrometers called lactometers (American Public Health Association, 1960). A modification (Watson, 1957) using a smaller lactometer and sample, is considered to be more rapid and less tedious. Various formulae have been developed for calculating the solids-not-fat from the lactometer reading (Sommer, 1952). More accurate results are obtained by first heating milk to 39°C to melt the butterfat. The use of plastic disks or spheres of various densities has recently been advocated (Golding, 1959). This method has obvious advantages.

Conclusions

The keen nose of a trained man inspecting incoming milk shipments is the most important single means of detecting milk of unsatisfactory quality. For quality improvement a variety of laboratory tests may be used, the choice depending on the level of bacterial contamination and the availability of funds, facilities and trained personnel.

A full quality-control programme would include routine testing for sediment, total bacteria (by plate count, direct microscopic count, or methylene blue or resazurin reduction test) fat and total solids. Supplementary tests to be run less frequently should include a laboratory pasteurization test, a test for watering, and one for mastitis (leukocytes, Whiteside, California Mastitis Test). Where bacterial growth is virtually eliminated, as with farm bulk tanks, preliminary incubation of samples at 12.8°C for 18 hours is useful for indicating where cooling is being substituted for cleanliness. The coliform count on bulk tank milk may also provide valuable information concerning the cleanliness of milking equipment.

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